PRACTICAL ZOOLOGY

INVERTEBRATE

S.S. LAL



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Contents

Chapters *Page No.*

1. Introduction 1–2

Significance of Classification and Naming Animals

2. Study of Museum Specimens 3–198

Instructions to Draw Museum Specimens (3)

Phylum-Porifera (3)
Natural history
Diagnostic characters
Classification

1. *Leucosolenia* (5)
2. *Clathrina* or *Olynthus* (6)
3. *Sycon* or *Scypha* (6)
4. *Grantia* (7)
5. *Leucilla* (7)
6. *Euplectella* (8)
7. *Hyalonema* (9)
8. *Pheronema* (9)
9. *Oscarella* (10)
10. *Chondrilla* (11)
11. *Cliona* (12)
12. *Spongilla* (12)
13. *Tethya* (13)
14. *Chalina* (13)
15. *Halichondria* (14)
16. *Microciona* (15)
17. *Poterion* (15)
18. *Ephydatia* (16)
19. *Hippospongia* (16)
20. *Euspongia* (17)
21. *Hircinia* (18)

Phylum-Coelenterata or Cnidaria (18)
Natural history
Diagnostic characters
Classification

22. *Hydra* (21)
23. *Ceratella* (22)

24. *Hydractina* (23)
25. *Millepora* (24)
26. *Stylaster* (24)
27. *Gonionemus* (25)
28. *Diphyes* (26)
29. *Halistema* (27)
30. *Physalia* (28)
31. *Porpita* (30)
32. *Velella* (31)
33. *Lucernaria* (31)
34. *Charybdea* (32)
35. *Chiropsalmus* (33)
36. *Pericolpa* (34)
37. *Aurelia* (35)
38. *Aurelia* : Stages of Life Cycle (36)
39. *Cynea* (38)
40. *Rhizostoma* (39)
41. *Tubipora* (39)
42. *Telesto* (40)
43. *Alcyonium* (41)
44. *Hartea* (41)
45. *Heliopora* (42)
46. *Gorgonia* (42)
47. *Corallium* (44)
48. *Pennatula* (45)
49. *Pteroides* (46)
50. *Renilla* (46)
51. *Cavernularia* (47)
52. *Virgularia* (47)
53. *Metridium* (48)
54. *Metridium* : V.S. (48)
55. *Adamsia* (49)
56. *Minyas* (50)
57. *Edwardsia* (50)
58. *Cerianthus* (51)
59. *Zoanthus* (52)
60. *Madrepora* (52)
61. *Meandrina* (53)
62. *Astrea* (54)
63. *Favia* (54)
64. *Astrangia* (55)
65. *Dendrophylla* (55)
66. *Fungia* (55)

Phylum-Ctenophora (56)
Diagnostic characters
Classification
67. *Cestum* (56)
68. *Coeloplana* (57)
69. *Ctenoplana* (58)
70. *Tjalfiela* (58)
71. *Beroe* (59)

Phylum-Platyhelminthes (60)
Natural history
Diagnostic characters
Classification
72. Planaria (= *Dugesia)* (62)
73. *Bipalium* (63)
74. *Fasciola hepatica* (64)
75. *Taenia solium* (65)
76. *Taenia saginata* (67)
77. *Moniezia expansa* (68)

Phylum-Aschelminthes (69)
Natural history
Diagnostic characters
Classification
78. *Ascaris lumbricoides* (70)

Phylum-Annelida (71)
Natural history
Diagnostic characters
Classification
79. *Nereis* (72)
80. *Heteronereis* (73)
81. *Polynoe* (74)
82. *Eunice* (75)
83. *Syllis* (76)
84. *Glycera* (77)
85. *Aphrodite* (77)
86. *Tomopteris* (79)
87. *Chaetopterus* (79)
88. *Sabella* or *Parasabella* (80)
89. *Sabellaria* (81)
90. *Arenicola* (82)
91. *Amphitrite* (83)
92. *Terebella* (84)
93. *Serpula* (84)
94. *Spirorbis* (85)
95. *Sternaspis* (86)
96. *Pheretima* (87)
97. *Lumbricus* (88)
98. *Tubifex* (89)
99. *Acanthobdella* (90)
100. *Pontobdella* (90)
101. *Clepsina* (91)
102. *Branchileon* (92)
103. *Hirudo medicinalis* (92)

104. *Hirudinaria granulosa* (94)
105. *Nepheles* (95)
106. *Haemopis* (95)
107. *Polygordius* (96)
108. *Protodrilus* (96)

Phylum-Mollusca (97)
Natural history
Diagnostic characters
Classification
109. *Chaetoderma* (99)
110. *Chiton* (100)
111. *Dentalium* (101)
112. *Patella* (102)
113. *Fissurella* (102)
114. *Haliotis* (103)
115. *Cyprea* (103)
116. *Pila* (104)
117. *Murex* (105)
118. *Aplysia* (106)
119. *Doris* (107)
120. *Aeolis* (107)
121. *Limnaea* (108)
122. *Planorbis* (109)
123. *Helix* (109)
124. *Limax* (110)
125. *Mytilus* (110)
126. *Unio* (111)
127. *Mya* (112)
128. *Venus* (112)
129. *Teredo* (114)
130. *Ensis* (115)
131. *Solenocurtus* (115)
132. *Ostrea* (116)
133. *Pecten* (117)
134. *Pinctada vulgaris* (118)
135. *Loligo* (119)
136. *Sepia* (120)
137. *Octopus* (121)
138. *Nautilus* (122)
139. *Argonauta* (123)

Phylum-Arthropoda (123)
Natural history
Diagnostic characters
Classification
140. *Apus* (128)
141. *Lepas* (129)
142. *Balanus* (129)
143. *Sacculina* (130)
144. *Gammarus* (131)
145. *Caprella* (132)
146. *Oniscus* (133)
147. *Bopyrus* (133)
148. *Squilla* (134)
149. *Penaeus* (135)
150. *Palaemon malcolmsonii* (136)
151. *Astacus* (137)
152. *Palinurus* (138)
153. *Eupagurus* (139)
154. *Hippa* (140)
155. *Carcinus* (141)
156. *Scolopendra* (142)
157. *Julus* (143)
158. *Peripatus* (143)
159. *Palamnaeus* (144)
160. *Aranea* (146)
161. *Limulus* (147)
162. *Galeodes* (148)
163. *Lepisma* (148)
164. *Periplaneta* (149)
165. *Gryllus* (150)
166. *Schistocerca* (151)
167. *Melanopus* or *Poecillocerus* (152)
168. *Gryllotalpa* (153)
169. *Carausius* (154)
170. *Phyllium scythe* : Leaf Insect (154)
171. *Mantis religiosa* (155)
172. *Forficula* (156)
173. Queen Termite (157)
174. *Ephimera* (157)
175. Dragon fly (158)
176. *Nepa* (159)
177. *Bellostoma* (160)
178. Aphid (161)
179. *Cicada* (161)
180. Butterfly (162)
181. Moth (163)
182. *Melolontha* : Beetle (164)
183. *Apis* : Honey bee (164)
184. *Apis* : Stages of Life Cycle (166)
185. Termite : Stages of Life Cycle (167)
186. *Bombyx mori* : Silkworm Stages of Life Cycle (168)
187. *Pollistis* (169)

Phylum-Echinodermata (170)
Natural history
Diagnostic characters
Classification
188. *Antedon* (172)
189. *Asterias* (173)
190. *Pentaceros* (174)
191. *Anthena* (175)
192. *Luidia* (176)
193. *Astropecten* (177)
194. *Ophioderma* (178)
195. *Ophiocoma* (179)
196. *Ophiolepis* (180)
197. *Ophiothrix* (181)
198. *Echinus* (182)
199. *Strongylocentrotus* (183)
200. *Echinarachinus* (183)
201. *Clypeaster* (184)
202. *Echinocardium* (185)
203. *Cucumaria* (186)
204. *Holothuria* (186)
205. *Thyone* (187)
206. *Synapta* (188)

Minor Phyla (198)
Minor Acoelomate group
Minor Coelomate group
207. *Bonellia* (189)
208. *Echiuris* (190)
209. *Sipunculus* (191)
210. *Priapulus* (191)

Phylum-Brachiopoda (192)
211. *Lingula* (192)
212. *Magellania* (193)

Phylum-Hemichordata (194)
Natural history
Classification
213. *Balanoglossus* (194)
214. *Saccoglossus* (196)
215. *Rhabdopleura* (197)
216. *Cephalodiscus* (198)

3. Microscope and its Practical Use 199–205

History (199)
Light Microscopes
1. Simple microscope (200)
2. Compound microscope (201)
3. Reverse type of research microscope (202)
4. Binocular microscope (202)
5. Low power dark field binocular microscope for differential colour illumination (203)
6. Comparison microscope (203)
7. Slit immersion and reflecting ultramicroscope (204)
8. Phase contrast and interference microscopy (204)
9. Electron microscope (205)

4. General Method of Microscopic Preparations 206–208

1. Killing and Narcotization (206)
2. Fixing (206)
3. Washing (207)
4. Staining (207)
5. Destaining (207)
6. Dehydration (207)
7. De alcoholization or Clearing (207)
8. Mounting (208)
9. Precautions and Instructions (208)
10. Chart for Single Staining (208)
11. Chart for Double Staining (208)

5. Culture Methods 209–210

Phylum-Protozoa (209)
Amoeba, Paramecium, Vorticella and *Euglena* (209)
Phylum-Porifera (210)
Fresh Water Sponge (210)
Phylum-Coelenterata (210)
Hydra (210)
Phylum-Platyhelminthes (210)
Dugesia (210)
Phylum-Annelida (210)
Nereis, Earthworm and Leech (210)
Phylum-Arthropoda (210)
Daphnia, Gammarus and Cockroach (210)
Phylum-Mollusca (210)
Marine Molluscs, *Pila globosa* (210)
Phylum-Echinodermata (210)
Asterias, Echinus and *Ophioderma* (210)

6. Preparation of Permanent Stained Slides (Study of Living Animals) 211–218

Phylum - Protozoa (211)
– Slowing Protozoa (211)
– Examining Protozoans in hanging drop (211)
– Vital staining of protozoans (211)
– Preparation of blood films for protozoans blood parasite (*Plasmodium, Leishmania*) (211)
– Preparation and examination of some free living and parasitic protozoans (213) *(Amoeba, Paramecium, Vorticella,* Rectal ciliates and *Monocystis)* (213)
Phylum-Porifera (214)
Gemmule, Spicule (214)
Phylum-Coelenterata (215)
Hydra, Obelia (215)
Phylum-Platyhelminthes (215)
Planaria, Liver fluke and Tape worm (215)
Phylum-Nemathelminthes (216)
Nematodes (216)
Phylum-Annelida (216)
Pheretima, Nereis and *Hirudinaria* (216)
Phylum-Mollusca (217)
Gill Lamella of *Unio,* Osphradium of *Pila* and Radula of *Pila* (217)
Phylum-Echinodermata (217)
Pedicellariae of starfish, Tube feet of starfish (217)
Phylum-Arthropoda (217)
Hastate plate of prawn, Statocyst of prawn, *Cyclops, Daphnia,* Nauplius, Zoaea, Megalopa, Pecten, Book lungs of scorpion, Salivary gland of cockroach, Mouth parts of cockroach, Spiracles of cockroach, Trachea of cockroach (218).

7. Study of Prepared Slides 219–364

General Instructions to Draw and Study The Prepared Slides (219)

Phylum-Protozoa (219)
Diagnostic characters (219)
Classification (219)
1. *Chrysamoeba* (221)
2. *Euglena* (222)
3. *Copromonas* (223)
4. *Chlamydomonas* (224)
5. *Volvox* (225)
6. *Noctiluca* (226)
7. *Ceratium* (227)
8. *Trypanosoma* (228)

9. *Leishmania* (229)
10. *Trichomonas* (230)
11. *Giardia* (231)
12. *Trichonympha* (231)
13. *Amoeba* (232)
14. *Entamoeba histolytica* (233)
15. *Entamoeba coli* (234)
16. *Entamoeba gingivalis* (235)
17. *Arcella* (236)
18. *Difflugia* (237)
19. *Euglypha* (237)
20. *Polystomella* (238)
21. *Globigerina* (239)
22. Foraminifera ooze (241)
23. Radiolarian ooze (241)
24. *Actinosphaerium* (242)
25. *Actinophrys* (243)
26. *Monocystis* (244)
27. *Gregarina* (245)
28. *Eimeria* or *Coccidium* (246)
29. *Plasmodium* (248)
30. *Opalina* (250)
31. *Paramecium* (250)
32. *Paramecium* : Binary fission (252)
33. *Paramecium* : Conjugation (252)
34. *Balantidium* (253)
35. *Nyctotherus* (254)
36. *Stentor coerules* (254)
37. *Vorticella* (255)
38. *Ephelota* (256)

Phylum-Porifera (256)

39. *Sycon* : L. S. (256)
40. *Sycon* : T. S. (257)
41. *Grantia* : L. S. (258)
42. *Grantia* : T. S. (258)
43. Spicules of Sponge (259)
44. Gemmules (259)
45. Amphiblastula (260)

Phylum-Coelenterata (261)

46. *Hydra* : Entire (261)
47. *Hydra* : L.S. (263)
48. *Hydra* : T.S. passing through Body Plain (263)
49. *Hydra* : T.S. passing through Testis (264)
50. *Hydra* : T.S. passing through Ovary (264)
51. *Hydra* : T.S. passing through Bud (265)
52. *Bougainvillea* (265)
53. *Tubullaria* (266)
54. *Pennaria* (267)
55. *Sertularia* (268)
56. *Plumularia* (268)
57. *Eudendrium* (269)
58. *Obelia* (270)
59. *Obelia* : Medusa (271)
60. *Companularia* (272)
61. *Aurelia* : Planula Larva (272)
62. *Aurelia* : Scyphistoma Larva (273)
63. *Aurelia* : Ephyra Larva (273)
64. *Aurelia* : Vertical Section (274)

Phylum-Platyhelminthes (274)

65. *Dugesia* (Planaria) (274)
66. *Dugesia* (Planaria) : T.S. passing through Pharynx (275)
67. *Gunda segmentina* (276)
68. *Polystoma* (277)
69. *Diplozoon* (278)
70. *Fasciola hepatica* : Entire : Sheep Liver Fluke (278)
71. *Fasciola hepatica* : T.S. passing through Testes (280)
72. *Fasciola hepatica* : T.S. passing through Uterus (281)
73. *Fasciola hepatica* : T.S. passing through Testes and Uterus (281)
74. *Fasciola hepatica* : T.S. passing through Cirrus Sac (282)
75. *Fasciola hepatica* : M.L.S. of Anterior Region (283)
76. *Paramphistomum* (283)
77. *Gastrothylax* (284)
78. *Schistosoma haematobium* : Blood Fluke (284)
79. *Opisthorchis* or *Clonorchis sinensis* (285)
80. *Fasciola hepatica* : Eggs (286)
81. *Fasciola hepatica* : Miracidium Larva (287)
82. *Fasciola hepatica* : Sporocyst Larva (288)
83. *Fasciola hepatica* : Redia Larva (289)
84. *Fasciola hepatica* : Cercaria Larva (289)
85. *Taenia solium* : Scolex (290)
86. *Taenia solium* : Mature Segment (290)
87. *Taenia solium* : Gravid Segment (291)
88. *Taenia solium* : T. S. passing through Mature Segment (292)
89. *Taenia solium* : Cysticercus Larva (293)
90. *Echinococcus granulosus* (294)

Phylum-Nemathelminthes (295)
91. *Ascaris lumbricoides* : T.S. Male passing through Middle of the Body (295)
92. *Ascaris lumbricoides* : T.S. Female passing through Midbody (296)
93. *Enterobius vermicularis* (297)
94. *Oxyuris* (298)
95. *Trichinella spiralis* (299)
96. *Trichinella spiralis* : Encysted Larvae (300)
97. *Wuchereria bancrofti* (300)
98. *Wuchereria bancrofti* : Encysted Microfilaria (301)
99. *Ancylostoma duodenale* : Hookworm (302)
100. *Dracunculus medinensis* (303)

Phylum-Annelida (305)
101. *Tubifex* (305)
102. *Aelosoma* (305)
103. Earthworm : M L.S. of Anterior Region (306)
104. Earthworm : T.S. passing through Pharynx (307)
105. Earthworm : T.S. passing through Gizzard (308)
106. Earthworm : T.S. passing through Spermathecal Region (308)
107. Earthworm : T.S. passing through 11th Segment (309)
108. Earthworm : T.S. passing through 12th Segment (310)
109. Earthworm : T.S. passing through 18th Segment (311)
110. Earthworm : T.S. passing through Typhlosolar Region (312)
111. Earthworm : *Setae in situ* (313)
112. Earthworm : Ovary (314)
113. Earthworm : Septal Nephridia (314)
114. *Nereis* : T.S. Body through Parapodia (315)
115. *Nereis* : T.S. Body without Parapodia (316)
116. *Nereis* : Parapodium (316)
117. *Heteronereis* : Parapodium (316)
118. *Nereis* : Trochophore Larva (317)
119. Leech : T.S. passing through Buccal Cavity and Jaws (317)
120. Leech : T.S. passing through Crop with Diverticula (318)
121. Leech : T.S. passing through Crop without Diverticula (319)
122. Leech : T.S. passing through Stomach (320)
123. Leech : T.S. passing through Penis-Sac and Epididymis (320)
124. Leech : T.S. passing through Rectum and Posterior Sucker (321)
125. Leech : Jaws (322)
126. Leech : Salivary Glands (322)
127. Leech : Nephridium (323)

Phylum-Mollusca (323)
128. *Unio* : T.S. of Gill-Lamina (323)
129. *Unio* : Cross Section of Body (324)
130. *Unio* : Glochidium Larva (325)
131. *Unio* : T.S. Shell (325)
132. *Pila* : L.S. Osphradium (326)
133. *Pila* : Radula (326)

Phylum-Arthropoda (327)
134. *Peripatus* : T.S. passing through Body (327)
135. *Culex* : Egg Raft (328)
136. *Anopheles* : Eggs (328)
137. *Culex* : Larva (328)
138. *Anopheles* : Larva (329)
139. *Culex* : Pupa (329)
140. *Anopheles* : Pupa (330)
141. *Culex* : Male : Head and Mouth Parts (330)
142. *Culex* : Female : Head and Mouth Parts (330)
143. *Anopheles* : Male : Head and Mouth Parts (331)
144. *Anopheles* : Female : Head and Mouth Parts (331)
145. *Musca domestica* : Housefly : Head and Mouth Parts (332)
146. Butterfly : Head and Mouth Parts (332)
147. *Apis* : Honey bee : Mouth Parts of Worker (333)
148. *Apis* : Honey bee : Legs (334)
149. *Apis* : Honey bee : Sting Apparatus (335)
150. *Cimex* : Bedbug : Mouth Parts (335)
151. *P. americana* : Cockroach : Mouth Parts (336)
152. *Xenopsylla* : Rat Flea (337)
153. *Pediculus humanis* : Human Body Louse (337)
154. *Cyclops* (338)

155. *Daphnia* (339)
156. *Branchipus* (340)
157. *Cypris* (341)
158. *Argulus* (341)
159. *Nebalia* (342)
160. *Lucifer* (343)
161. *Mysis* (343)
162. *Mysis* : Larva (344)
163. Nauplius Larva (344)
164. Zoaea Larva (345)
165. Megalopa Larva (346)
166. Prawn : Hastate Plate (346)
167. Prawn : Hand cut T.S. Abdomen (346)
168. Prawn : V.S. Cuticle and Body Wall (347)
169. Prawn : V.S. Compound Eye (348)
170. Prawn : Statocyst (348)
171. Scorpion : Book-lung (349)
172. *Ixodes* : Tick (349)

Phylum-Echinodermata (350)
173. Starfish : T.S. of Arm (350)
174. Starfish : L.S. of Arm (351)
175. Starfish : Pedicellariae (352)
176. Starfish : Bipinnaria Larva (352)
177. Starfish : Brachiolaria Larva (353)
178. *Echinus* : Echinopluteus Larva (353)
179. Brittle Star : Ophiopluteus Larva (354)

Phylum-Rotifera (355)
Outline classification (355)
180. *Brachionus* (355)

Phylum-Ectoprocta (356)
Outline classification (356)
181. *Bugula* (356)
182. *Balanoglossus* : L.S. through Anterior Region (357)
183. *Balanoglossus* : T.S. through Post-hepatic Region (358)
184. *Balanoglossus* : T.S. through Collar (358)
185. *Balanoglossus* : T.S. through Proboscis Region (359)
186. Study of Cells and Cell Organelles in Living Conditions (359)
187. Study of Photographs of Animal Tissues
1. Simple cuboidal epithelium (360)
2. Simple columnar epithelial cells (360)
3. Goblet cells (361)
4. Simple squamous epithelial cells (361)
5. Adipose tissue (361)
6. Reticular tissues (362)
7. Blood smear of frog (362)
8. Blood smear of rabbit (363)
9. Frog : T.S. passing through the testis (363)
10. Frog : T.S. through ovary (363)
188. TMV (Tobacco Mosaic Virus) (363)
189. Experiment : Demonstration of Haemolysis and Crenation in Red Blood Corpuscles (364)

8. Dissections (Major and Minor) 365–413

Significance and Purpose of Dissections (365)
General Instructions for Dissections (365)
1. ***Ascaris*** **:** Round Worm (366)
1. External features (366)
2. General anatomy (366)
2. ***Nereis*** **:** Clam Worm (368)
1. External features (368)
2. Digestive system (369)
3. ***Pheretima posthuma*** **:** Earthworm (369)
1. External features (369)
2. General anatomy (370)
3. Alimentary canal (372)
4. Reproductive system (372)
5. Nerve ring (374)
4. ***Hirudinaria granulosa*** **:** Leech (374)
1. External features (374)
2. General anatomy (375)
3. Alimentary canal (376)
4. Reproductive system (377)
5. Nervous system (377)
5. ***Unio*** or ***Lamellidens*** **:** Fresh-water Mussel (377)
1. External features (378)
2. Inner view of shell (378)
3. General anatomy (378)
4. Nervous system (379)

6. ***Mytilus*** **:** Sea Mussel (380)
Nervous system (381)
7. ***Pila globosa*** **:** Apple snail (381)
1. External features (381)
2. Soft parts (381)
3. General anatomy (382)
4. Nervous system (383)
8. ***Loligo*** **:** Squid (384)
1. External features (384)
2. Nervous system (384)
9. ***Sepia*** **:** Cuttle fish (386)
1. External features (386)
2. Nervous system (386)
10. ***Periplaneta americana*** **:** Cockroach (387)
1. External features (387)
2. General anatomy (390)
3. Reproductive system (391)
11. ***Poecilocerus*** or ***Schistocerca*** **:** Grasshopper or Locust (392)
1. General anatomy (392)
2. Digestive system (392)
3. Reproductive system (392)
4. Nervous system (394)
12. ***Palaemon malcolmsonii*** **:** Prawn (395)
1. External features (395)
2. Appendages (397)
3. General anatomy (399)
4. Nervous system (403)
13. ***Squilla*** (404)
1. External features (404)
2. Nervous system (404)
14. ***Paratelphusa*** **:** Freshwater Crab (405)
1. External features (405)
2. Nervous system (405)
3. Ventral nerve cord (406)
15. ***Palamnaeus*** **:** Scorpion (406)
1. External features (407)
2. General anatomy (407)
3. Reproductive system (407)
4. Nervous system (409)
16. ***Pentaceros*** **:** Starfish (409)
1. External features (409)
2. General anatomy (409)
3. Water vascular system (409)
17. ***Echinus*** **:** Sea Urchin (411)
Dissection of Aristotle's Lantern (411)
18. ***Holothuria*** **:** Sea Cucumber (412)
1. External features (412)
2. General anatomy (412)

9. Wonder Invertebrates 414–416

10. Preparation of Fixatives, Stains and Other Reagents 417–420

11. Experimental Cytology 421–432

1. Prokaryotic and Eukaryotic Cells (421)
2. Preparation of Chromosomes (424)
3. Stages of Mitosis from Prepared Slides from Plant and Animal Materials (426)
4. Stages of Meiosis from Prepared Slides from Plant and Animal Materials (427)
5. Microphotographs of Certain Cell Organelle (429)

12. Study of *Drosophila* and Human Chromosomes 433–440

Study of *Drosophila* (433)
Study of Human Chromosomes (439)

13. Genetic Exercises 441–445

14. Experimental Ecology 446–453

15. Study of Embryological Slides 454–472

16. Practicals on Evolution and Animal Behaviour 473–498

Evolution
(A) Study of Evolution of Horse through Various Models (473)
(B) Study of Evolution through Homologous and Analogous Organs and Forms (477)
(C) Adaptive Modification of Feet or Claws in Birds (486)
(D) Adaptive Modification in Mouth Parts of Insects (488)
(E) Serial Homology (492)

Animal Behaviour
(A) Study of Photographs (495)
(B) Phototaxis or Photoreception and Toxicological Responses (498)

17. Viva Voce 499–512

(Z–20/JMD/0808)

1 Introduction

The study of Invertebrate Practical Zoology shall help us to a great extent in understanding the basic concepts regarding the animals, their structure and usefulness to mankind. Most of the outstanding discoveries regarding human welfare have come through animal model system.

During pre-Darwinian period studies in Zoology involved a little more than a knowledge of different kinds of animals. Students of Zoology spent much of their time in studying anatomy, relationships and classification of various groups of animals. But the post-Darwinian period witnessed great advancements in the knowledge of Zoology. Besides Morphology (Anatomy), **Embryology**, **Physiology** and **Cytogenetics** became favourite subjects of study. Another tremendous increase in the knowledge of Zoology came after the invention of electron microscope. The post-electron microscope era and especially in last few decades, various modern disciplines emerged such as **Ultrastructural studies**, **Cell** and **Molecular Biology**, **Immunology**, **Parasitology**, **Biophysics**, **Biochemistry**, **Biostatistics**, **Ecology**, **Animal Behaviour**, **Pollution**, **Biotechnology**, **Environmental Toxicology** and **Cytochemistry**. **Light Microscopic** studies about the structure of animals are being replaced by ultrastructural studies. Under scanning electron microscope, ciliation of a protozoan, tentacles of sea anemones, lips of nematodes, and ornamentations on nematode body are very fascinating to look.

Although now students devote comparatively lesser time in acquiring detailed knowledge of animal forms and classification, which is the primary language of the subject Zoology. Animal forms and classification are of greater importance to day. Proper identification is absolutely essential for the interpretation of the research. For instance, action of drugs is specific on parasites and from drug designing angle, the proper classification and identification of the parasites is equally important alongwith other studies such as Physiology and Biochemistry. In Ecology, for instance, from course studies to Ph.D thesis, surveys and projects depend on the identification of the different animals that are found together in ponds or forests or whatever habitat is studied. First step in this direction is the recognition of the Major groups—*Phylum, class* and *order*-to which the animal belongs. This Text book of Practical Zoology (Invertebrate) helps in the placing of different animals into groups and to provide information on which their classification is based. The book is therefore a sort of summary of an immense amount of knowledge about invertebrate animals mentioned in the book.

Significance of Classification and Naming Animals

The classification is a human-made system for orderly arrangements of different animals. Nomenclature of animals provides a terminology essential in the exchange of knowledge and ideas in research and teaching. The name given to animals has specific meaning. For instance, the name '*Physalia*' means to Zoologists not only a particular genus of coelenterates but also a particular body form, mode of life and so forth. Biological classification is based on the *bionomial system of nomenclature* introduced by Linnaeus (1707-78) who is referred to as father of classification. International rules for Zoological nomenclature were prepared in 1931. Linnaeus subdivided plants and animals into groups or taxas as given below :

Empire
Kingdom
Class
Order
Genus
Species
Variety

The above is called Linnaean Hierarchy. For details of international rules of nomenclature, student can study in taxonomy books (Mayer, Woodsworth, etc). Here students must remember how to write generic and specific names. The first name is, the generic name. It should be written either in all capital letters or in all italic letters or underlined. The first letter must always be written with capital letter. Similarly, while writing the second name or specific name, either it should be written in capital letter or italicised or underlined, but the first letter is always written with a small letter. For example, the name of the sheep liver fluke can be written in any of the following three ways :

(1) **FASCIOLA HEPATICA**
(2) ***Fasciola hepatica.*** The name of generic name with capital letter and the names of specific name with small letter.
(3) **Fasciola hepatica.** Both generic and specific names to be underlined always. The generic name starting with capital letter and specific name with small letter.

Similarly, the Zoological binomial names of some other animals are ***Amoeba proteus***, ***Plasmodium vivax***, ***Taenia solium***, and ***Ascaris lumbricoides***.

Recent trend in some cases is to follow the trinomial nomenclature. For instance, the Roundworm is found in the intestines of man and pig differing in their strains. In such cases the names are written as ***Ascaris lumbricoides*** var. ***Humanis*** (Human Roundworm) and ***Ascaris lumbricoides*** var **Suis** (Pig Roundworm). The above two Round worms now conventionally called an ***Ascaris lumbricoides*** (Found in man) and ***Ascaris suum*** (Found in pig).

Recently term **BIODIVERSITY** has assumed global importance for studying different animals. They may produce new drugs, new foodstuffs, and new materials. These days biotechnology and biodiversity are linked together. With the use of biotechnology (tissue culture etc.) useful varieties of animals and plants can be developed.

Study of Museum Specimens

2

Instructions to Draw the Museum Specimens

(1) Before leaving home for Zoology practical laboratory, check that you are equipped with a Zoology practical exercise book, a text book of practical Zoology, H.B. pencil, pencil sharpener, pencil eraser (good quality rubber) and a piece of soft cloth.
(2) Try to obtain advance information about the museum specimens to be drawn so that you come prepared for their study.
(3) Special care should be taken to give a very correct proportion about the dimensions (length and breadth) of the specimen.
(4) Usually draw only 2 diagrams on one page, but these should be of the same class.
(5) Classification should be written on the right top of the diagrams.
(6) Line diagrams only should be drawn.
(7) Shading should be avoided as far as possible.
(8) Important features must be exhibited in the diagrams.
(9) Each diagram must be fully labelled with the help of the book. The labelling should be horizontal.
(10) Write both zoological and common names of each specimen below the diagram.

PHYLUM PORIFERA

Natural history

The initial advantage of becoming multicellular is the opportunity for increase in size. Larger organisms are less subject to attack; they have greater reserves within the body to withstand temporary unfavourable conditions. Multicellularity has been achieved independently perhaps four or five times in plants, Mesozoa, sponges and Metazoa.

Sponges belonging to phylum Porifera (*L. Porus,* pores+*ferre,* to bear) are sessile organisms with a low degree of individuality and cellular organisation. Sponges appear like plants being sessile and attached to rocks, shells and other solid objects. Most sponges are marine distributed from arctic to tropical seas, living from the low tide line to depths of 6 kilometers. One family (Spongillidae) is distributed in freshwater. Many sponges are drab coloured and others are brilliantly red, orange, yellow,

violet, blue and black. The sponges have commercial importance being used in bathroom or in automobiles.

Diagnostic characters

(1) Cellular grade of organization.
(2) Body bears several pores and hence the name Porifera.
(3) Presence of canal system.
(4) Skeleton of calcareous or siliceous spicules or horny spongin fibers.
(5) Commonly called as sponges.
(6) Asexual reproduction by gemmules and sexual reproduction by sperm and ova.

Classification

CLASS I CALCAREA
1. Skeleton of calcareous spicules.
2. Body asconoid, syconoid or leuconoid.

Order 1 Homocoela (= Asconosa)
1. Skeleton of calcareous spicules.
2. Body asconoid, syconoid or leuconoid.
Ex. *Leucosolenia, Clathrina.*

Order 2 Heterocoela (= Syconosa)
1. Syconoid canal system.
2. Solitary or colonial.
Ex. *Sycon, Scypha, Grantia.*

CLASS II HEXACTINELLIDA
1. Six-rayed siliceous spicules.
2. Exclusively marine.

Order 1 Hexasterophora
1. Spicules hexasters.
2. Usually attached to substratum.
Ex. *Euplectella, Staurocalyptus.*

Order 2 Amphidiscophora
1. Spicules amphidisks.
2. Attached to substratum by root tufts.
Ex. *Hyalonema, Pheronema.*

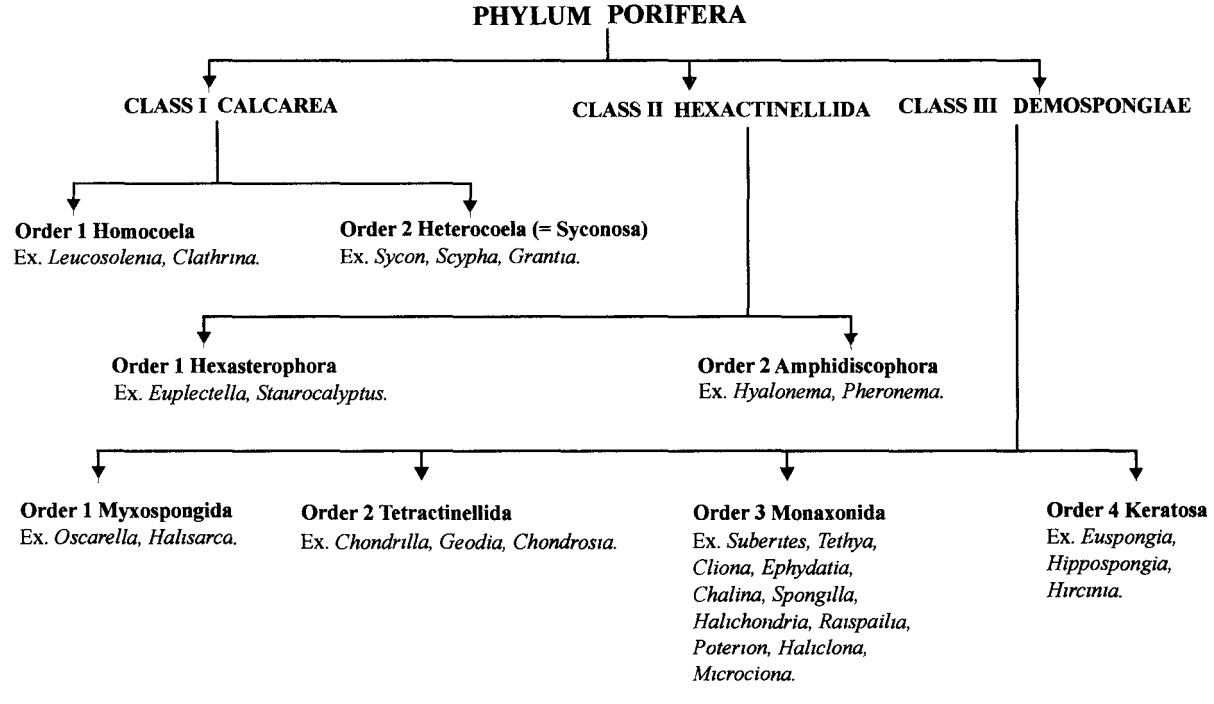
CLASS III DEMOSPONGIAE
1. Spicules of Spongin fibers or Siliceous spicules or both.
2. Large, solitary or colonial.

Order 1 Myxospongila
1. Spicules absent.
2. Simple structure.
Ex. *Oscarella, Halisarca.*

Order 2 Tetractinellida
1. Tetraxon spicules.
2. Spongin present.
Ex. *Chondrilla, Geodia, Chondrosia.*

Order 3 Monaxonida
1. Spicules monaxon.
2. Fresh–water or marine.
Ex. *Suberites, Tethya, Cliona, Ephydatia, Chalina, Spongilla, Halichondria, Raispailia, Poterion, Haliclona, Microciona.*

Order 4 Keratosa
1. Spicules of spongin only.
2. Horny sponges of massive sizes.
Ex. *Euspongia, Hippospongia, Hircinia.*



1. *Leucosolenia*

Classification :

Phylum.....Porifera	→	Pore bearing, cellular grade, asymmetrical or radially symmetrical.
Class.....Calcarea	→	Calcareous spicules present.
Order.....Homocoela	→	Canal system of ascon type.
Genus.....*Leucosolenia*		

Habit and habitat : Marine colonial sponge found in shallow waters below tidemark on seashore rocks, having intense wave action of the water.

Distribution : Distributed from Matha's vineyard to Gulf of St. Lawrence. From Casco bay to Arctic ocean and common in Europe.

Comments :

(1) **Colony** is composed of bunches of whitish vertical cylinders and tubes about 25 mm long.
(2) Vertical tubes of the colony contain **osculum** distally. They are joined together by horizontal tubes at the base. The surface of the body is perforated by numerous **pores** or **ostia** or incurrent pores.
(3) Magnified portion of the colony shows **vase-shaped individuals, inhalent ostia, tri-radiate spicules** and **horizontal branches** attached to **substratum**.
(4) Simplest sponge with **ostia → spongocoel → osculum** arrangement of water current. Canal system is simplest of **ascon type**. Osculum is surrounded by **oscular fringe**.
(5) Body wall is composed of **dermal epithelium** forming outer layer, and **Choanocyte layer** forming inner layer, separated by middle **mesenchyme** layer.
(6) **Calcareous spicules** are **monaxon** or **Triaxon**.
(7) Asexual reproduction by budding, branching and regeneration.
(8) Sexual reproduction by **ova** and **spermatozoa**. Larva is **parenchymula**.
(9) ***Leucosolenia*** has phylogenetic significance because complex sycon and leucon sponges pass through ascon stage during their development.

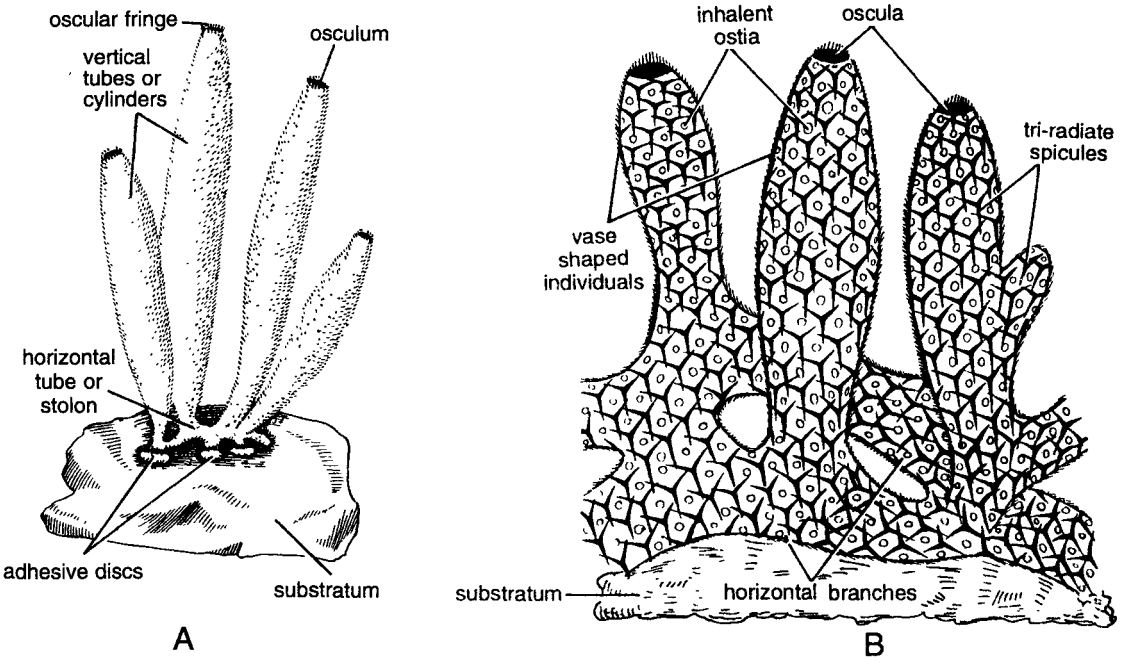


Fig. 1. *Leucosolenia.* **A.** Colony, **B.** Portion of colony (magnified).

Identification : Since the above specimen contains oscula, ostia, anastomosing colony and all above characters and hence it is ***Leucosolenia***.

Instructions : *Draw a portion of the colony after thoroughly studying it. Locate pores and oscula. What creates the water current in sponges and of what use is it ?*

2. *Clathrina* or *Olynthus*

Classification : Same as that of ***Leucosolenia***.

Genus.....*Clathrina*

Habit and habitat : ***Clathrina*** is a simple, marine sponge attached to rocks or **substratum.**

Distribution : Same as that of ***Leucosolenia***.

Comments :

(1) **Originally** it was presumed as adult and was called as ***Olynthus***, but now it is known to represent the late developmental stage of some sponge.
(2) Sedentary sponge with a free end containing **osculum**.
(3) Spongocoel opens through the osculum.
(4) Body is cylindrical and perforated by various **ostia**.
(5) **Triradiate calcareous spicules** form the skeleton.
(6) Development is complicated.

Identification : Since the animal has broad anterior, portion with **osculum, ostia** and narrow posterior portion attached to substratum and all above characters, hence it is ***Clathrina***.

Instructions : *Study, draw and compare with other sponges.*

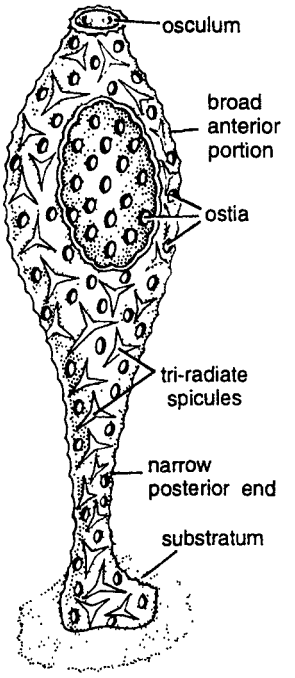


Fig. 2. *Clathrina* (=*Olynthus*).

3. *Sycon* or *Scypha*

Classification :

Phylum.....Porifera	→	Pore bearing, cellular grade, asymmetrical or radially symmetrical.
Class.....Calcarea	→	Calcareous spicules present.
Order.....Heterocoe	→	Syconoid sponges with internal folds.
Genus.....*Sycon*		

Habit and Habitat : ***Sycon*** or ***Scypha*** is a small, solitary or colonial marine sponge found in shallow to approximately 60 fathoms deep in well oxygenated water.

Distribution : Common in Europe. Distributed from Rhode Island to Greenland.

Comments :

(1) Complex **vase-shaped** body, measuring 20 to 25 mm in length and 5 to 6 mm in diameter.
(2) Each cylinder bulges in the middle and opens to the exterior by **osculum**. Body surface is covered by a **ostia** bearing membrane.
(3) At the distal free end there is a large **osculum**, encircled by a **fringe** of large giant **monaxon spicules** forming **funnel-shaped collar** or **oscular fringe**.
(4) Proximal and or **base** attached to **substratum**.

(5) Body wall is thick through which **monaxon, triaxon** and **tetraxon** spicules project.
(6) Body wall is composed of outer **dermal epithelium**, middle **mesenchyma** and inner **flattened epithelium** lining **spongocoel** which opens through the **osculum**.
(7) **Canal system** is **syconoid. Choanocytes** are restricted to radial canals. Course of water current is **ostia** → **prosopyles** → **radial** → **canals** → **apopyles** → **spongocoel** → **osculum** → exterior. Nutrition, respiration and excretion by canal system.
(8) **Hermaphroditic**.
(9) Reproduction by **sexual** or **asexual** methods. Asexual reproduction by **budding** and **regeneration**, while sexual by **ova** and **sperms**. Larva is **amphiblastula**.

Identification : Since the animal has **radial tubes**, **oscular fringe**, **ostia** and all above features, hence it **is *Sycon*.**

Instructions : *Draw radial tubes, circular fringe, ostia and spicules, boil a fragment of Sycon in an aqueous KOH solution which dissolves the cells but not the spicules. Wash with water, pipette some of the spicules over the slide and examine.*

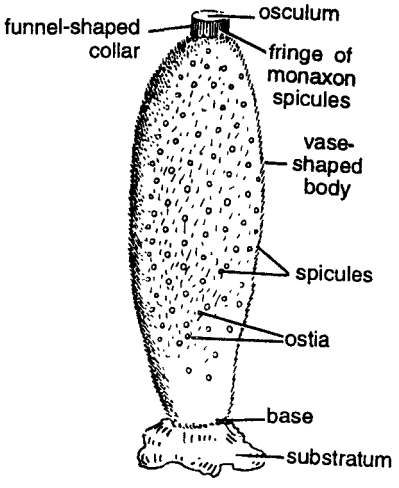


Fig. 3. *Sycon.*

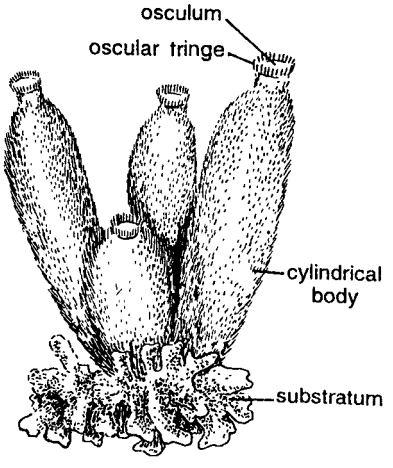


Fig. 4. *Grantia.*

4. *Grantia*

The classification and other general characters are similar to ***Sycon,*** But ***Grantia*** differs from ***Sycon*** so that the dermal membrane spreads over the entire surface of the sponge, forming a cortex of varying thickness having special cortical spicules. Found in Gulf of St. Lawrence.

5. *Leucila*

Classification : Same as that of ***Sycon.***
Genus.....*Leucila*
Habit and habitat : It is a small solitary and marine sponge.
Distribution : Found in Europe and U.S.A.

Comments :

(1) Anterior **apical portion** is narrow.
(2) Posterior **basal portion** is **broad** and attached to **substratum**.
(3) **Osculum** is situated at the anterior extremity and is surrounded by **oscular fringe of monaxon spicules**.
(4) **Canal system** is of primitive leuconoid type.
(5) Each radial canal is subdivided into elongated flagellated chambers, grouped around a common excurrent channel.
(6) **Skeleton** is of inarticulate type.

Identification : Since the specimen has narrow anterior end with pores, oscular fringe and all above features hence it is ***Leucila***.

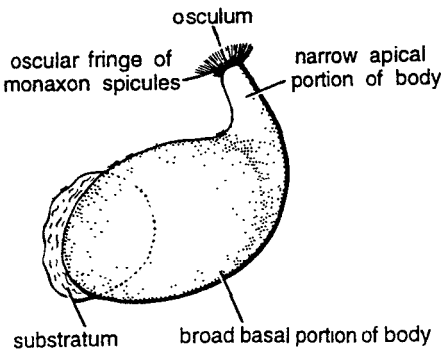


Fig. 5. *Leucila.*

6. *Euplectella*

Classification :

Phylum.....Porifera	→	Pore bearing cellular grade, asymmetrical or radially symmetrical.
Class.....Hexactinellida	→	Glass sponges with siliceous spicules of triaxon or six-pointed type.
Order.....Hexasterophora	→	Hexaster spicule present. Amphid is absent.
Genus.....*Euplectella*		

Habit and habitat : ***Euplectella*** is solitary animal found abundantly in deep waters at the depths of 500 to 5,000 meters in slow running water, adapted for low water current.

Distribution : It is distributed near Philippines and West Indies.

Comments :

(1) **Commonly** called as **Venus's flower basket** due to its beautiful elegant glossy shape like knitted elongated basket.
(2) Animal measures 15 to 30 cm in length and 2 to 5 cm in diameter.
(3) Body is long, rigidly curved and cylindrical.
(4) Body is composed of four and six-rayed **siliceous spicules** interlaced and fused at their tips forming three dimensional network with **parietal gaps**.
(5) Spicules are joined together forming a network.
(6) Lower end contains usually a mass of long siliceous spicules in form of **root tuft** which fasten the animal with mud.
(7) Cloacal cavity is closed in above with a sieve plate.
(8) **Osculum** contains sieve called as **oscular sieve plate**.
(9) **Canal system** is of simple ***Sycon* type**.
(10) ***Euplectella*** displays an interesting commensal relation with certain species of shrimps. A young female and male shrimp enter into spongocoel and after growth become unable to come out. Their entire life is passed in sponge prison. They feed on plankton in water current.

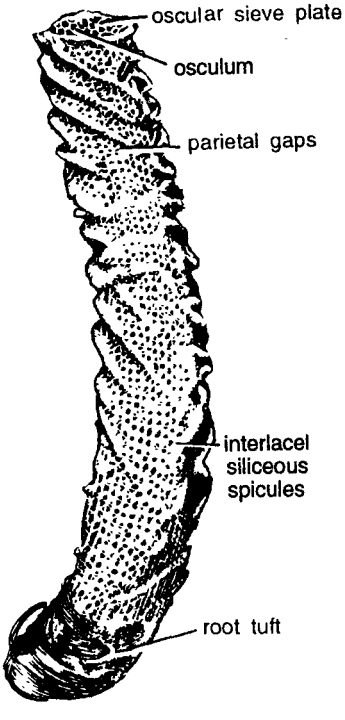


Fig. 6. *Euplectella.*

Special features : ***Euplectella*** has great social and mythological value. The skeleton of this sponge, having imprisoned shrimps inside, is presented as wedding gift to newly married couples in Japan, signifying close association.

Identification : Since the specimen has knitted basket-shaped body, ostia, oscular sieve plate and all above features, hence it is ***Euplectella***.

Instructions : *Draw the specimen showing cylindrical basket-shaped body, oscular sieve plate, parietal gaps and root tuft.*

7. *Hyalonema*

Classification :

Phylum.....Porifera	→	Pore bearing cellular grade, asymmetrical or radially symmetrical.
Class.....Hexactinellida	→	Glass sponges with siliceous spicules of triaxon or six-pointed type.
Order.....Amphidiscophora	→	Hexaster spicules absent and amphidisks present.
Genus.....*Hyalonema*		

Habit and habitat : ***Hyalonema*** is marine animal, found 60 to 95 fathoms deep (Fig. 7).

Distribution : Found along new England coast.

Comments :

(1) **Commonly** called as **glassrope sponge.**

(2) Body is spherical or ovoidal and axially traversed by a bundle of long spicules.

(3) **Spicules** are often fused to form a lattice-like skeleton, giving the sponge a glasslike appearance when dried.

(4) Glass sponges are most symmetrical and most individualized. Body is cup or vase-shaped measuring 10 to 30 cm in height. Spongocoel is well developed. **Osculum** contains **sieve plate.**

(5) Stick or columella is composed of a root tuft or root spicules which acts as **hold fast** organ.

(6) **Root spicules** are compact, stalklike elongated, twisted and giving the appearance of a rope. The middle columella contains **symbiotic** polyps (***Epizoanthus***).

(7) It possesses large and small **amphidisk spicules** like fresh-water sponges. Entire body contains small, branching, six-rayed spicules resembling **Christmas trees** on cross-shaped bases.

(8) When the upper surface of the sponge is depressed, spongocoel is formed and excurrent canals open into it but when columella is projected into **gastral cone**, no spongocoel exists.

(9) **Flagellated chambers** are arranged radially and in parallel planes in the sponge wall.

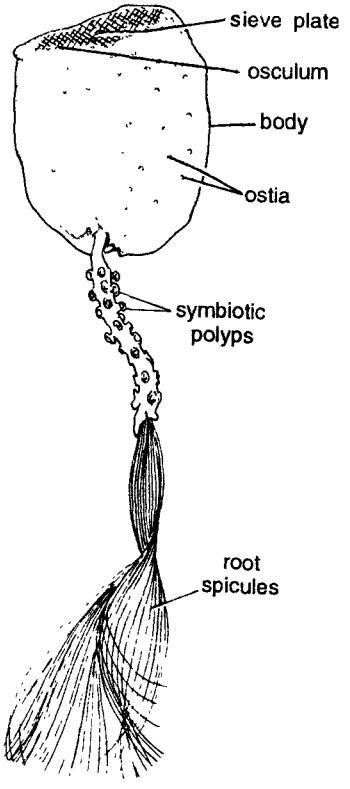


Fig. 7. *Hyalonema.*

Identification : Since the specimen has glossy root tuft, large osculum, ostia symbiotic polyps and all above features hence it is ***Hyalonema.***

Instructions : *Study and draw root spicules stalk, body, ostia and symbiotic polyps. Compare the morphoanatomical features of* ***Leucosolenia, Sycon, Euplectella*** *and* ***Hyalonema.***

8. *Pheronema*

Classification : Same as that of ***Hyalonema.***

Genus.....*Pheronema*

Habit and habitat : ***Pheronema*** is found on the bottom of sea. It is the commonest hexactinellid amphidiscophore adapted for deep-sea life (Fig. 8).

Distribution : It is found in U.K., U.S.A., and Europe.

Comments :

(1) **Animal** has a thick-walled cup or bowl-shaped body with the spongocoel opening above and with **spicules** in the form of **tufts.**

(2) **Pleural tufts** and long-twisted **root tufts** are present resembling glass wool.

(3) Projecting **marginal** and **pleural prostals** possess long monactines with small spines at one end, called as **scepters.**

(4) Spongocoel opens through the **osculum** which is encircled by upright spicules or marginal prostals.

(5) The animal in attached to the rocks by **root spicules.**

Identification : Since the specimen contains **spicular tufts** such as marginal prostals and pleural prostals, hence it is ***Pheronema.***

Instructions : *Draw the different types of spicules.*

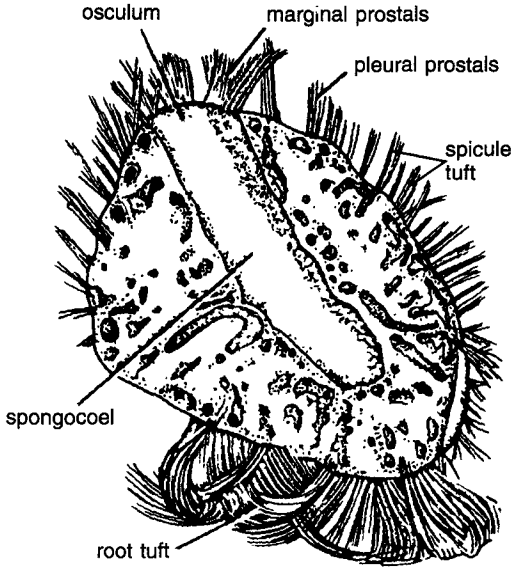


Fig. 8. *Pheronema* in longitudinal section.

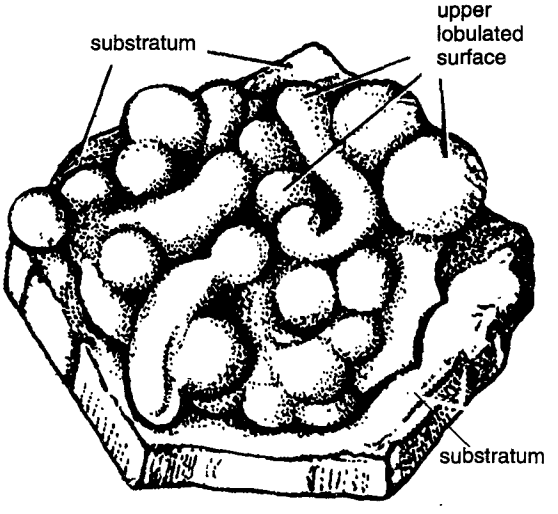


Fig. 9. *Oscarella.*

9. *Oscarella*

Classification :

Phylum.....Porifera	→	Pore bearing, cellular grade, asymmetrical or radially symmetrical.
Class.....Demospongiae	→	Skeleton of spongin fibres or siliceous spicules which are not six-rayed.
Order.....Myxospongida	→	Skeleton absent.
Genus.....*Oscarella*		

Habit and habitat : ***Oscarella*** is found in shallow water forming encrustation over the rocks and submerged objects. It is a simple, primitive, sedentary and marine sponge (Fig. 9).

Distribution : Found in British waters.

Comments :

(1) ***Oscarella*** is a bright, velvety coloured specimen with lobulated upper surface.
(2) **Spicules** are completely absent.
(3) Lower surface is attached to **substratum**.
(4) Basal part contains **eggs**, while peripheral part contains **canal** system. Thick cortex is absent.
(5) **Lobules** are covered by thin dermal layer. Each lobule encloses an **excurrent canal**, surrounded by **flagellated chambers**. Depressions between the lobules contain **incurrent** canals. Chambers vary from **eurypylous** to the **aphodal** type.
(6) **Canal system leuconoid.**
(7) Skeleton is absent. The structures without skeleton.

Identification : Since the specimen has lobulated upper surface, ostia and leuconoid canal system, hence it is ***Oscarella.***

10. *Chondrilla*

Classification :

Phylum.....Porifera	→	Pore bearing, cellular grade, symmetrical or asymmetrical.
Class.....Demospongia	→	Skeleton of spongin fibres or siliceous spicules which are not six-rayed.
Order.....Tetractinellida	→	Spicules tetraxon.
Genus.....*Chondrilla*		

Habit and habitat : ***Chondrilla*** is a marine tetractinellid demosponge.

Distribution : Found in British waters and U.S.A.

Comments :

(1) Entire **sponge body** looks like a rounded mass attached to **substratum**.
(2) Free surface contains few **oscula**, while rest of the **body** is perforated by several **pores**.
(3) Body surface is smooth, but mesogloea is thick and stony due to spherasters.
(4) Canal system is of **leuconoid** type.
(5) **Spheraster** in thick cortex.
(6) Spherasters found in the cortex between the cones are well developed while other spicules are absent.

Identification : Since the specimen contains pores, oscula and spherasters in thick cortex and all above features hence it is ***Chondrilla.***

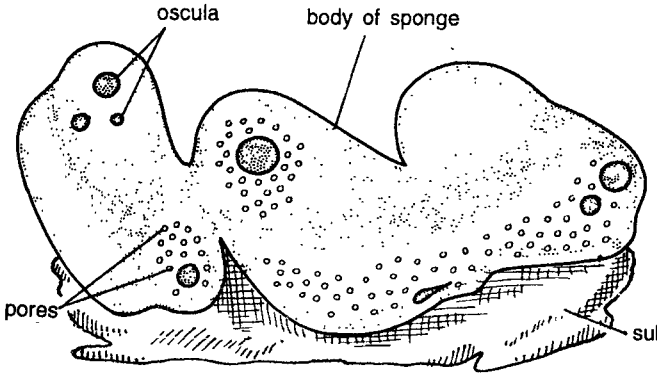


Fig. 10. *Chondrilla.*

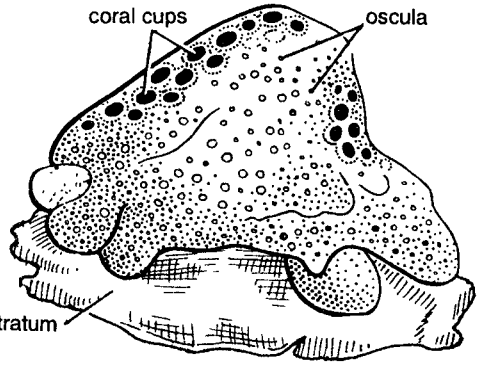


Fig. 11. *Cliona.*

11. *Cliona*

Classification :

Phylum.....Porifera	→	Pore bearing, cellular grade, asymmetrical or radial symmetry.
Class.....Demospongia	→	Spongin fibres or siliceous spicules, leuconoid type canal system.
Order.....Monaxonida	→	Spongin may or may not be present; spicules monaxon.
Genus.....*Cliona*		

Habit and habitat : ***Cliona*** forms low encrustation on rocks, coral skeletons, mollusc shells and other calcareous objects.

Distribution : Cosmopolitan, very common in South Carolina.

Comments :

(1) **Commonly** called as **boring sponge** (Fig. 11).
(2) It is a light yellow coloured sponge.
(3) Sponge forms a mass up to approximately 20 cm in diameter.
(4) Proximal end or base is attached to **substratum**.
(5) Clam shell, specially **Venus**, is completely riddled by it.
(6) It enters the interior of above animals and lives permanently there, forming extensive burrows and tunnels.
(7) Each **tunnel** has a raised opening, called **osculum**.
(8) The surface shows various elevations each containing an **osculum** and large number of **coral cups**.
(9) Reproduction **sexual** and early stages-free-living. The larva grows into a compact mass, 17 to 70 cm in diameter made up of spongin fibres and monaxial siliceous spicules.
(10) Various **oscula** are seen over the surface.

Special features : The sponge beings its existence by boring in the dead or living shells of various molluscs. It honeycombs the shell and after destroying it grows over it. ***Cliona celata*** has sulphurous odour.

Identification : Since the specimen has raised oscula, pores and coral cups and all above features hence it is ***Cliona.***

Instructions : *Study and draw the specimen.*

12. *Spongilla*

Classification : Same as that of ***Cliona.***

Genus.....*Spongilla*

Habit and habitat : ***Spongilla*** is a **colonial** sponge, abundantly found in ponds or streams.

Distribution : It is found in Atlantic, Europe and American waters.

Comments :

(1) **Commonly** known as **fresh-water sponge**.
(2) **Colony** is profusely branched, exhibiting various shades of green colour due to the presence of green algae, called as ***Zoochlorellae,*** in the cellular system.
(3) **Body wall** consists of very thin dermal membrane, perforated with **dermal pores** or **ostia** and several **oscula**.
(4) Skeleton is composed of **spongin fibres**. The siliceous spicules are in the form of network of smooth or spiny large and small **oxeas**, embedded in the **spongin**.
(5) **Canal system** is of the **rhagon type**. Water enters through dermal **pores → sub-dermal cavity → incurrent canals → several flagellated chambers → excurrent canal → osculum**.
(6) **Asexual** reproduction by **gemmules**.

(7) **Sexual** reproduction by **sperm** and **ova**.
(8) Gemmules are protected by amphidisk spicules.
(9) Larva is free swimming. It develops on floating submerged **twigs** or **sticks**.

Identification : Since the specimen has branched colony, ostia, rhagon type canal system and all above features and hence it is ***Spongilla.***

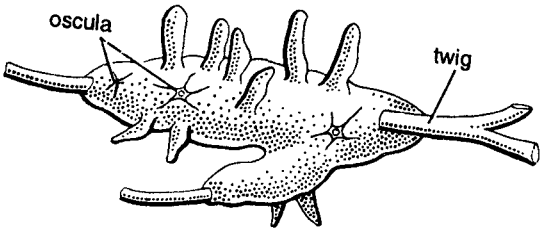


Fig. 12. *Spongilla.*

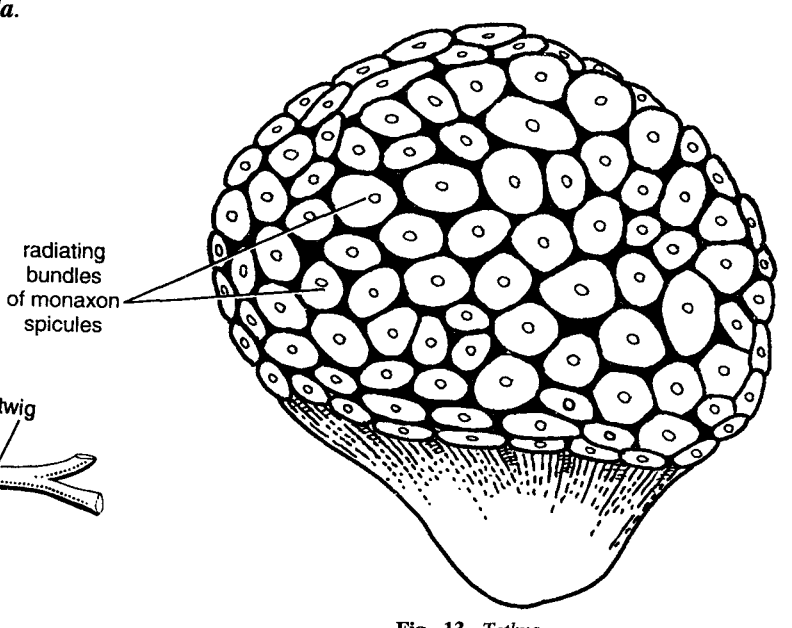


Fig. 13. *Tethya.*

13. *Tethya*

Classification : Same as that of ***Cliona.***

Genus.....*Tethya*

Habit and habitat : ***Tethya*** is found in the sea (Fig. 13).

Comments :

(1) Spherical sponge attached to substratum.
(2) Body surface **tuberculate** with radiating bundles of **monaxon spicules** and **several exasters.**
(3) **Styles** have indistinct tylote ends.
(4) Spongin fibres are entirely absent.

Identification : Since the sponge has radiating bundles of monaxon spicules and all above characters hence it is ***Tethya.***

14. *Chalina*

Classification : Same as that of ***Cliona.***

Genus.....*Chalina*

Habit and habitat : ***Chalina*** is found in deep waters. In shallow waters it is only found when detached from its **stalk** and washed ashore (Fig. 14).

Distribution : Found in Europe. Common from Rhode Islands to Labrador. North Carolina to Cape Cod. Very common in long Island Sound.

Comments :

(1) ***Chalina*** is commonly called as **Dead man's fingers** or **Mermaid's** gloves.
(2) Orange or yellowish-brown or red-coloured sponge attached to rocks by stalk.
(3) Surface of the body is flattened consisting of bunches of finger-like branches and perforated by several **ostia** and several **oscula**.
(4) Skeleton comprise spongin and siliceous spicules. It may be joined or enclosed.
(5) Canal system is of leucon type.
(6) It reproduces **sexually** and **asexually** by regeneration and budding.
(7) Sexual reproduction by sperm and ova.

Identification : Since the animal has finger shaped, forked or digitate stalk shaped body, ostia and all above characters and hence, it is ***Chalina***.

Instructions : *Study and draw the specimen.*

15. *Halichondria*

Classification : Same as that of ***Cliona***.

Genus.....*Halichondria*

Habit and habitat : ***Halichondria*** is a **colonial** form. In shallow water it forms low encrustations on rocks while in deep water it develops into extensive **masses** of various kinds (Fig. 15).

Distribution : Cosmopolitan, specially found in Rhode Island to Arctic ocean, North Pacific-Europe.

Comments :

(1) **Commonly** called as **crumb of 'bread sponge'**.
(2) Soft green, brown or yellow coloured.
(3) **Oscula** are placed at the top of **conical projection of sponge**.
(4) In encrusting kinds, each osculum communicates with the surface and body is vase-shaped.
(5) In encrusting kinds each osculum communicates with the surface.
(6) Skeleton consists of irregularly scattered oxeas spicules of several sizes with little or no spongin.

Identification : Since the animal has massive colony, irregularly scattered spicules vase-shaped body, oscula and all above characters, hence it is ***Halichondria***.

Instructions : *Study and draw the specimen.*

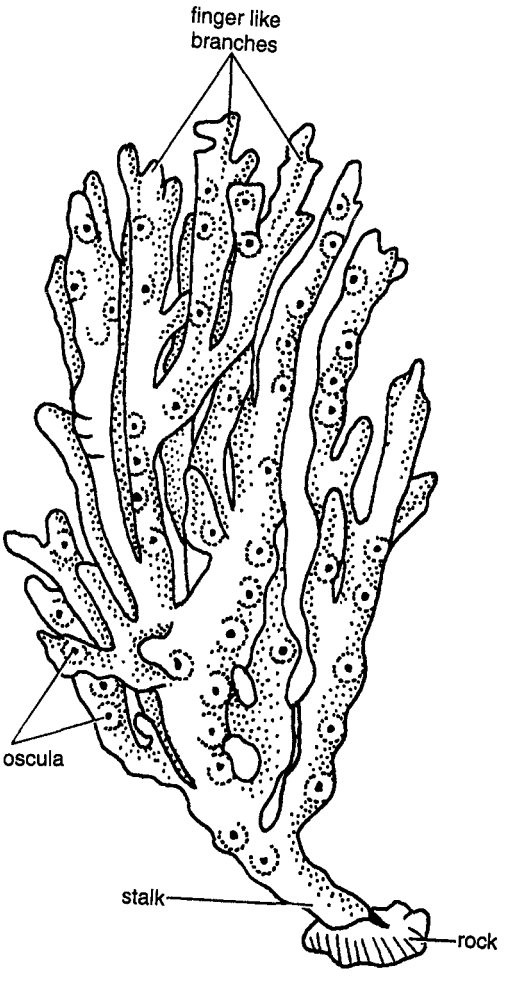


Fig. 14. *Chalina.*

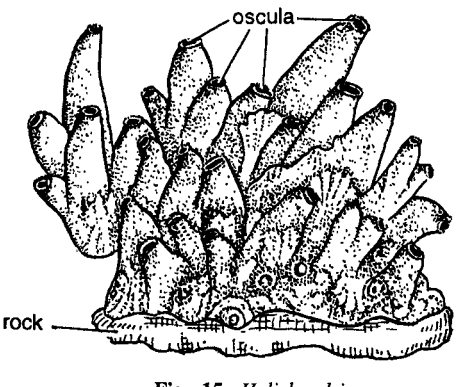


Fig. 15. *Halichondria.*

16. *Microciona*

Classification : Same as that of ***Cliona***.

Genus.....*Microciona*

Habit and habitat : ***Microciona*** is a **colonial dimorphic, marine** encronting shape. Pound in shallow water as a soft, thin, encrusting layer on rocks, **molluscan shells** and calcareous objects and ascending lobes (Fig. 16).

Distribution : ***Microciona prolifera*** is very common, in Long Island Sound and also present in South Carolina to Cape Cod.

Comments :

(1) In deep-sea water the colony becomes massive and develops upto 10 cm in total length.
(2) It is **bright red** coloured.
(3) Sponge comprises of several **finger like projections** in ascending order.
(4) It has large **spicules** united by **spongin** into a regular network.
(5) It is largely used to study **regeneration** and **reassociation** experiments.
(6) Dissociated cells from same species reaggregate. Humphrey has shown that in this animal calcium and magnesium ions along with some cells surface are necessary for aggregation.

Identification : Since the animal has branched lobe like form in ascending order and all above characters and hence it is ***Microciona***.

Instructions : *Study, measure and drana the part of the colony.*

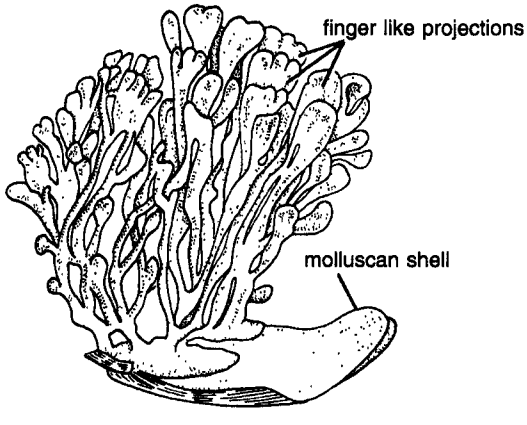


Fig. 16. *Microciona.*

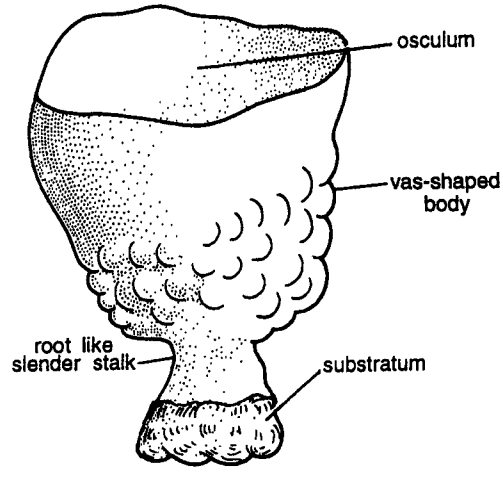


Fig. 17. *Poterion.*

17. *Poterion*

Classification : Same as that of ***Cliona***.

Genus.....*Poterion*

Habit and habitat : ***Poterion*** is a solitary, marine and boring sponge.

Distribution : It is found in the Gulf of Mexico and off coast of North Carolina.

Comments :

(1) **Commonly** called as **Neptune's goblet**.
(2) It is supposed to be one of the **largest sponges**, which may attain a diameter or height of 1 to 2 meters.

(3) Body becomes free, large, **vase-shaped**, with incurrent apertures on the outer surface and excurrent on the inner surface.
(4) Skeleton comprises **tylostyles**.
(5) There is a large **osculum** at anterior end.
(6) Posterior end has root-like processes in the form of **slender stalk** attached to **substratum**.

Identification : Since the specimen has large osculum, large cup-shaped body with a small stalk and all above feature, hence it is ***Poterion***.

Instructions : *Study and draw the specimen.*

18. *Ephydatia*

Classification : Same as that of ***Cliona***.

Genus.....*Ephydatia*

Habit and habitat : ***Ephydatia*** is a greyish or greenish fresh-water sponge, found in clear water in streams, rivers, ponds and lakes. It attaches itself over rocks, twigs, plants or seed stems and **sticks**.

Distribution : Found in Vancouver Island, Eastern and Central States.

Comments :

(1) **Body** of the animal consists of delicate **chimney like tubes** or **finger like outgrowths**.
(2) At the end of each chimney lies an **osculum**.
(3) Surface is perforated by several large **oscula** and large number of pores or **ostia**.
(4) Scattered monaxon **spicules** are protective. **Amphidisk spicules** present.
(5) Food consists of organic particles, unicellular plants and infusorians.
(6) Species growing in bright light acquire a greenish colour due to **intracellular symbiotic Zoochlorellae**.

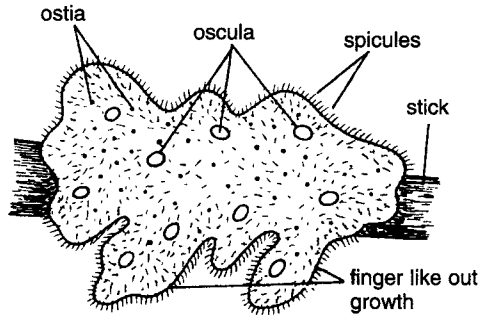


Fig. 18. *Ephydatia.*

(7) McNair found that stimuli applied at the oscular rim would be transmitted down the chimney, resulting in contraction or collapse of the latter. It shows sensory nature of the osculum.
(8) **Asexual reproduction** by **gemmules**.

Identification : Since the specimen has pores, oscula, chimney like tube and all above features and hence it is ***Ephydatia***.

Instructions : *Draw the specimens after studying its characters.*

19. *Hippospongia*

Classification :

Phylum.....Porifera	→	Cellular grade, asymmetrical or radially symmetrical.
Class.....Demospongia	→	Spongin fibres or siliceous spicules. Canal system leuconoid type.
Order.....Keratosa	→	Skeleton of spongin fibres only.

Genus.....*Hippospongia* (Commercial horse sponge).

Habit and habitat : ***Hippospongia*** is a marine sponge found 9 to 16 meters deep (Fig. 19).

Distribution : Most valuable American sponge. Found in Mediterranean, West Indies and common in Florida.

Comments :

(1) **Commonly** called as **horse sponge**.

(2) **Body** massive and permeated by large, often cavernous canals; fibres delicate and forming an irregular network.
(3) Body is covered by a dark and dead membrane provided with numerous **flagellated chambers**. Body surface is raised at several places bearing **oscula**. It harbours several small commensal worms and crustaceans.
(4) A single sponge is made up of few to many individuals, provided with few to many **oscula**.
(5) Skeleton is made up of **spongin**; **siliceous spicules** are absent.
(6) ***Hippospongia*** has great water-imbibing capacity.
(7) Water enters by **prosopyles** and leaves by **aphodus**. **Canal system** is **leuconoid type** with **aphodal** chambers.
(8) Sponge can live up to 50 years, growing massively and extensively.

Identification : Since the specimen has oscula, pores, massive cavernous body and all above characters hence it is ***Hippospongia***.

Instructions : *Study and draw the specimen. Locate oscula and pores.*

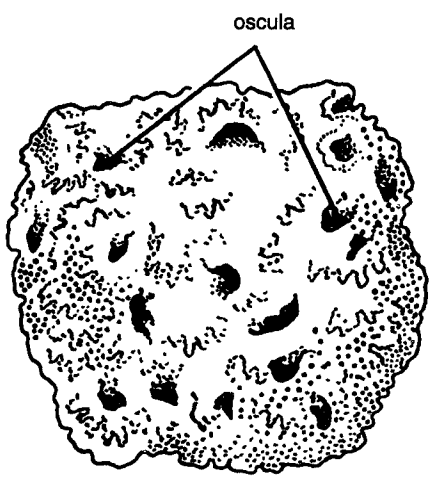


Fig. 19. *Hippospongia.*

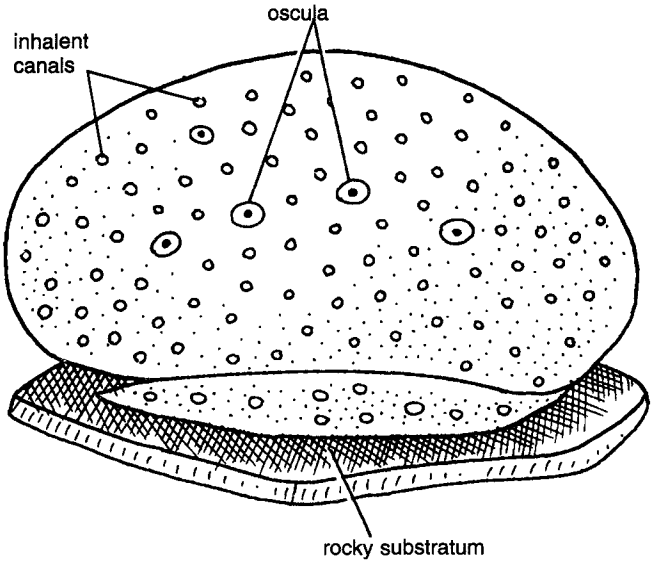


Fig. 20. *Euspongia.*

20. *Euspongia*

Classification : Same as that of ***Hippospongia***.

Genus.....*Euspongia*

Habit and habitat : ***Euspongia*** is found in shallow water on rocky bottom. It is a sedentary form attached to the rocks by horny spongin in secretion.

Distribution : Cosmopolitan. Common in eastern Mediterranean, West India, U.S.A., Asia and Australia.

Comments :

(1) **Commonly** called as **bath sponge** attached to rocky **substratum**.
(2) It attains a large and massive size with globular or cup-shaped body with dark black colour. The slender spongin fibres form small network.
(3) Complex type of sponge, in which there is a further increase in the folding of the body wall.
(4) Surface of the body contains large openings called as **oscula**, and small opening called as **inhalant canals**.

(5) Bath sponge is of household use. It is prepared-by squeezing and bleaching or dyeing the sponge. The common bath sponge mainly consists of **spongin fibres** having the **capacity of holding water**.
(6) Commonly used in offices, etc. for wetting postal tickets and counting currency notes or papers, etc.

Identification : Since the specimen has oscula, pores, globase body with meshy spongia fibres and all above features, hence it is ***Euspongia***.

Instructions : *Locate oscula, pores and draw the specimen.*

21. *Hircinia*

Classification : Same as that of ***Hippospongia***.
Genus.....*Hircinia*

Habit and habitat : ***Hircinia*** is a marine and sedentary animal attached to **substratum**.

Distribution : Cosmopolitan.

Comments :
(1) **Commonly** called **horny sponge**.
(2) Sponge attains considerable size and rounded massive form with a number of conspicuous **oscula**.
(3) **Oscula** are mounted on raised region of sponge called as **conules**.
(4) Sponge is characterised by having peculiar filaments of unknown nature throughout the body.
(5) Skeleton consists of spongin fibres forming net-work like structures.
(6) Skeleton consists of spongin fibres.

Identification : Since the specimen has **conules, oscula** and all above features, hence it is ***Hircinia***.

Instructions : *Study and draw. Dehydrate a small portion of the dried sponge with alcohol, clear in xylol and mount in balsam. Note the horny spongin in fibres which form a network. Compare the structure of the three principal types of sponges.*

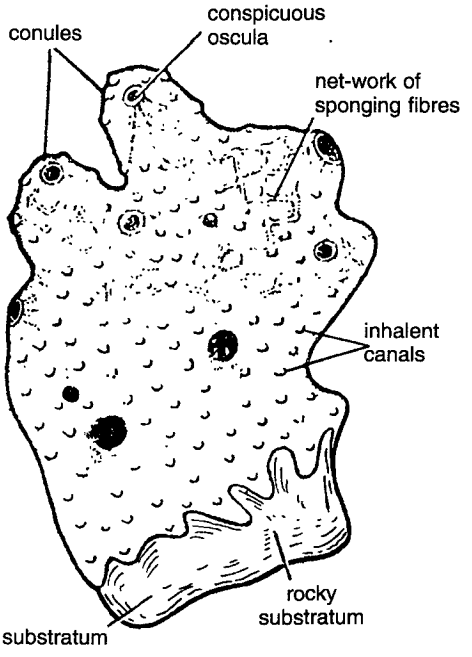


Fig. 21. *Hircinia.*

PHYLUM COELENTERATA

Natural history

Coelenterates are full of natural beauties. They are all aquatic but chiefly marine, attached or pelagic. Originating from lower Cambrian, they are still flourishing and comprise about 10,000 species. Coelenterates are the first animals to have tissues. They may be solitary as *Hydra* or colonial like corals. Further, they may be either polypoid, medusoid existing in polyp form or medusa form or both. The phylum includes the hydroids and hydromedusae, jelly fishes, sea anemones and corals. Several hydroids may grow plant like colonies while jelly fishes and many hydroids swim freely. The flower like sea anemones stick on rocky ocean coasts and the corals with their tiny skeletons constitute reefs. Many Coelenterates are bioluminiscent. The corals are used for jewellery and other decorative purposes.

Diagnostic characters

(1) Tissues grade animals.
(2) Diploblastic made of ectoderm, endoderm and intervening mesoglea.
(3) Only a single cavity, gastrovascular cavity or coelenteron present.
(4) Division of labour occurs.
(5) Solitary or colonial, fresh-water or marine.

(6) Colony dimorphic consisting of feeding zooids or polyps and reproductive zooids or medusae, with several variations. Nematocysts present.
(7) Reproduction sexual or asexual.

Classification

CLASS I HYDROZOA
1. Either polypoid or medusoid or both.
2. Solitary or colonial.

Order 1 Hydroidea
1. Polypoid stage predominant.
2. Medusa present or absent.

Sub-order I Athecata or Anthomedusae
1. Polyp athecate (perisarc does not form hydrotheca)
2. Freshwater or marine
Ex. *Hydra, Ceratella, Hydractinia, Eudendrium, Pennaria, Bougainvillea, Tubularea.*

Sub-order II Thecata or Leptomedusae
1. Both polyp and medusae thecate (with hydrotheca and gonotheca).
2. Statocyst mostly present.
Ex. *Obelia, Plumularia. Companularia, Antennularia.*

Order 2 Hydrocorallina
1. Exoskeleton calcareous.
2. Polyps are gastrozooids and dactylozooids.

Sub-order I Milleporina
1. Polyps scattered.
2. Separate pores for gastrozooids and dactylozooids.
Ex. *Millepora.*

Sub-order II Stylasterina
1. Calcareous exoskeleton, branching or encrusting.
2. Dactylozooids surround gastrozooids.
Ex. *Stylaster.*

Order 3 Trachylina
1. Medusoid stage dominant polyps absent or poorly developed.
2. Sense organs statocysts or tentaculocysts.

Sub-order I Trachymedusae
1. Marginal tentacles oral.
2. Gonads on radial canals.
Ex. *Gonionemus.*

Sub-order II Narcomedusae
1. Gonads on stomach floor.
2. Tentaculocysts naked.
Ex. *Cunia, Aggina.*

Order 4 Siphonophora
1. The animals show polymorphism.
2. Different polypoid and medusoidzooids.

Sub-order I Calycophora
1. Pneumatophore absent.
2. Polypoid and medusoid.
Ex. *Praya, Abyla, Diphyes.*

Sub-order II Physophorida
1. Pneumatophore present.
2. Polypoid and medusoid.
Ex. Physalia, Porpita, Velella.

CLASS II SCYPHOZOA
1. Exclusively medusoid.
2. Medusae umbrella-shaped without velum.

Order 1 Stauromedusae
1. Bell trumpet shaped.
2. Sessile, attached by stalk.
Ex. *Lucernaria, Haliclystus.*

Order 2 Cubomedusae
1. Bell cubical.
2. Found in tropical and subtropical oceans.
Ex. *Charybdea Chiropsalmus.*

Order 3 Coronatae
1. Bell conical with transverse construction.
2. Deep see forms.
Ex. *Pericolpa.*

Order 4 Semaeostomae
1. Bell disc-shaped.
2. Cosmopolitan.
Ex. *Aurelia, Cyanea, Pelagia, Chrysaora.*

Order 5 Rhizostomae
1. Bell margin with no tentacle.
2. Tropical and subtropical
Ex. *Rhizostoma, Cassiopea, Mastigias.*

CLASS III ACTINOZOA (= ANTHOZOA)
1. Exclusively polypoid. No medusae.
2. Gastrovascular cavity divided by 8 or more mesenteries.

Sub-class A. Octocorallia
1. Tentacles and mesenteries 8 or multiple of 8.

Order 1 Stolonifera
1. Organ pipe coral.
2. Polyps not fused and arise from a creeping mat or stolon.
3. Skeleton of calcareous tubes or spicules or absent.
Ex. *Tubipora.*

Order 2 Telestacea
1. Lateral polyps on single or branched stem.
2. Skeleton of calcareous spicules.
Ex. *Telesto.*

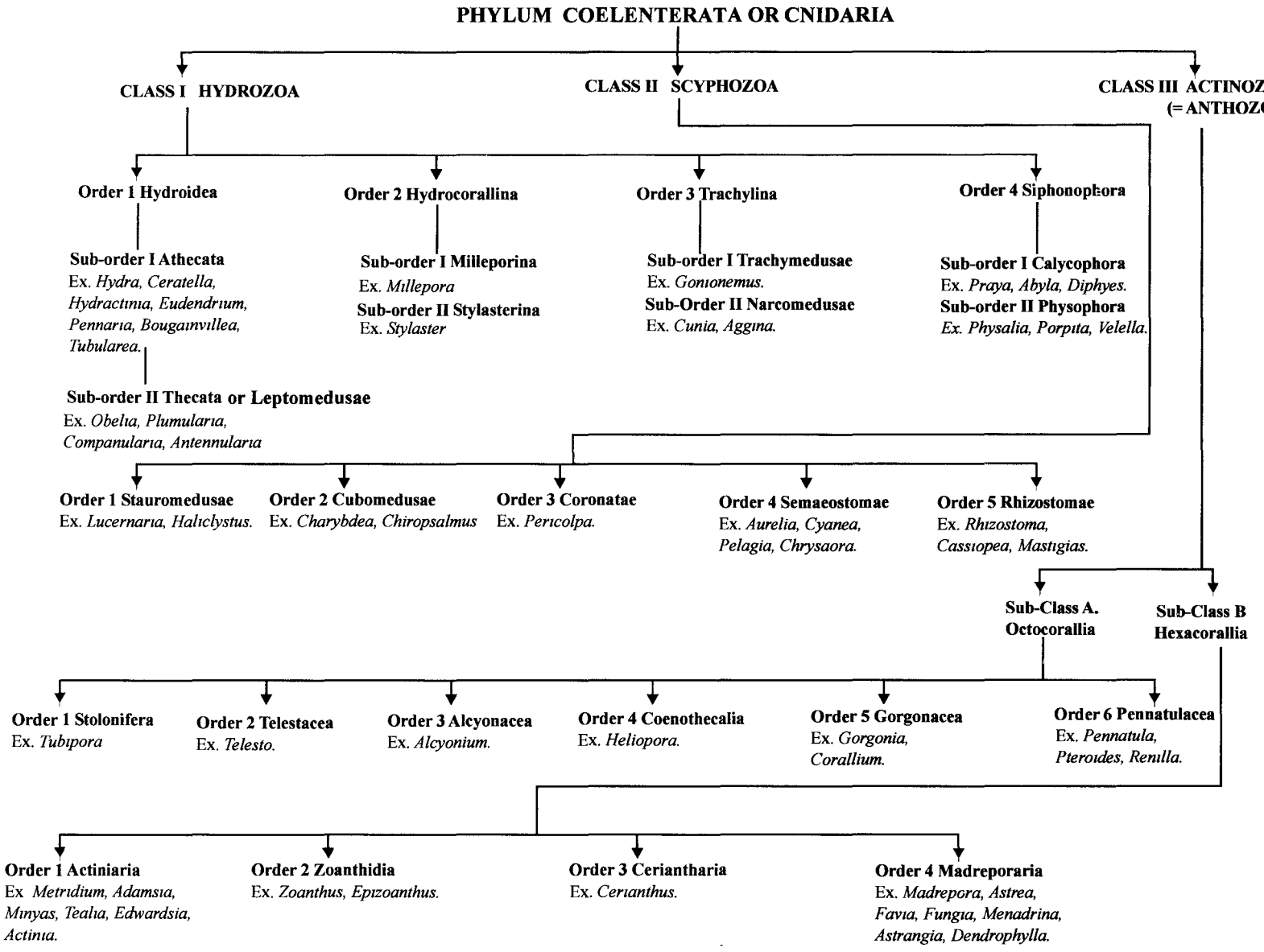
Order 3 Alcyonacea
1. Polyps and spicules embedded in fleshy coenenchyme
2. Soft corals.
Ex. *Alcyonium.*

Order 4 Coenothecalia
1. Brown polyps. Skeleton massive and calcareous.
2. Blue corals.
Ex. *Heliopora.*

Order 5 Gorgonacea
1. Tree or feather like colony containing short polyps and central skeleton of Gorgonin.
Ex. *Gorgonia, Corallium.*

Order 6 Pennatulacea
1. Colony consists of stalk and rachis with lateral branches. bearing dimorphic polyps.
2. Sea pens.
Ex. *Pennatula, Pteroides, Renilla.*

Sub-class B. Hexacorallia
Tentacles and mesenteries 6 or multiple of 6.


PHYLUM COELENTERATA OR CNIDARIA
CLASS I HYDROZOA
CLASS II SCYPHOZOA
CLASS III ACTINOZOA (=ANTHOZOA)
Order 1 Hydroidea
Order 2 Hydrocorallina
Order 3 Trachylina
Order 4 Siphonophora
Sub-order I Athecata
Ex. Hydra, Ceratella, Hydractinia, Eudendrium, Pennaria, Bougainvillea, Tubularea.
Sub-order II Thecata or Leptomedusae
Ex. Obelia, Plumularia, Companularia, Antennularia
Sub-order I Milleporina
Ex. Millepora
Sub-order II Stylasterina
Ex. Stylaster
Sub-order I Trachymedusae
Ex. Gonionemus.
Sub-Order II Narcomedusae
Ex. Cunia, Aggina.
Sub-order I Calycophora
Ex. Praya, Abyla, Diphyes.
Sub-order II Physophora
Ex. Physalia, Porpita, Velella.
Order 1 Stauromedusae
Ex. Lucernaria, Haliclystus.
Order 2 Cubomedusae
Ex. Charybdea, Chiropsalmus
Order 3 Coronatae
Ex. Pericolpa.
Order 4 Semaeostomae
Ex. Aurelia, Cyanea, Pelagia, Chrysaora.
Order 5 Rhizostomae
Ex. Rhizostoma, Cassiopea, Mastigias.
Sub-Class A. Octocorallia
Sub-Class B Hexacorallia
Order 1 Stolonifera
Ex. Tubipora
Order 2 Telestacea
Ex. Telesto.
Order 3 Alcyonacea
Ex. Alcyonium.
Order 4 Coenothecalia
Ex. Heliopora.
Order 5 Gorgonacea
Ex. Gorgonia, Corallium.
Order 6 Pennatulacea
Ex. Pennatula, Pteroides, Renilla.
Order 1 Actiniaria
Ex Metridium, Adamsia, Minyas, Tealia, Edwardsia, Actinia.
Order 2 Zoanthidia
Ex. Zoanthus, Epizoanthus.
Order 3 Ceriantharia
Ex. Cerianthus.
Order 4 Madreporaria
Ex. Madrepora, Astrea, Favia, Fungia, Menadrina, Astrangia, Dendrophylla.

Order 1 Actiniaria
1. Body muscular without skeleton.
2. Tentacles and mesenteries.
   Ex. *Metridium, Adamsia, Minyas, Tealia, Edwardsia, Actinia.*

Order 2 Zoanthidia
1. Mostly epizoic, solitary or colonial.
2. One complete and one incomplete mesentery in each pair.
   Ex. *Zoanthus, Epizoanthus.*

Order 3 Ceriantharia
1. Without pedal disc.
2. Numerous mesenteries.
   Ex. *Cerianthus.*

Order 4 Madreporaria
1. Solitary or Colonials hard corals.
2. Hard calcareous skeleton.
   Ex. *Madrepora, Astrea, Favia Fungia, Menadrina, Astrangia, Dendrophylla.*

PHYLUM CTENOPHORA

Diagnostic Characters

1. Tissue grades, biradial, marine and pelagic.
2. Nematocysts absent. Instead adhesive cells, called colloblasts present.
3. Locomotory combrows present.
4. Skeleton, circulatory, respiratory system absent.

Classification

CLASS I TENTACULATA
Tentacles present.

Order 1 Cydipidia
1. Two long branched retractile tentacles.
2. Body rounded.
   Ex. *Pleuroprachia, Meritensia.*

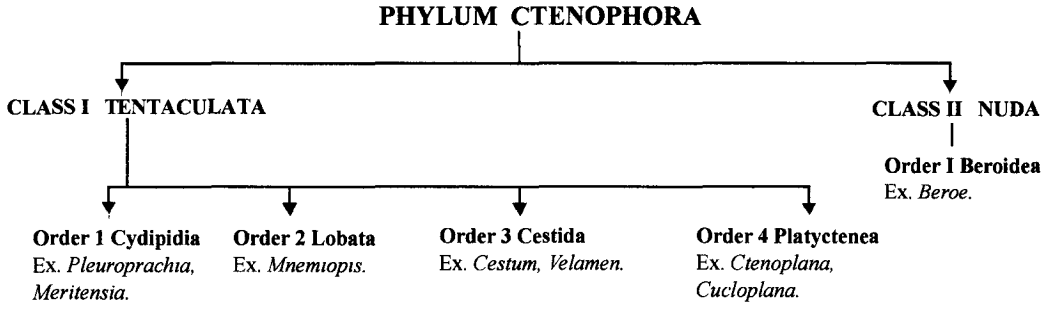
Order 2 Lobata
1. Tentacles present only in larva, absent in adults.
2. Body ovate.
   Ex. *Mnemiopis.*

Order 3 Cestida
1. Two main tentacles and many small tentacles. Body ribbon like.
2. Four combrows.
   Ex. *Cestum, Velamen.*

Order 4 Platyctenea
1. Body greatly flattened.
2. Comb rows reduced.
   Ex. *Ctenopiana, Cucloplana.*

CLASS II NUDA
Tentacles absent.

Order 1 Beroidea
1. Body laterally compressed.
2. Mouth large, stomach voluminous.
   Ex. *Beroe.*



22. *Hydra*

Classification :

Phylum.....Coelenterata	→	Tissue grade, diploblastic and acoelomate.
Class.....Hydrozoa	→	Hydroids containing medusa with velum.
Order.....Hydroidea	→	Polypoid generation well developed.
Sub-order.....Athecata	→	Hydrotheca absent.
Genus.....*Hydra*		

Habit and habitat : ***Hydra*** is a solitary and sedentary fresh-water form, found attached to stones, rocks and weeds.

Distribution : Cosmopolitan, but most common in India, Canada and U.S.A.

Comments :

(1) **Cylindrical body** is tube-like measuring approximately 1.3 cm in length.

(2) Anterior end contains **mouth** or **hypostome**, which is crowned with 6 to 10 filiform **nematocyst bearing tentacles.**

(3) Proximal end of the body contains **pedal** or **basal disc** or **foot** meant for attachment to the substratum.

(4) Body is **diploblastic**, consisting of outer **ectoderm**, inner **endoderm** and intervening **mesogloea**. Body wall encloses a gastrovascular cavity extending into the tentacles.

(5) In **female** ***Hydra*** **ovary** and **buds** are found on sides in mid position.

(6) In **male** ***Hydra*** 3 or 4 pairs of testes, are found anteriorly and a full grown bud with tentacles on side.

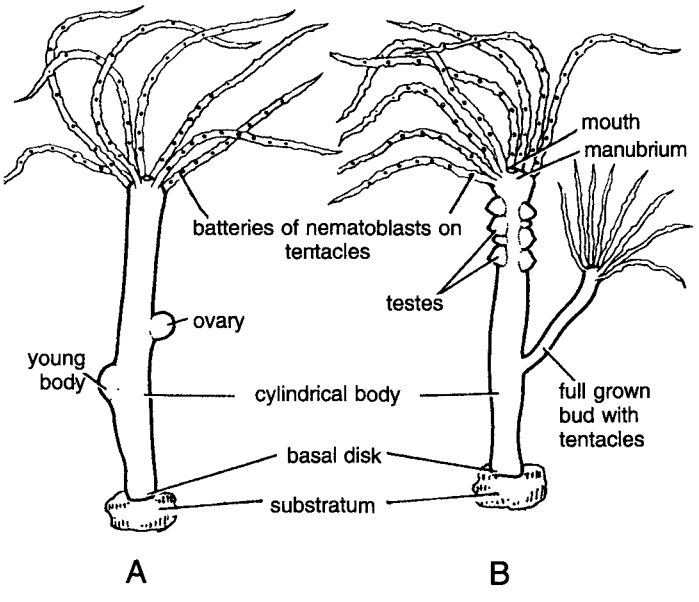


Fig. 22. *Hydra.* **A.** Female. **B.** Male.

(7) Testes develop near the oral end and ovaries near the base.

(8) It reproduces **sexually by** fusion of **sperms** and **ova.**

(9) During **asexual** reproduction, lateral buds develop on the sides of the body which later on detach and develop into new ***Hydra.***

Special features : ***Hydra viridis*** contains symbiotic green algae **Zoochlorellae.** ***Hydra*** is famous for **division of labour for the first time in animal kingdom** and moreover it has great experimental value as most of the **regeneration** and **grafting** experiments are conducted on it.

Identification : Since the animal contains 6-10 filliform tentacles anteriorly and gonads and buds on side and all above characters and hence it is ***Hydra.*** Male ***Hydra*** has 3 to 4 pairs of testes near oral end.

Other species of ***Hydra*** are : I. ***H. utahensis***, Hermaphroditic form; II. ***H. littoralis*** (i) Male, (ii) Female; III. ***Pelmetohydra oligactis*** (brown ***Hydra***).

Instructions : *Collect some pond water near the bank and examine for* ***Hydra.*** *Make drawing of* ***Hydra*** *to show its external features.*

23. *Ceratella*

Classification : Same as that of the ***Hydra.***

Genus.....*Ceratella*

Habit and habitat : ***Ceratella*** is a colonial. Sedentary hydroid coelenterate (Fig. 23).

Comments :

(1) Tree like and highly branched.

(2) **Branches** arising from central axis or **hydrorhiza** are intertwining and **anastomosing.**

(3) ***Ceratella*** has sea fan like appearance.

(4) Hydrothecae cover **polyps** and **gonothecae** enclose **medusae.**

(5) Medusae bear gonads on the manubrium and devoid of lithocytes.

(6) **Eye-spots** are present.

Identification : Since the specimen has anastomosing fern-like appearance and all above features hence it is ***Ceratella***.

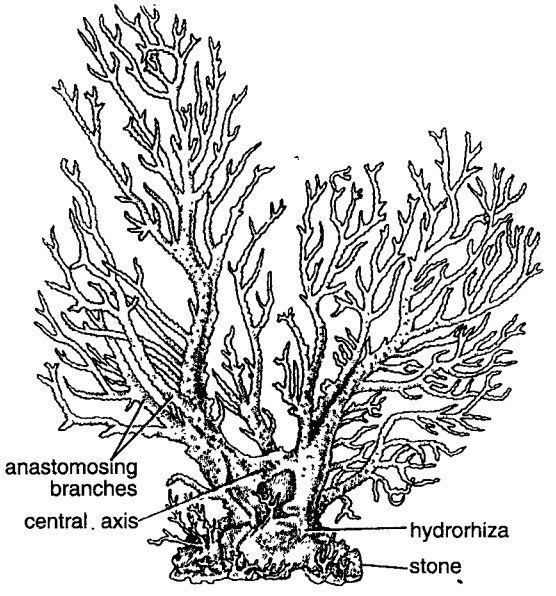


Fig. 23. *Ceratella.*

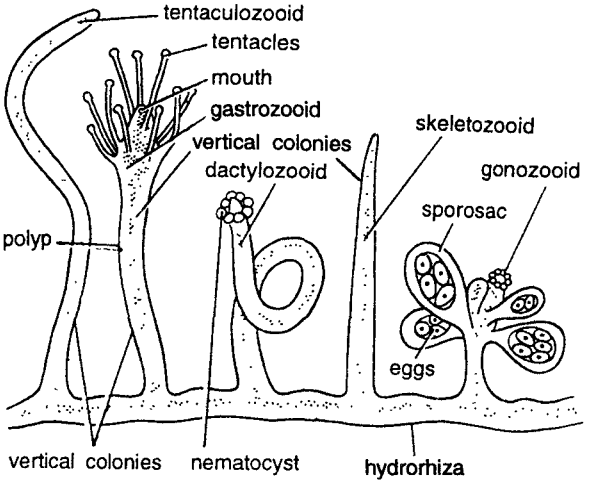


Fig. 24. *Hydractinia.*

24. *Hydractinia*

Classification : Same as that of ***Hydra***.

Habit and habitat : ***Hydractinia*** is a small, shallow-water, marine, colonial and sedentary hydroid, found on rocks, stones, fucus and piles (Fig. 24).

Distribution : Very common on Atlantic coast, Europe, U.S.A. (Alaska to San Francisco bay) and found in Sanjuan Island.

Comments :

(1) It consists of **vertical colonies** arising from hydrorhiza.

(2) **Polyps** arise separately from incrusted spiny hydrorhiza.

(3) It is noteworthy that stolons or hydrorhizae are fused, forming brown encrustation enclosed in perisarc which is raised into several spines.

(4) **Perisarc** is confined only in hydrorhiza.

(5) It shows **polymorphism**.

(6) Animal contains several **zooids** borne on unbranched pedicles.

(7) **Zooids** are of four kinds (i) **gastrozooids** (feeding polyps) having single whorl of **tentacles** and **mouth**, (ii) **gonozooids** (reproductive polyps) bearing clusters of **sporosacs** containing **eggs**. (iii) **dactylozooids** (protective polyps) and (iv) **skeletozooids**.

Special features : ***H. echinata*** is found on gastropodan shells inhabited by hermit-crabs, which show **commensalism** but, according to Schijifsma (1935), the relationship is merely epizoic or facultative.

Identification : Since the specimen has vertical zooids and all above features hence it is ***Hydractinia***.

25. *Millepora* : Stinging Coral

Classification :

Phylum.....Coelenterata	→	Tissue grade, diploblastic and acoelomate.
Class.....Hydrozoa	→	Coenosarc secretes exoskeleton and polyps dimorphic.
Order.....Hydrocorallina	→	Coenosarc secretes exoskeleton and polyps dimorphic.
Sub-order..... Milleporina	→	Polypus scattered, skeleton massive.
Genus.....*Millepora*		

Habit and habitat : Marine form, found associated with coral reefs in tropical seas. It is colonial hydroid with much branched hydrorhiza.

Distribution : Found in U.S.A. (Florida coast) and West Indies.

Comments :

(1) **Commonly** called as **stinging coral.**

(2) **Colony** varies in form, consisting of a broad basal mass which is incrusted on the rocks and from which short irregular branches are thrown into the water.

(3) **Ectoderm** secretes a large skeleton of **perisarc**, resembling corals perforated by numerous pores.

(4) Dried colony of lime carbonate contains pores of two types:
   (i) **gastropores** or **larger pores**, through which gastrozooids protrude in lifetime.
   (ii) **dactylopores** or **smaller pores** are found around gastropores, through which dactylozooids come out.

(5) **Gastropores** and **dactylopores** randomly distributed. **Gastrozooids** are feeding zooids, having 4 to 5 short knobbed tentacles and dactylozooids, with capitate **tentacles** having **nematocysts**, are protective zooids.

(6) Pores lead into a canal which forms network in coenosarc.

(7) **Medusae** with 4 or 5 rudimentary tentacles are free, simple and originate from coenosarc.

(8) Dried colony forms irregular mass.

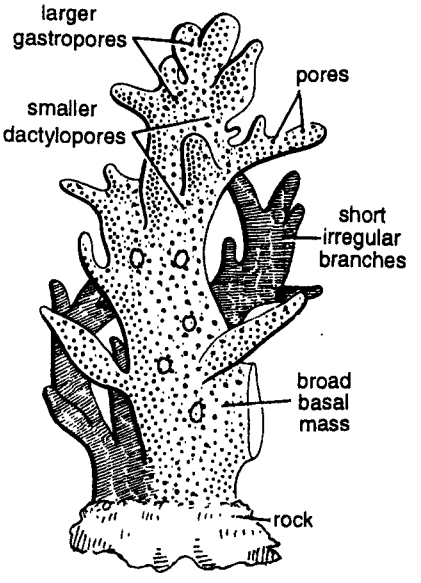


Fig. 25. *Millepora.*

Special features : It is called as stinging coral because its powerful nematocysts are painful to man. Due to the presence of numerous pores, it is called as ***Millepora.***

Identification : Since the specimen has random distribution of gastropore and dactylopores and all above characters, hence it is ***Millepora.***

26. *Stylaster*

Classification :

Phylum.....Coelenterata **Class.....Hydrozoa** **Order.....Hydrocorallina**	→	Characters same as those of *Millepora.*
Sub-order.....Stylasterina	→	Polyps arranged in systems.
Genus.....*Stylaster*		

Habit and habitat : It is marine and colonical.

Distribution : ***Stylaster*** is found in tropical and sub-tropical regions.

Comments :

(1) **Colony** consists of upright calcareous pink coloured tree like branches.

(2) Surface of the body bears **gastropores** and **dactylopores**, arranged in a cyclic manner.

(3) Branches of the colony are provided with cup-like projections with radiating septa.

(4) Centre of each cup contains tentacle-bearing **gastrozooid**, surrounded by tentacleless **dactylozooids**. **Gastrozooids** are short and stout bearing few solid short projections. **Dactylozooids** are simple and hollow finger-line projection without tentacles arising from peripheral compartments.

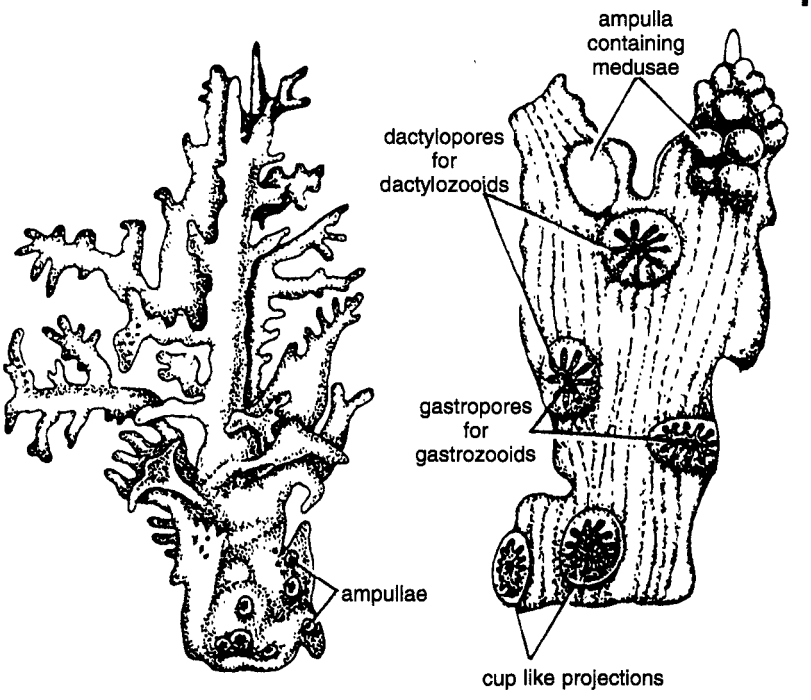


Fig. 26. *Stylaster.*

(5) Cups rest on calcareous projection called as **style** and hence the name **Stylaster**. Style in a pointed calcareous projection present at the base of each cup.

(6) **Cups** are wihtout tabulate and rest on a calcareous projection called as style and hence the name **stylaster**.

(7) **Medusae** degenerate, forming **sporosacs**, lying inside the chambers of coral called **ampullae**.

(8) Young ones escape in **planula** stage.

Identification : Since the specimen has upright branches with cup like projection and all above characters, hence it is ***Stylaster***.

27. *Gonionemus*

Classification :

Phylum.....Coelenterata	→	Tissue grade, diploblastic and acoelomate.
Class.....Hydrozoa	→	The hydroids and craspedote medusa.
Order.....Trachylina	→	Polypoid generation reduced or absent.
Sub-order.....Trachymedusae	→	Bell margin smooth gonads in radial canals.
Genus.....*Gonionemus*		

Habit and habitat : It is a marine solitary medusoid form.

Distribution : Cosmopolitan, Vineyard and Long Island Sounds, Pacific coast from Washington to Alaska.

Comments :

(1) ***Gonionemus*** is dioecious consisting of **trophosome** and **gonosome** forms.

(2) **Gonosome** is a medusoid hydrozoan jellyfish measuring approximately 2 cm.

(3) Superficially it resembles ***Obelia*** medusa, but differs from it in shape of **ex-umbrellar surface** and number and size of **marginal tentacles**.

(4) Body consists of **ex-umbrellar** and **sub-umbrellar surfaces**. Ex-umbrellar surface has **radial canals, mouth, velum, gastro-vascular cavity, hypostome, gonads** and **ring canal**. The **marginal tentacles** of sub-umbrellar surface are long.

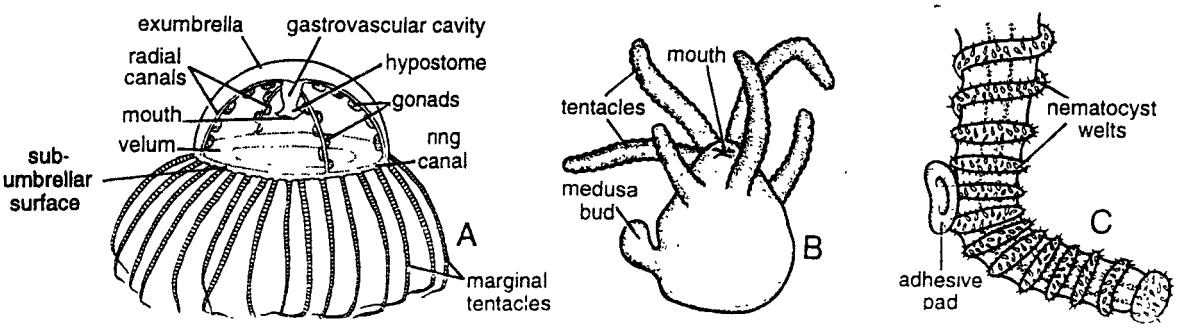


Fig. 27. *Gonionemus.* **A.** Medusa, **B.** Polyp stage with medusa bud, **C.** Tentacle showing adhesive pad.

(5) **Manubrium** is short and has 4 oral lobes.
(6) Marginal tentacles vary from 16 to 80 in number. They are highly contractile and bend at a sharp angle near the tip.
(7) During rest, each tentacle is attached to the seaweeds by means of an adhesive disc present at its bend.
(8) **Polyp** stage has **medusa bud**, **mouth** and **tentacles**. Tentacles have **adhesive pads** and **nematocysts welts**.
(9) ***Gonionemus*** is a favourite hydrozoan to study behaviour. In the presence of food, it becomes more active and displays random searching.

Identification : Since the specimen has characteristic shape, number of tentacles in gonosome and all above characters hence it is ***Gonionemus***.

28. *Diphyes*

Classification :

Phylum.....Coelenterata	→	Tissue grade, diploblastic and acoelomate.
Class.....Hydrozoa	→	The hydroids and craspedote medusa.
Order.....Siphonophora	→	Polymorphic colonies without perisarc.
Sub-order.....Calycophora	→	The colony consists of one or more swimming bells.
Genus.....*Diphyes*		

Habit and habitat : Polymorphic, free swimming, **marine**, **pelagic** and **colonial** hydromedusae.

Distribution : Cosmopolitan, **tropical** and **sub-tropical**, Atlantic, Mediterranean, Pacific coast, San Francisco to Alaska.

Comments :

(1) ***Diphyes*** is divided into upper and lower parts without **pneumatophores**.
(2) Upper part of the colony contains two identical **swimming bells** or **nectophores** having **tandem** arrangement.
(3) Each bell contains **mouth**.
(4) Lower part represents rest of the colony containing widely separated groups of zooids or **cormidia**.
(5) Each zooid contains mouth, **coenosarc**, a **hydrophylum**, a **medusoid** form, a **polyp or gastrozooid** and number of terminally knobed **tentacles bract** and **radial canal**.
(6) **Knobed part** of the tentacle contains battery of **nematocysts**.
(7) The colony is constantly being shortened due to breaking of old and terminal zooids at the internodes.
(8) Detached zooids are called as **endoxia** which swim about like independent organisms and later on become sexually mature.

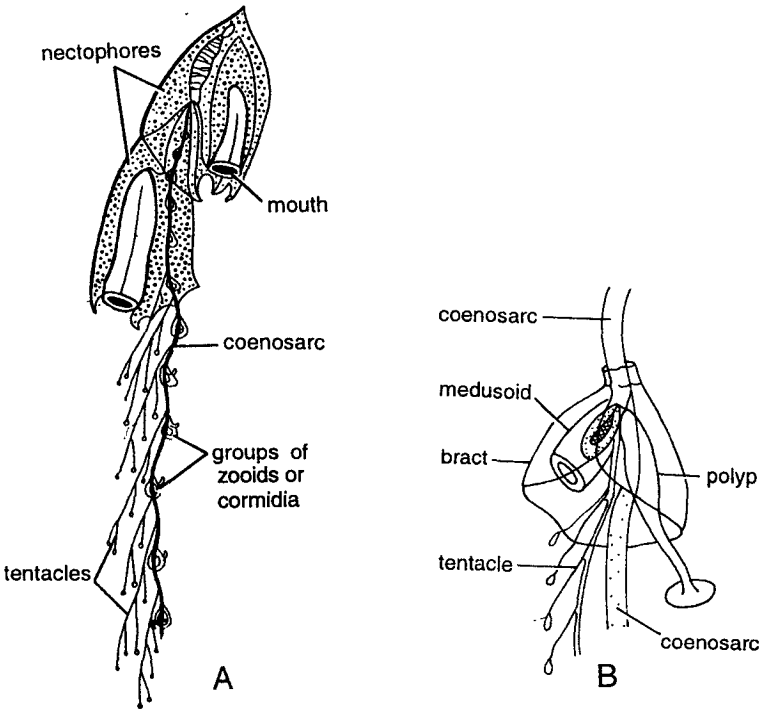


Fig. 28. *Diphyes.* **A.** Entire, **B.** Single zooid.

Identification : Since the specimen has two identical and tandem swimming bells and all above characters, hence it is ***Diphyes***.

29. *Halistemma*

Classification :

Phylum.....**Coelenterata**
Class.....**Hydrozoa**
Order.....**Siphonophora** } → Characters same as in *Diphyes.*
Sub-order.....**Physophorida** → Upper end of colony contains float or pneumatophore.
Family.....**Physonectae** → Pneumatophore small. It is followed by a stem bearing column of swimming bells.
Genus.....***Halistemma***

Habit and habitat : ***Halistemma*** is **colonial**, **pelagic** and highly **polymorphic siphonophore** with complex zooids.

Distribution : Found in Mediterranean and other seas.

Comments :

(1) Entire animal comprises of **pneumatophore**, **swimming bells** and simple **cormidia** in floating axial stem.

(2) Small **pneumatophore** or float represents first part of the stem which secretes gas to keep colony up in water.

(3) Float is followed by several pairs of closely-set, transparent **medusa-like**, swimming bells or **nectocalyces** or **nectophores.**

(4) Below nectocalyx, the axial stem gives at regular intervals several closely-set individuals, called as **cormidia.**

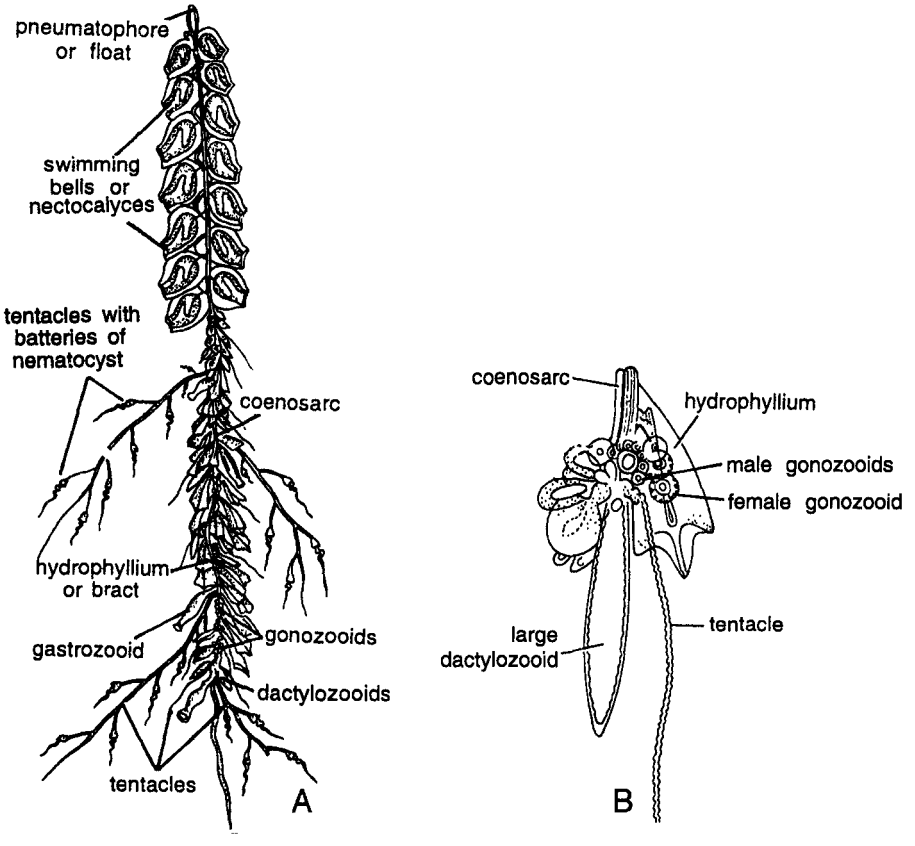


Fig. 29. *Halistemma*.. **A.** Colony. **B.** Single Zooid.

(5) Each **cormidium** contains **coenosarc** bract or **hydrophyllium gastrozooid**, large **dactylozooid**, male **gonozooids**, larger **female gonozooids** with eggs and tentacles with **batteries of nematocyst.**
(6) **Nematocysts** are very much elongated measuring 1-12 mm.
(7) Fertilization external life-history includes **Planula larva.**

Identification : Since the specimen has several pairs of medusae like swimming bells and all above characters and hence it is ***Halistemma.***

30. *Physalia*

Classification :

Phylum..... Coelenterata	→	Tissue grade, diploblastic and acoelomate.
Class..... Hydrozoa	→	The hydroids and craspedote medusa.
Order..... Siphonophora	→	Polymorphic colonies with various polypoid and medusoid zooids.
Sub-order..... Physophorida	→	Upper end of colony contains float or pneumatophore, without swimming bells or bracts and with simplified cormidia.
Family..... Physalidae	→	Large float with apical pore.

Genus..... *Physalia* (The Portuguese man-of-war)

Habit and habitat : ***Physalia*** is a marine, **colonial**, floating, **pelagic coelenterate.**

Distribution : Found in the warm sea in the gulf stream from Florida to Vineyard, U.S.A.

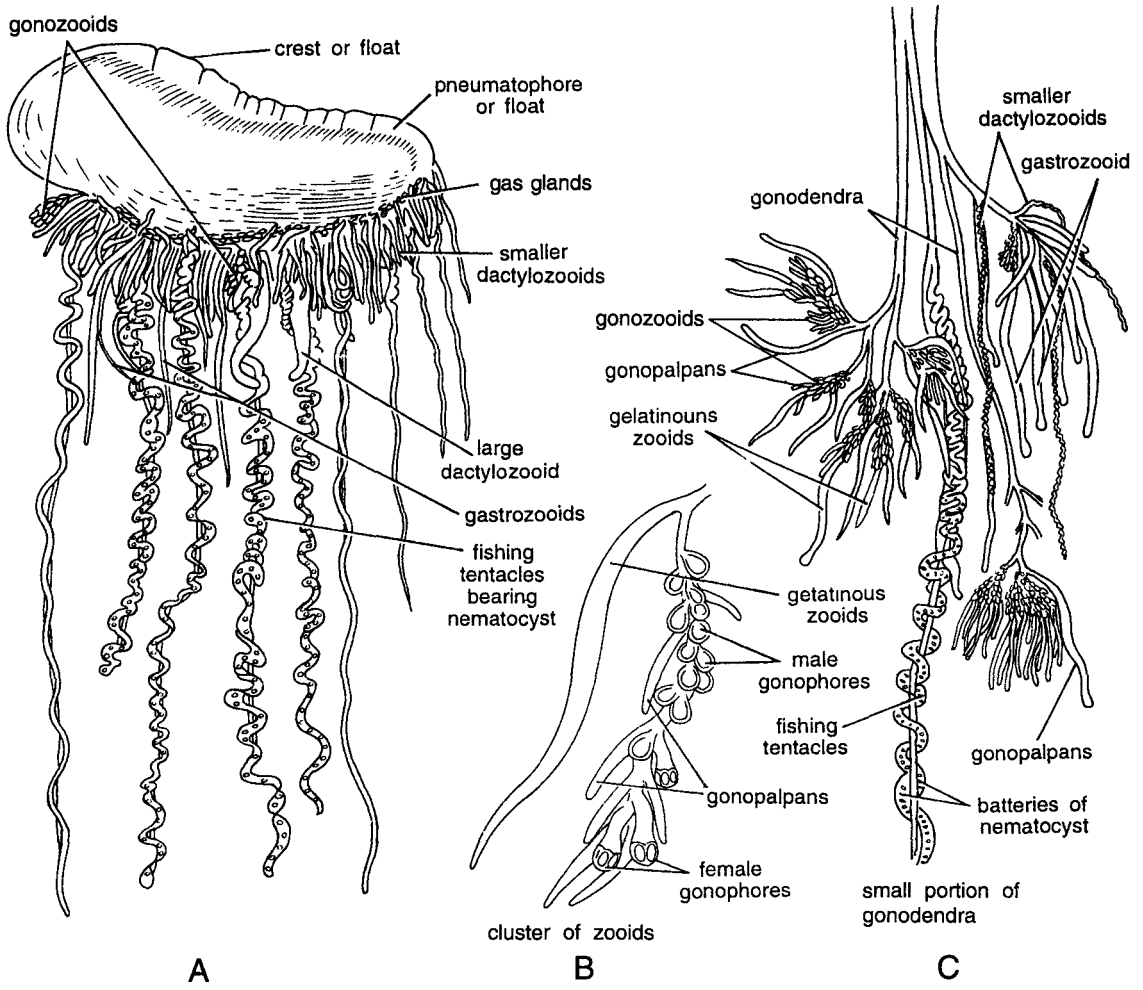


Fig. 30. *Physalia.* **A.** Entire colony, **B.** Portion of cluster of zooids, **C.** Small portion of gonodendra.

Comments :

(1) **Commonly** called as **Portuguese man-of-war**. It is so named because of its sudden appearance and disappearance like Portuguese ships during war.

(2) Most beautiful siphonophore having irredescent peacock, blue or orange colour.

(3) **Size** 10 to 30 **cm long** but **tentacles** measure several metres.

(4) Animal is composed of upper large crested **pneumatophore** or **float** and lower various **zooids**.

(5) **Pneumatophore** contains **gas glands** which secrete air composed off 7.5% to 13.5% oxygen, 1·5% **argon** and 85% to 91% **nitrogen**.

(6) **Gas** fills the **float** to swim or float and when animal has to sink, gas is forced out through the pneumatophore.

(7) Ventrally the float contains budding coenosarc from which **dactylozooids**, **gastrozooids**, **gonozooids** and **gonodendra** hang down.

(8) A portion of cluster of zooids reveal large **fishing tentacles** with **batteries** of **pneumatocyst**, **gastrozooids** without tentacles, **large dactylozooids**, **small dactylozooids**, **gonodendra** and large **gelatinous zooids** of unknown function.

(9) A part of **gonodendra** shows upper small **male gonophores**, lower large rounded **female gonophores** with eggs. Along with gonophores are several cylindrical **gonopulpons**.

Identification : Since the specimen has floats hanging gastrozooids, tentacles, gonozooids and all above characters, hence it is ***Physalia***.

31. *Porpita*

Classification :

Phylum.....Coelenterata	→	Tissue grade, diploblastic and acoelomate.
Class.....Hydrozoa	→	The hydroids and craspedote medusa.
Order.....Siphonophora	→	Polymorphic colonies with various polypoid and medusoids.
Sub-order.....Physophorida	→	Upper end of colony contains pneumatophore. No swimming bell and bracts.
Family.....Chondrophorae	→	Float forms a disk like structure.
Genus.....*Porpita*		

Habit and habitat : ***Porpita*** is marine and colonial, found in warm seas.

Distribution : It is found along the South Atlantic coast and occasionally near U.K. coast.

Comments :

(1) It superficially resembles a **medusa**. It is most modified **siphonophore**. The stem is shortened to a flat coenosarc which along with float forms a rounded disk having several concentric air chambers.
(2) **Body** is discoidal, enclosing a chambered, chitinous and porous shell, having air corresponding with pneumatophore of ***Physalia***.
(3) A large **gastrozooid**, having central mouth is encircled by **several blastostyles**.
(4) Margin of disk contains numerous **dactylozooids** or tentacles armed with nematocysts.
(5) **Nectocalyces** or **swimming bells** are absent.
(6) Each air chamber opens to outside by a pair of pores.
(7) Space between the gastric cavity of the gastrozooid and the **pneumatophore** is occupied by a large cellular mass traversed by canals, the so-called **liver**, supposed to have an excretory function.
(8) The reproductive zooids are liberated as free medusae.

Identification : Since the animal has central disc surrounded by tentacles and all above feature, hence it is ***Porpita***.

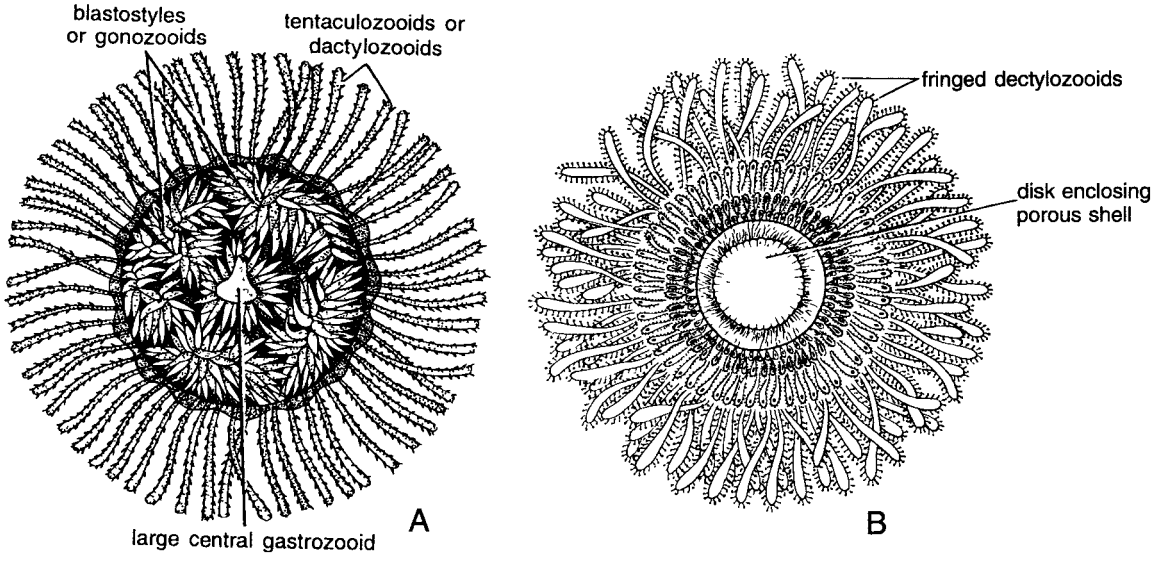


Fig 31. *Porpita.* **A.** Oral ventral side, **B.** Dorsal side.

32. *Velella*

Classification :

Phylum.....Coelenterata	→	Tissue grade, diploblastic and acoelomate.
Class.....Hydrozoa	→	The hydroids and craspendote medusae.
Order.....Siphonophora	→	Polymorphic colonies with various polypoid and medusoid zooids.
Sub-order.....Physophorida	→	Upper end of colony contains pneumatophore. No swimming bells.
Family.....Chondrophorae	→	Float forms a disc like structure.
Genus.....*Velella* (Little sail)		

Habit and habitat : ***Velella*** is polymorphic marine colonial form.

Distribution : Commonly found in warm sea; Pacific coast from Puget Sound to Mexico, South Atlantic coast; occasionally off New England.

Comments :

(1) ***Velella*** is referred as **sail by wind** animal.

(2) It is most beautiful open-sea form.

(3) Deep blue **colony** consists of a rhomboidal disk **pneumatophore** or **float** containing air chambers without marginal identations.

(4) **Float** differs from ***Porpita*** having a clear transparent **vertical ridge** or **crest** passing obliquely across the float and called as **sail**. Both float and sail are filled with gases.

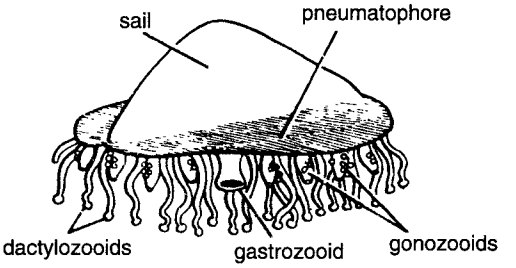


Fig 32. *Velella.*

(5) On ventral surface hangs a single large **gastrozooid** and edge of disk is beset with numerous **dactylozooids** or **tentaculozooids**. **Gonozooids** are found around gastrozooid.

(6) **Gonozooids** produce free **medusae**.

(7) ***Velella*** is one of the most beautiful open-sea forms.

Identification : Since the specimen contains sail, short dactylozooid, gastrozooid, gonozooid and all above characters, hence it is ***Velella***.

Instructions : *Compare* ***Porpita*** and ***Velella***.

33. *Lucernaria*

Classification :

Phylum.....Coelenterata	→	Tissue grade, diploblastic and acoelomate.
Class.....Scyphozoa	→	Medusa well developed, hydroid reduced.
Order.....Stauromedusae	→	Gastrovascular septa present—Two kinds of nematocysts are present katrichous isorhizas and microbasic heterotrichous euryteles.
Genus.....*Lucernaria*		

Habit and habitat : ***Lucernaria*** is sessile, sedentary and marine animal. It is inhabitant of bays, coastal waters mostly in colder parts.

Distribution : It is found in India; Crusade Islands, America Cape Cod to Greenland (USA) and Europe.

Comments :

(1) ***Lucernaria*** and its allied genera can be compared to sexual scyphistomes as persistent larval forms.

(2) It is a small **sessile scyphozoan** with a **polypoid**, goblet or **trumpet-shaped** body that flares at the oral end into a broad concave **sub-umbrella** and tapers aborally into a long or short **stalk** or **peduncle**.

(3) Peduncle is attached temporarily to sea-weeds by foot gland.

(4) Umbrellar margin is divided into 8 prominent, short hollow, **adhesive lobes** or **arms**.

(5) Each arm possesses a cluster of short, knobbed **adhesive tentacles** at its end.

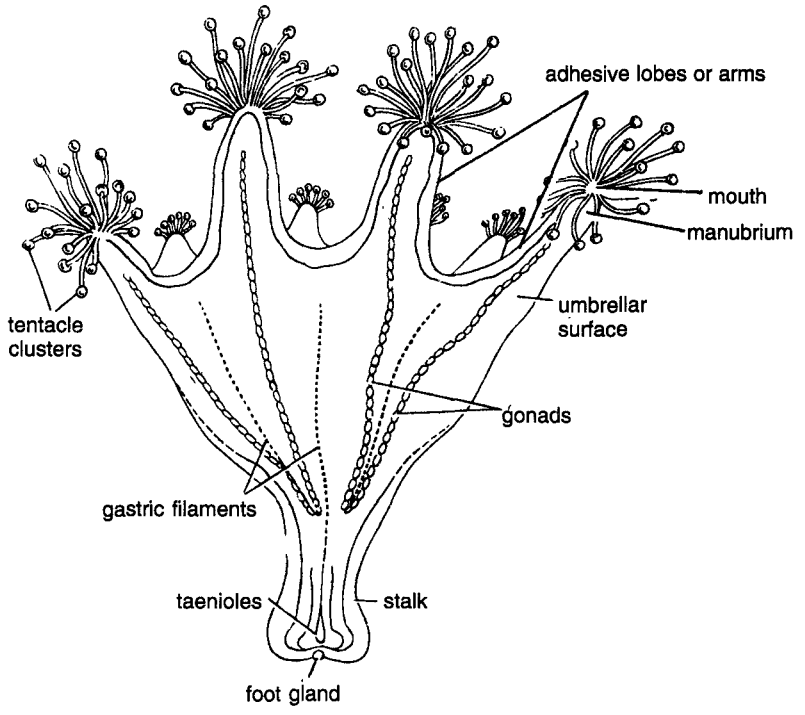


Fig 33. *Lucernaria.* Side view.

(6) **Mouth** is cruciform (four-cornered) with small oral lobes and a short **manubrium.**
(7) Internally gastrovascular system consists of a central stomach and **four per radial pouches** divided by **inter-radial septa.**
(8) There are several **gastric filaments Gonads** are band-like, borne on septa. Marginal statorhabs or anchors, velum and tentaculocysts are absent.
(9) It breeds in all seasons. Sex cells are ejected through mouth.

Identification : Since the animal contains 8 prominent arm and all above features, hence it is ***Lucernaria.***

34. *Charybdea*

Classification :

Phylum.....Coelenterata
Class.....Scyphozoa } → Characters same as in *Lucernaria.*
Order.....Cubomedusae → Bell margin bent inward forming false velum.
Genus.....*Charybdea*

Habit and habitat : It is marine Jelly-fish. It is found in warm shallow waters inhabiting bays, harbours, shore of continents, islands and open sea. It is strong graceful swimmer, voracious feeder on fish.

Distribution : Tropical and subtropical regions.

Comments :

(1) **Commonly** called as **Sea wasp.**
(2) It is best known genus of cubomedusae.
(3) Shape of the body is more or less cubical in form with a deep ball having somewhat flattened top.
(4) Body divisible into **ex-umbrellar and** sub-umbrellar surfaces. Exumbrellar surface contains manubrium.

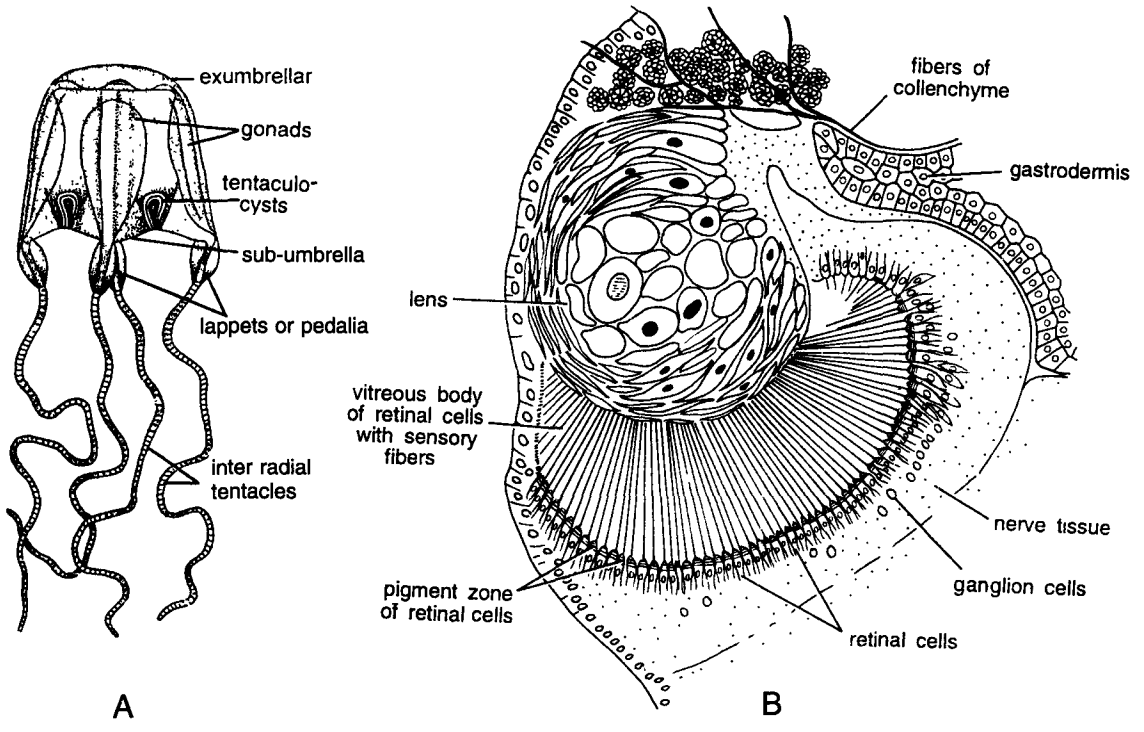


Fig 34. *Charybdea.* **A.** Entire, **B.** Section of rhopalium showing eyes.

(5) Sub-umbrellar surface contains four per-radial **rhopalium.**
(6) Each rhopalium has 2 **large eyes** and 2 small **ocelli** clearly visible in section.
(7) In sub-umbrellar surface, each corner of the bell contains a expanded structure in inter-radial position called as **pedalia.** Pedalia contains **inter-radial tentacle.**
(8) Various structures seen in section of rhopalium are fibers of collenchyme, gastiodermis, nerve tissue ganglion cell retinal cells. Vitreous body of retinal cell, pigment zone and lens.
(9) It is noted for the virulence of its sting.

Identification : Since the specimen contains pedalia, rhopalium and all above characters and hence it is ***Charybdea.***

35. *Chiropsalmus*

Classification :

Phylum.....**Coelenterata**
Class.....**Scyphozoa**
Order.....**Cubomedusae**
Genus.....***Chiropsalmus***

→ Characters same as those of *Charybdea.*

Habit and habitat : ***Chiropsalmus*** is marine, and solitary inhabiting bays, harbours, shorewaters and in open sea. It is also strong and graceful swimmer and voracious feeder on fishes. It is found in warm waters. Young stages are bottom dwellers, while adults are pelagic.

Distribution : Found in U.S.A. (California).

Comments :

(1) **Body** is bell-shaped with somewhat rounded upper surface.
(2) Body divisible into **ex-umbrellar** and **sub-umbrellar** surfaces.

(3) Ex-umbrellar surface has angular membrane, called as **velarium**, which together with their energetic swimming gives the animals the appearance of **hydromedusans**.

(4) Upper parts of the gastric pockets are evaginated and hang down into the sub-umbrellar cavity as eight simple or branched **sub-umbrellar sacs**.

(5) On each side of the bell corner emerges a large thick pedalium that branches into a number of smaller **pedalia** with tentacles.

(6) Four **rhopalia** are found between the **tentacles**.

Special features : ***Chiropsalmus*** is one of the most dangerous coelenterates and is greatly feared by Philippinese and Japanese natives who term it **'fire medusa'**. Its sting can cause serious illness and even death.

Identification : Since the specimen contains pedalium, pedalia and all above characters and hence it is ***Chiropsalmus***.

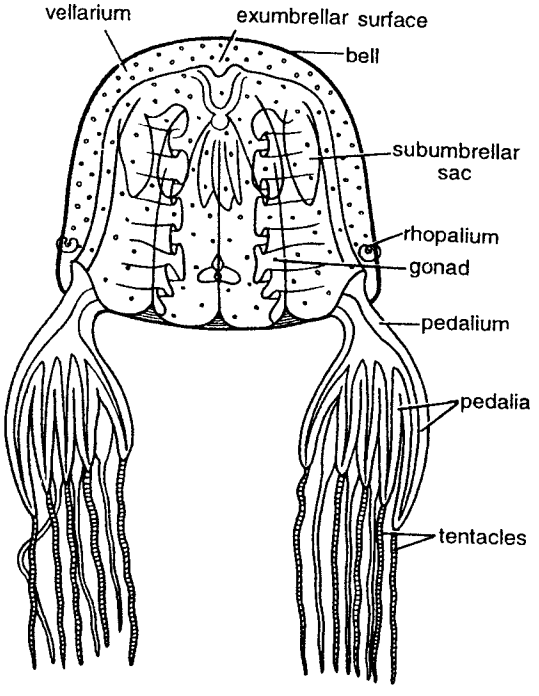


Fig 35. *Chiropsalmus.*

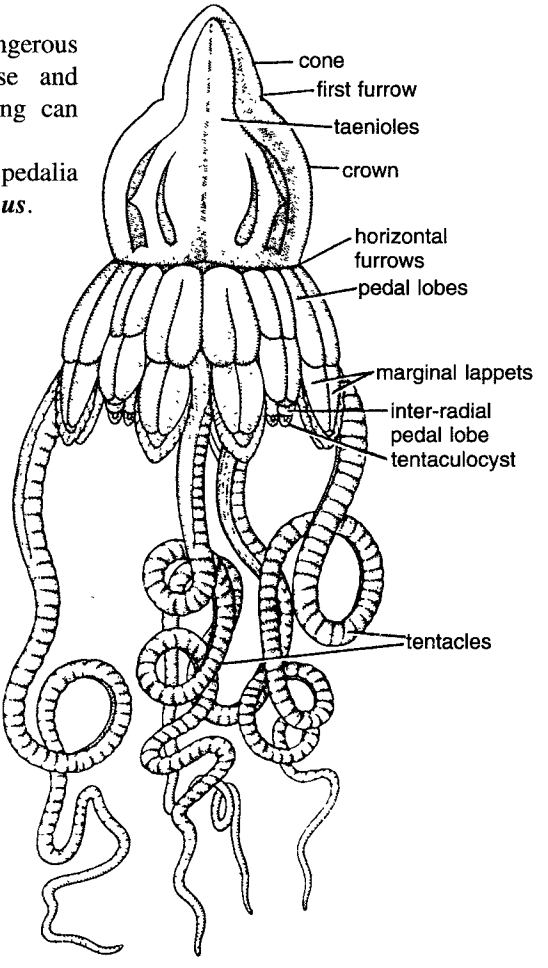


Fig 36. *Pericolpa.*

36. *Pericolpa*

Classification :

Phylum.....Coelenterata	→	Tissue grade, diploblastic and acoelomate.
Class.....Scyphozoa	→	Medusa well developed, hydroid reduced.
Order.....Coronatae	→	Umbrella divided by horizontal coronary groove.
Genus.....*Pericolpa*		

Habit and habitat : ***Pericolpa*** is marine, and solitary, typically inhabitant of deeper waters of ocean. They are obtained only by deep-sea dredging expeditions (Fig. 36).

Distribution : Cosmopolitan, open sea form especially found in Greenland and Gulf Stream.

Comments :

(1) ***Pericolpa*** is a beautiful scyphozoan medusa in which **umbrella** is divided by a horizontal furrow called as **coronary groove.**

(2) Umbrella is usually conical in shape and is divided into apical region or cone and marginal region or **crown** by furrow.

(3) **Crown** is again divided by second horizontal furrow into a series of anterior **pedal lobes**, and a series of posterior marginal **lappets** forming free edge of the bell.

(4) Pedal lobes and marginal lappets lie in same radii.

(5) Four interradial pedal lobes bear **tentaculocysts.**

(6) Other four perradially situated pedal lobes give long hollow tentacles.

(7) **Mouth** is large and leads into a spacious stomach by a wide manubrium.

Identification : Since the specimen contains cone, crown, pedal lobes, marginal lappets and all above characters hence it is ***Pericolpa***.

37. *Aurelia*

Classification :

Phylum.....Coelenterata	→	Tissue grade, diploblastic and acoelomate.
Class.....Scyphozoa	→	Medusa well developed, hydroid reduced.
Order.....Semaeostomeae	→	Free-swimming scyphomedusae with umbrella-like disk and oral lobes.
Family.....Ulmariidae	→	Simple or branched radial canals and a ring canal.
Genus.....*Aurelia* (Jelly-fish)		

Habit and habitat : ***Aurelia*** is a solitary marine and medusoid jelly-fish often living in brackish water. It inhabits coastal water of all oceans in all zones and in abundant number, mostly living in warm and temperate latitudes (Fig. 37).

Distribution : Very common along the entire Atlantic coast and Pacific coast and only form reported in temperate regions.

Comments :

(1) **Commonly** called as **Jelly-fish** measuring approximately 30 cm in diameter.

(2) **Body** is gelatinous, transparent, bluish, white, reddish or pinkish.

(3) Saucer-shaped body is distinguished into **convex ex-umbrellar** and **concave sub-umbrellar surfaces.**

(4) Various other structures seen are **gastric filaments, sub-genital pits** and **velarium.**

(5) Sub-umbrellar margin contains **marginal tentacles** having stinging cells and 8 **marginal lappets** having sense organs or **tentaculocysts** in 8 lobes.

(6) Mouth 4-**cornered.** Each corner is drawn out into an oral arm along **perradii.**

(7) **Inter-radial, adradial** and **per-radial gastrovascular canals** open in **circular canal. Velarium** present.

(8) Jelly fish feeds on molluscs, crustaceans, protozoans, nematodes, rotifers, diatoms, polychaetes and copepods.

(9) It swims by rhythmic contractions of umbrellar surfaces.

(10) Male and female separate individuals. Life-cycle shows **alteration** of generation.

(11) It responds to mussel juice, proteins, peptones, amino acids but not to sugars, starches or glycogen.

Identification : Since the specimen has jelly like texture, marginal tentacles, oral arms and all above characters, hence it is ***Aurelia.***

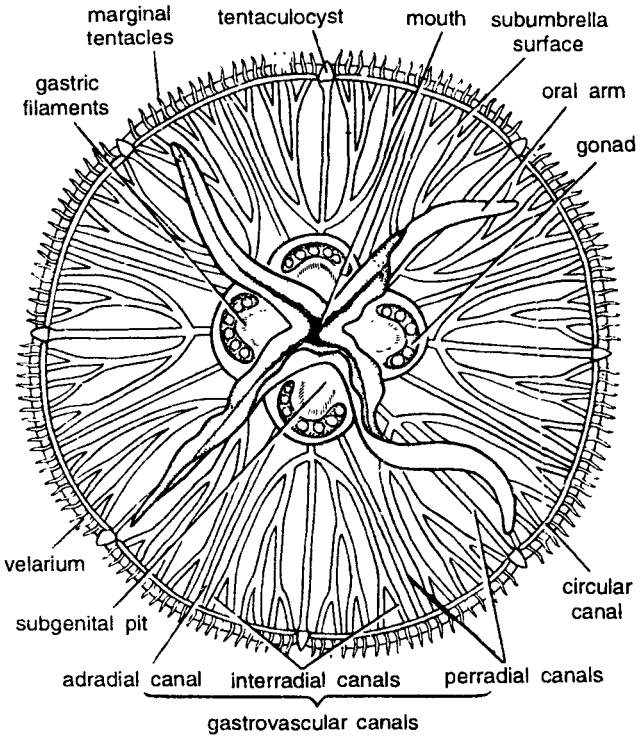


Fig 37. *Aurelia.* Oral view.

38. *Aurelia* : Stages of Life Cycle

The model shows the following stages of the life cycle :

(1) **Adult male and female :** There is no sexual dimorphism but male and female are separate.

(2) **Fertilized egg :** Sperms produced by male reach gastric pouches of female where fertilization occur to give **zygote**. Zygote reaches into groove of an oral arm.

(3) In oral arm **zygote** undergoes cleavage and after passing through the blastula and gastrula stages develops into a free-swimming **Planula larva**.

(4) Planula larva is microscopic, oval hallow, ciliated consisting of mouth, **oral pole**, **ectoderm**, **mesoglea**, **endoderm**, **enteron** and **aboral pole**.

(5) **Scyphistoma larvae :** Planula larva charges into next polyp like, elongated scyphistoma larva Blastopore is replaced by mouth opening surrounded by a circlet of 16 tentacles.

(6) **Ephyra stage :** Elongated scyphistome undergoes transverse fissions or **Strobilization** and forms number of saucer like piled stages called as **Ephyrae**.

(7) Each ephyra later on detaches and after swimming for sometimes, metamorphoses into adult.

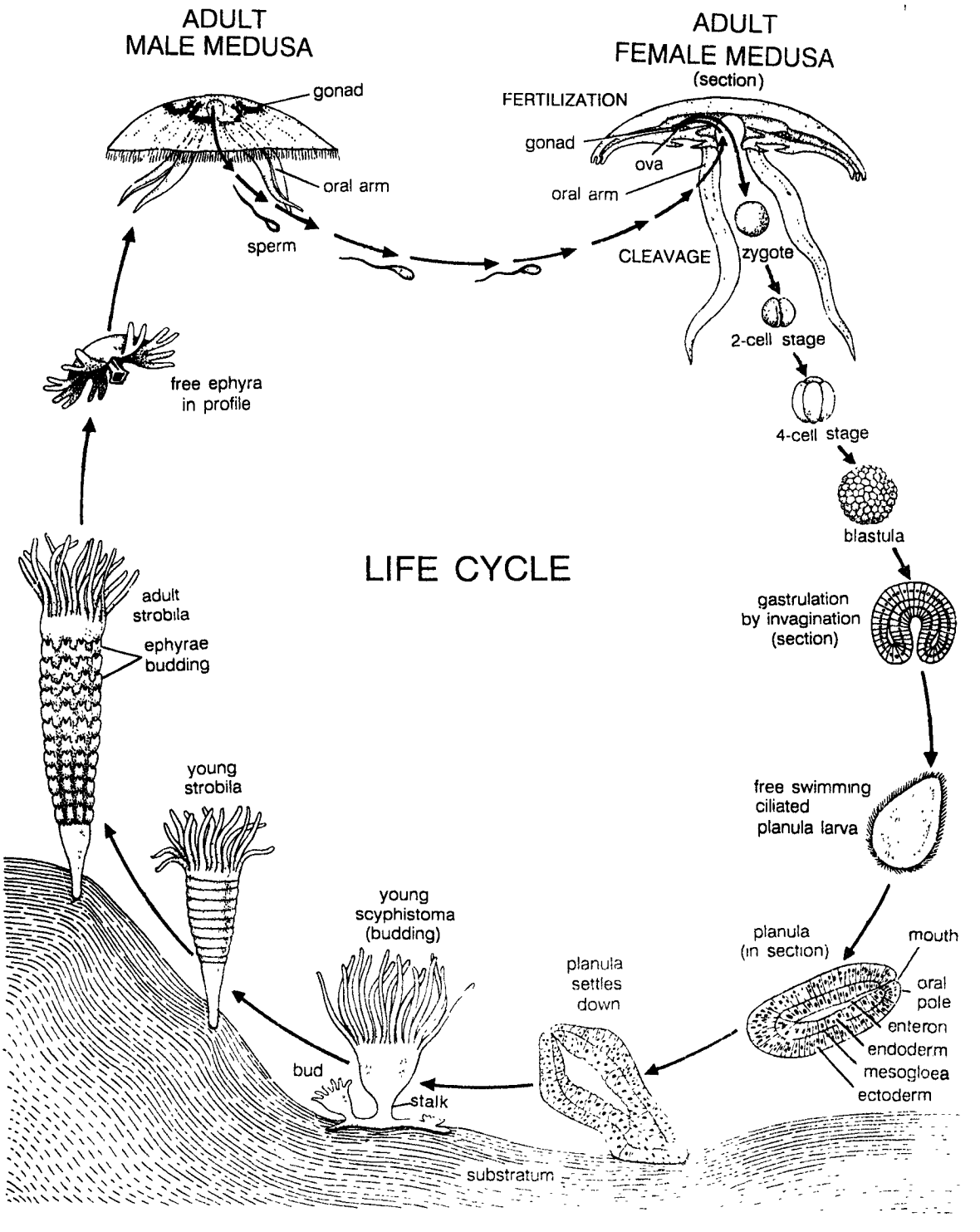


Fig. 38. *Aurelia.* Model. Stages of the life cycle

39. *Cyanea*

Classification :

Phylum..... **Coelenterata**
Class..... **Scyphozoa** } → Characters same as in *Aurelia.*
Order..... **Semaeostomeae**
Family..... **Cyaneidae** → Tentacles clustered, branched and radiating.
Genus..... ***Cyanea***

Habit and habitat : ***Cyanea*** is the largest, solitary, bioluminescent and marine medusa.

Distribution : It is found on the coastal waters of America, polar region and Pacific coast.

Comments :

(1) **Commonly** called as **Sun-jelly** or **Sea-blubber.**
(2) **Monstrous** red or wine-coloured jelly fish.
(3) Largest known scyphozoa measuring 5 cm to 2 metres across the disk and some tentacles measuring 40 metres in length.
(4) Body divided into **sub-umbrellar** and **ex-umbrellar** surfaces.
(5) Margin of umbrella contains 8 **bilobed lappets** and 8 **rhopalia** in each niche between lappets.
(6) Eight adradial **V-shaped clusters** of **tentacles** spring from sub-umbrella.
(7) 4 angles of mouth are drawn into 4 long, wide and voluminous **oral arms**. Radial canals extend into the **rhopalia** and tentacles. Circular canal is absent. Gonads prominent.
(8) It produces **burning sensation** when in contact with human body.
(9) It swims by rhythmic contractions of umbrellar surfaces with the help of **radial muscles** and **coronal muscles.**
(10) ***Cyanea*** also responds to mussel juice, proteins, peptones, amino acids but not to sugars, starches or glycogen.

Identification : Since the specimen has V-shaped clusters of tentacles, voluminous oral arms and all above characters, hence it is ***Cyanea.***

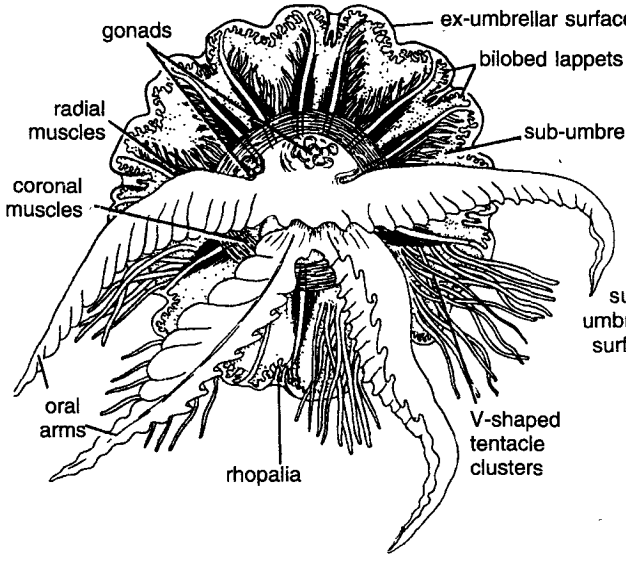


Fig. 39. *Cyanea.*

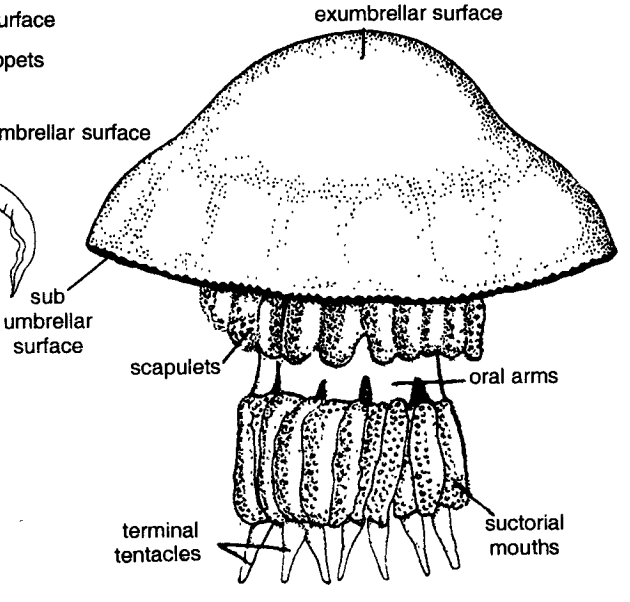


Fig. 40. *Rhizostoma.*

40. *Rhizostoma* (= *Pilema*)

Classification :

Phylum.....**Coelenterata** } → Characters same as those of *Aurelia*.
Class.....**Scyphozoa** }
Order..... **Rhizostomae** → Tentacles absent, mouth obliterated.
Genus..... ***Rhizostoma*** **(= *Pilema*)**

Habit and habitat : ***Rhizostoma*** is a marine solitary medusoid Scyphozoa. It is a vigorous swimmer.

Distribution : It is found in shallow waters in tropical and sub-tropical regions, especially Indo-pacific regions, North Carolina and South Wales, U.S.A. (Fig. 40).

Comments :

(1) **Body** is hemispherical without marginal tentacles and divisible into **ex-umbrellar** and **sub-umbrellar surfaces.**
(2) Under sub-umbrellar surface 8 **fused oral arms** hang down in central position.
(3) **Oral arms** are folded looking like root in appearance called as **scapulets.**
(4) Mouth is obliterated by growth of oral arms which are modified as funnel like securing pores called as **suctorial mouths.**
(5) Each oral arm ends in a **terminal tentacle.**
(6) Stomach is continued into canals, which open by funnel-shaped apertures on the edges of the arms.
(7) Young medusa has a single mouth which closes in the adult.
(8) Entire animal has 96% water, but does not contain gelatin or mucilage. Feeds on small fishes.

Identification : Since the specimen contains fused oral arms and all above characters and hence it is ***Rhizostoma.***

41. *Tubipora musica*

Classification :

Phylum.....**Coelenterata** → Tissue grade, diplogastic and acoelomate.
Class.....**Anthozoa or Actinozoa** → Only polypoid generation, sedentary, solitary, colonial.
Sub-class.....**Octocorallia** → Polyps with 8 tentacles, bioluminescent.
Order.....**Stolonifera** → Polyps not fused and communicate with each other by basal mat.
Genus..... ***Tubipora*** **(Organ pipe coral)**

Habit and habitat : ***Tubipora*** is a marine, colonial polypoid Actinozoa found in shallow waters of tropical and temperate regions (Fig. 41).

Distribution : Found abundantly among corals in hot waters of Atlantic-Indian and Pacific ocean.

Comments :

(1) **Commonly** called as **organ pipe coral** and is much calcified anthozoan.
(2) Highly calcified coral consisting of compact bright red coloured **vertical tubes** and **transverse platforms.**
(3) Genus ***Tubipora*** occupies an isolated position.
(4) Colony is composed of long parallel upright tubes having **polyps** in living conditions springing from **basal plate** and through the opening of polyp.
(5) Colony is supported by skeletal tubes of fused spicules embracing gastrovascular tubes. The tubes are joined together by **transverse partition** or **stolons** forming platforms by fused spicules.
(6) Skeleton is internal and is covered by ectoderm in living condition.
(7) ***Tubipora*** is very **favourite museum specimens.**
(8) Mesogloeal spicules become closely fitted together and form a continuous tube for each polyp.
(9) Reproduction by budding. Basal plate expands to give new **polyps.**

(10) Budding is peculiar. The base of original polyp expands from which new **polyps** originate.
(11) Living colony contains polyps.

Identification : Since the specimen contains compact red coloured vertical tubes and all above characters, hence it is ***Tubipora***.

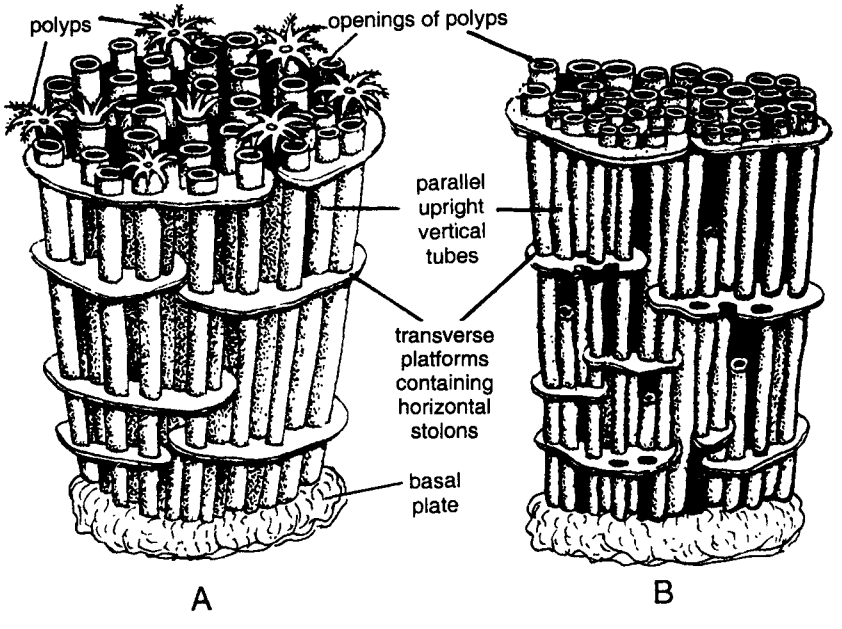


Fig. 41. *Tubipora musica.* **A.** Portion of living colony, **B.** Portion of dead coral.

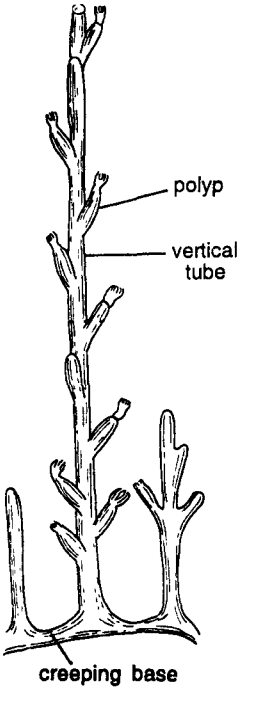


Fig 42. *Telesto.*

42. *Telesto*

Classification :

Phylum..... Coelenterata **Class**..... Actinozoa **Sub-class**..... Octocorallia	→	Characters same as in *Tubipora.*
Order..... Telestacea	→	Simple or branched stem.
Genus..... *Telesto*		

Habit and habitat : ***Telesto*** is a marine sedentary and colonial Actinozoa.

Distribution : Found along Atlantic coast.

Comments :

(1) **Colony** consists of simple or branched stem, which arises from a **creeping base.**
(2) Stem is formed by the elongation of a single polyp.
(3) Stem bears lateral **polyps** with alternate arrangement and vertical tubes.
(4) Lateral **polyps** originate by way of solenial networks as in Pennatulacea.
(5) Spicules may be somewhat united by calcareous and horny secretions.
(6) Another telestacean genus differs from ***Telesto*** in having branched colony resembling a gorgonian.

Identification : Since animal bears lateral polyps with alternate arrangements and all above characters, hence it is ***Telesto***.

43. *Alcyonium*

Classification :

Phylum.....**Coelenterata** → Tissue grade, diploblastic and acoelomate.
Class.....**Anthozoa** → Only polypoid generation, sedentary, solitary or colonial.
Sub-class.....**Octocorallia** → Polyps with 8 tentacles, bioluminescent.
Order.....**Alcyonacea** → Basal part of polyp forms fleshy mass, while oral part distinct, sort corals.
Family.....**Alcyoniidae** → Lobed colony with retractile anthocodia.
Genus.....***Alcyonium*** **(Dead man's finger).**

Habit and habitat : ***Alcyonium*** is marine sedentary and colonial animal. Alcyonaceans are typically littoral animals of warm water entering in the Indo-Pacific ocean. Many live between tidal zone at depth of approximately 200 m and few at a depth of approximately 3000 m. Number of species are found in temperate latitudes and even into Polar waters.

Distribution : ***Alcyonium*** is cosmopolitan, but chiefly found in temperate and cold sea waters and specially form long Island Sound to Gulf of St. Lawrence and form low water to approximately 80 fathoms.

Comments :

(1) **Commonly** called as **soft coral.**
(2) Colony consists of a **base, stalk** and a massive thick fleshy and **leathery lobes** or leathery branches.
(3) Fleshy mass is called as **coenonchyma** from which only oral ends of the polyps project.
(4) Usually the proximal part of the colony is devoid of **anthocodia** and is called sterile. In this animal anthocodia are strewn all over the distal part.
(5) Each **polyp** contains 8 **pinnate tentacles.**
(6) **Spicules** are found throughout the mesogloea which imparts solidity to coenenchyme.
(7) **Fertilization** is **external.**
(8) Life history includes a free-swimming **planual larva,** which becomes sedentary and forms colony by budding.

Identification : Since the specimen contains star-shaped polyps in proximal part only hence it is ***Alcyonium***.

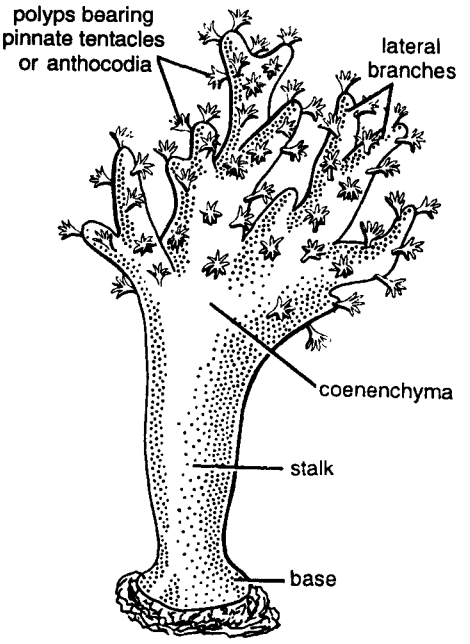


Fig. 43. *Alcyonium.*

44. *Hartea*

Classification : Same as in ***Alcyonium***.
Genus.....***Hartea***

Habit and habitat : ***Hartea*** is a marine solitary alcyonarian Actinozoa with strongly polyp-like shape.

Distribution : It is found in shallow water.

Comments :

(1) **Body** is elongated and cylindrical.
(2) Anterior end contains 8 **pinnately branched tentacles** around **mouth.**

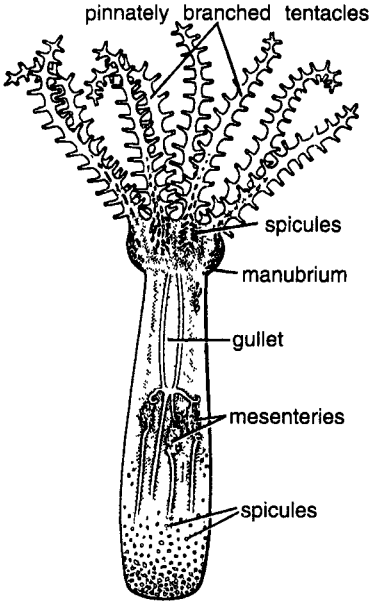


Fig. 44. *Hartea.*

(3) It has simple organization and is supposed to be persistent larval form.
(4) Skeleton has irregular deposits of calcium carbonate in the form of spicules deposited in **mesogloea**.
(5) Other structures seen are **manubrium**, **gullet**, **mesenteries** and **spicules**.

Identification : Since specimen has 8 pinnately branched tentacles and all above characters and hence it is ***Hartea***.

45. *Heliopora*

Classification :

Phylum.....Coeclenterata **Class.....Actinozoa**	→	Characters same as those of *Alcyonium*.
Sub-class.....Octocorallia	→	Skeleton of calcareous fibres.
Order.....Ceonothocelia	→	Solenial tubes present.
Genus.....*Heliopora*		

Habit and habitat : ***Heliopora*** is a marine sedentary coral.

Distribution : It is found on coral reefs in the Indo-Pacific ocean.

Comments :

(1) ***Heliopora*** is the only blue coral among the coral reefs.
(2) It has a massive calcareous skeleton, composed not of **spicules** but of crystalline fibres of arragonite fused into lamellae.
(3) Skeleton is perforated by closely set cylindrical cavities of 2 kinds : (i) **larger** ones occupied by lower ends of polyps; and (ii) much more abundant **smaller ones** occupied by erect **solenial tubes**.
(4) Surface contains flat coenenchyme, which contains solenial network connected to middle region of the polyp and also with erect **solenial tubes**.

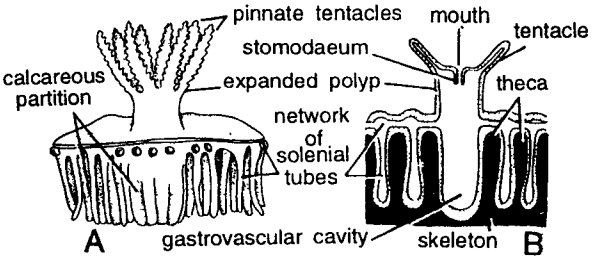


Fig. 45. *Heliopora.* **A.** A complete polyp, **B.** Polyp in vertical section.

(5) **Polyps** and **solenia** are pushed upwards by the formation of **calcareous partitions**.
(6) Blue colour is due to the iron salts.
(7) Iron salts are concealed in life by the brown colour of the polyps.
(8) ***Heliopora*** have been found to exist since Cretaceous period.
(9) Vertical section shows mouth of expanded polyp having **pinnately branched tentacles** and **theca**.

Identification : Since the skeleton contains vertical solenial tubes and all above characters and hence it is ***Heliopora***.

46. *Gorgonia*

Classification :

Phylum.....Coelenterata	→	Tissue grade, diploblastic and acoelomate.
Class.....Anthozoa	→	Only polypoid generation, sedentary, solitary or colonial.
Sub-class.....Octocorallia	→	Polyps with 8 tentacles, bioluminescent.
Order.....Gorgonacea	→	Horny corals, polyps short not reaching up to base.
Sub-order.....Scleraxonia	→	With axial spicule.
Family.....Gorgonida	→	Slender stem, thin, coenenchyme and partially retractile anthocodia.
Genus.....*Gorgonia* (Sea fan)		

Habit and habitat : ***Gorgonia*** is a colonial form inhabiting all seas from tide mark to over 4000 meters. Most of them are littoral. Some prefer warmer seas. Shallow water forms have fan-like structure. Deep

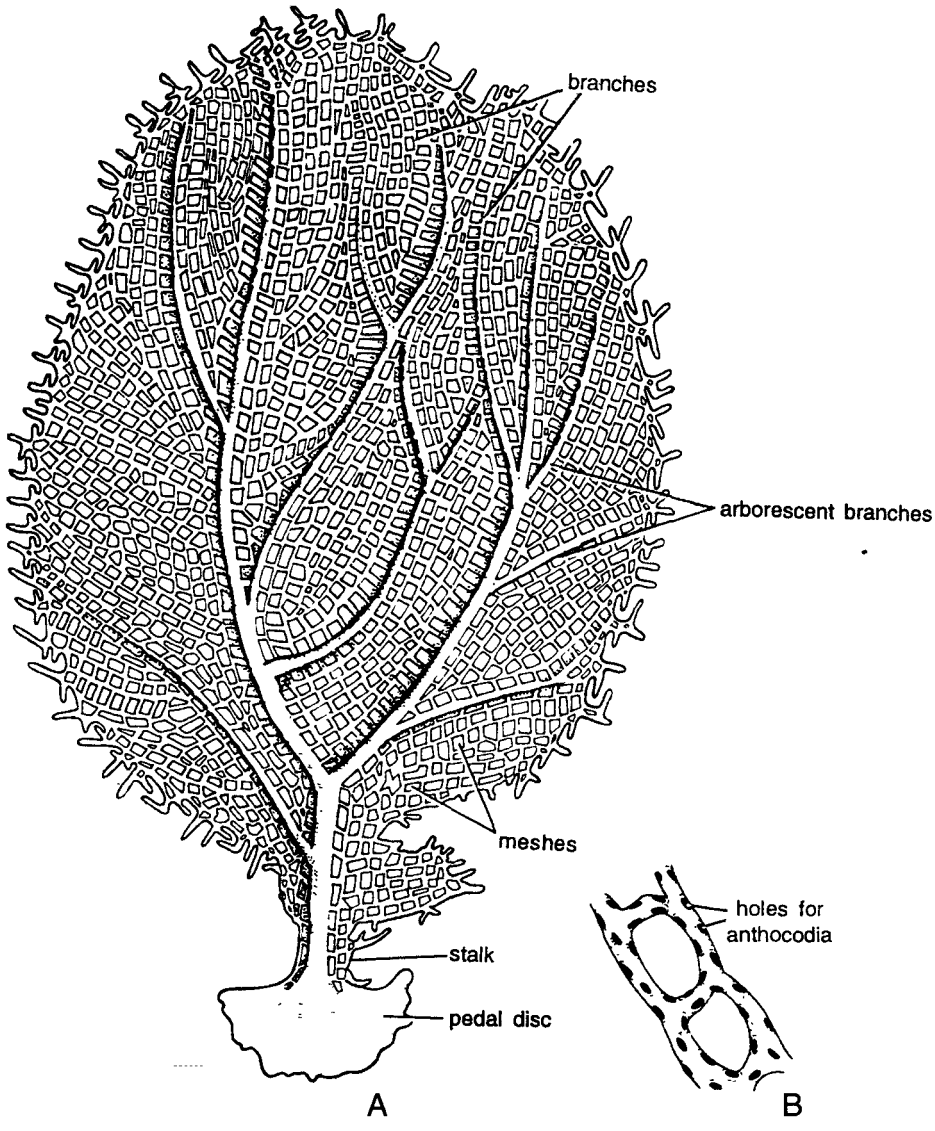


Fig. 46. *Gorgonia.* **A.** Complete specimen, **B.** A portion magnified.

sea forms branch in all directions. It forms one of the chief attractions of the submarine gardens of shallow tropical and subtropical waters (Fig. 46).

Distribution : Found in South Atlantic and West Indies, Indo-Pacific ocean, Malay Archipelago, Bermuda and Bahamas.

Comments :

(1) **Commonly** called as **Sea fan**, whose graceful form and soft colouration constitute one of the chief attractions of '**submarine**' **gardens**.

(2) It forms erect, yellowish or reddish **arborescent branches** in one plane connected by cross connections in a **feathery** manner and contour of the body becomes fan-like.

(3) Branches are united by numerous cross-branches, forming a network with **meshes** 2 to 5 mm wide, calcareous in nature.

(4) Base of the colony is expanded to form a hold fast organ called as **pedal disk**.

(5) Polyps or **anthocodia** emerge from branches and contain 8 pinnate tentacles, mouth, gastrovascular cavity, 8 gastric filaments and mesenteries.
(6) Polyps occur in rows and on two sides only of the stem and its branches. In magnified portions **holes for polyps** are seen.
(7) Skeleton consists of hornlike material called **Gorgonin** embedded in mesogloea. An axial rod extended throughout the colony and its branches. Axial rod consists of medulla and cortex. Gorgonin is proteinaceous consisting of tyrosine amino-acid.
(8) Sexes are separate.

Special features : ***Gorgonia*** is very familiar museum specimen due to its fan-shaped body. The dried skeleton is often displayed as ornament. Sea fan has power of regeneration. It can form new anthocodia when branches are broken off. The heavy harm caused to gorgonian bed by storm is repaired.

Identification : Since the specimen contains fan shaped body and all above characters and hence it is ***Gorgonia***.

47. *Corallium* : Red Coral

Classification :

Phylum..... Coelenterata	→	Tissue grade, diploblastic and acoelomate.
Class..... Anthozoa	→	Only polypoid generation, sedentary, solitary or colonial.
Sub-class.....Octocorallia	→	Polyps with 8 tentacles.
Order..... Gorgonacea	→	Horny corals, polyps short, not reaching up to base.
Family..... Corallidae	→	Solid axis of calcareous spicules cemented by calcium carbonate.
Genus..... ***Corallium*** **(Red coral)**		

Habit and habitat : ***Corallium rubrum*** is a littoral colonial species living on rocky bottoms of warmer seas.

Distribution : It is found in Mediterranean, Eastern Atlantic and off the coast of Japan, Africa and Italy. Most abundant is the Indo-Pacific ocean especially the Malay Archipelago.

Comments :

(1) **Commonly** called as **red coral**.
(2) Colony is erect, branching with a dense, calcareous axis of fused spicules surrounded by canaliferous **coenenchyme bearing** spicules.
(3) Skeleton is hard, calcareous, red in colour and represented by a branching axial rod running throughout the colony, as well as in the tinys spicules embedded in coenosarc.
(4) Gorgonin is completely absent.
(5) Colony has a firm outer tissue of coenosarc which contains delicate, white coloured, retractile and **dimorphic polyps**.
(6) Nutritive polyps are called as **autozooids** having 8 **pinnate tentacles**, mesenteries and gonads.
(7) Small water-pumping polyps or **siphonozooids** without tentacles.
(8) Due to cement-like deposits of carbonate in the centre, the solid limestone rod is formed.

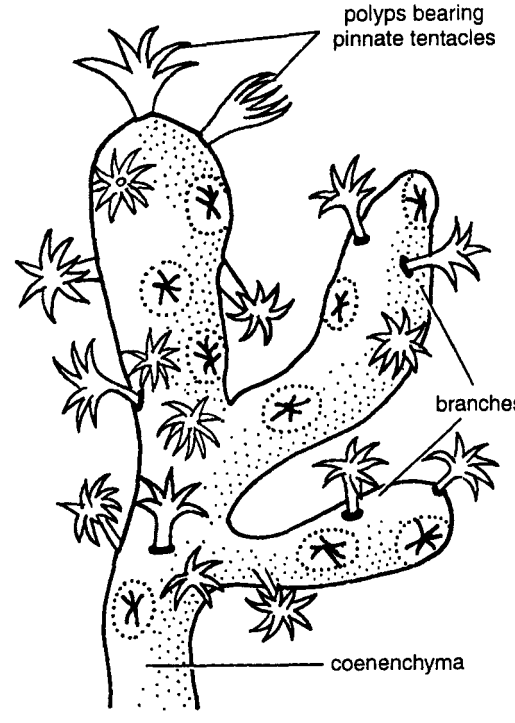


Fig. 47. *Corallium rubrum.*

Special features : Red coral is very precious and of great commercial value, as it is extensively used in jewellery. It is also called as '**red monga**'. Coral is fished along the African and Italian coasts.

Identification : Since the colony has red-coloured skeleton with whitish retractile dimorphic polyps and all above characters, hence it is ***Corallium***.

48. *Pennatula*

Classification :

Phylum..... Coelenterata	→	Tissue grade, diploblastic and acoelomate.
Class..... Anthozoa	→	Only polypoid generation sedentary, solitary or colonial.
Sub-class..... Octocorallia	→	8 tentacles.
Order..... Pennatulacea	→	Colony dimorphic with a long axial polyp and many lateral polyps.
Family..... Pennatulidae	→	Each leaf with single row of anthocodia. Highly evolved family.
Genus..... *Pennatula* (Sea pen)		

Habit and habitat : ***Pennatula*** is a sedentary and colonial actinozoan found in deep sea waters in sandy and muddy bottoms, 20 to 600 fathoms deep. It prefers warmer water (Fig. 48).

Distribution : It is found in the gulf of St. Lawrence to Carolina common in Europe and especially found in Newfoundland to Nomitueket.

Comments :

(1) **Commonly** called as sea pen or **sea feather**.

(2) Animal is fleshy consisting of a very elongated primary axial polyp which gives numerous **secondary bilateral polyps**.

(3) **Body** is divided into a proximal stalk or peduncle devoid of **anthocodia and distal rachis** having **secondary polyps**.

(4) Central axis or **rachis** posteriorly forms a **peduncle** with an **end bulb**.

(5) Anteriorly rachis bears **lateral fleshy branches** or pinnules containing a series of 8 to 12 gastrozooids or polyps. Each polyp has 8 **pinnate tentacles**.

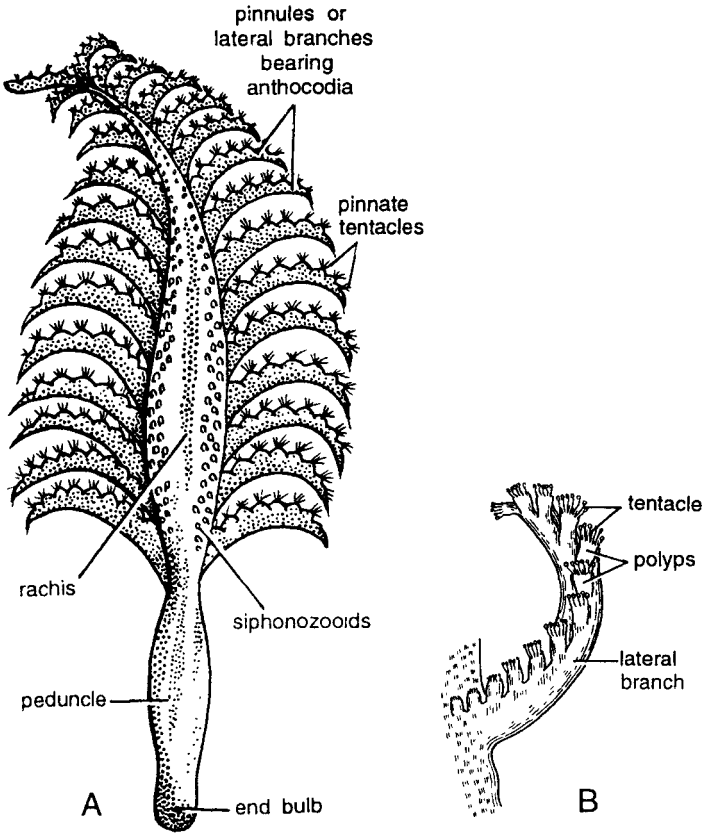


Fig. 48. *Pennatula.* **A.** Entire, **B.** Single pinnule.

(6) Each leaf has a single row or anthocodia of which the outermost one is the oldest and nearest the dorsal side and others are budded successively towards ventral side of the stem. The first polyp budded becomes the end polyp.

(7) Skeleton comprises of a long horny unbranched axis supporting rachis only. Rachis is deep red. Peduncle is rose coloured. Base is whitish.

(8) **Gastrozooids** are feeding zooids, while **siphonozooids** draw water current. The siphonozooids have **siphonoglyphs**, which maintain water current in the canal system of the colony.
(9) Sexes are separate (**dimorphic**) and **gametes** develop in gastrozooids.

Identification : Since the specimen contains rachis with lateral branches bearing polyps and all above characters and hence it is ***Pennatula***.

49. *Pteroides*

Classification : Same as in ***Pennatula***.
Genus.....*Pteroides*

Habit and habitat : ***Pteroides*** is also sedentary colonial deep sea form embedded in sandy or muddy bottom.

Distribution : Common in Europe.

Comments :
(1) **Commonly** called as **Sea pen**.
(2) Whitish **fleshy body** is composed of an elongated primary axial polyp and several secondary lateral polyps originating from it.
(3) Lateral polyps or branches of **pinnules** concentrated anteriorly which are very closely set together.
(4) Pinnules contains several **gastrozooids** or **siphonozooids** or **polyps** or **anthocodia**.
(5) Peduncle is elongated and thickened.

Identification : Since the specimen contains long peduncle, compact anterior pinnules and all above characters and hence it is ***Pteroides***.

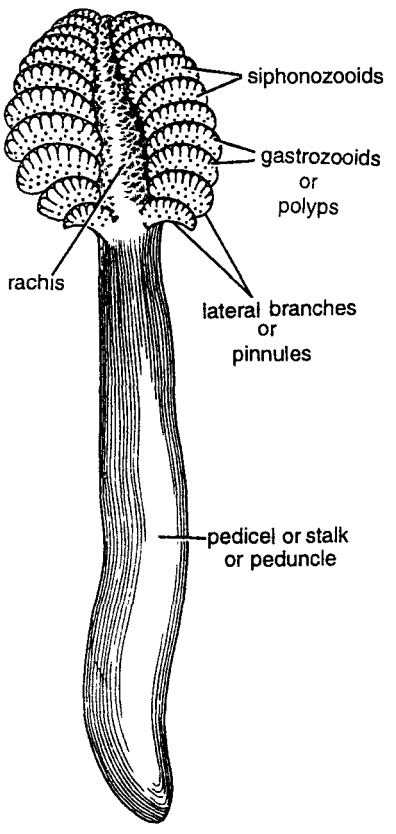


Fig. 49. *Pteroides.*

50. *Renilla*

Classification : Same as in ***Pennatula***.
Genus.....*Renilla*

Habit and habitat : ***Renilla*** is marine, **dimorphic**, colonial and benthic.

Distribution : It is found in shallow water on the Carolina coast and West Indies.

Comments :
(1) **Commonly** called as **Sea pansy**.
(2) Colony consists of a short **peduncle** or stalk embedded in the mud and a discoidal, **kidney shaped** or **reniform** body measuring 4 to 8 cm in diameter.
(3) **Body** divided into dorsal and ventral surfaces.
(4) Pink or violet dorsal surface contains several whitish zooids or **polyps**.
(5) Broad ventral and median rachis are devoid of polyps.
(6) There are 2 kinds of **zooids** : (i) **Anthocodia** or **autozooids**. They are nutritive in function and irregularly distributed on the dorsal surface, (ii) **Siphonozooids** are arranged in clusters and maintain water current in the colony.
(7) **Peduncle** contains tubes for water current.

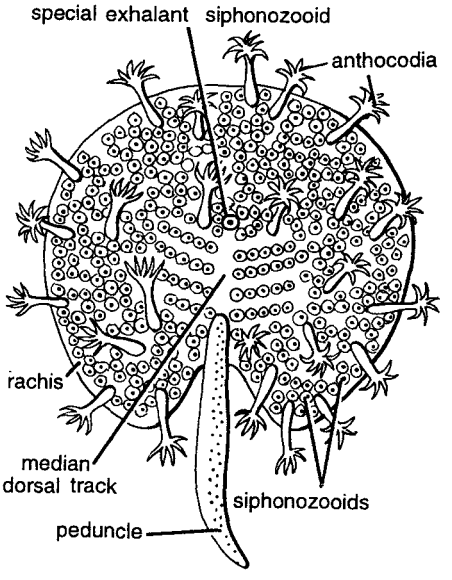


Fig. 50. *Renilla.*

(8) Axial skeleton is completely absent.
(9) A **median** track devoid of polyps extends from the peduncle up to the middle of the **rachis**, where it terminates as a **special exhalent siphonozooid**.

Identification : Since the specimen contains discoidal reniform body and all above characters, hence it is ***Renilla***.

51. *Cavernularia*

Classification : Same as in ***Pennatula***.
Genus.....*Cavernularia*

Habit and habitat : ***Cavernularia*** is a marine, dimorphic and colonial form.

Distribution : Found along the Atlantic coast.

Comments :
(1) **Body** is divided into a proximal stalk or stem or **Peduncle** which is divide of **anthocodia** or polyp and a distal part having polyps.
(2) Distal part is called as **rachis** which is covered by perisarc.
(3) Pigmentation is blue, violet, yellow and green.
(4) It is the primitive genus in which the rachis is stout radially symmetrical, cylindrical or club-shaped.
(5) **Anthozooids** and **siphonozooids** are distributed over the whole surface of the rachis.
(6) Coenenchyme or coenosarc is fleshy and is traversed by coenoceral canals containing long spicules.

Special features : ***Cavernularia*** is **bioluminescent coelenterate**. It produces light without heat.

Identification : Since body is divided into stem and rachis and contains all above parts, hence it is ***Cavernularia***.

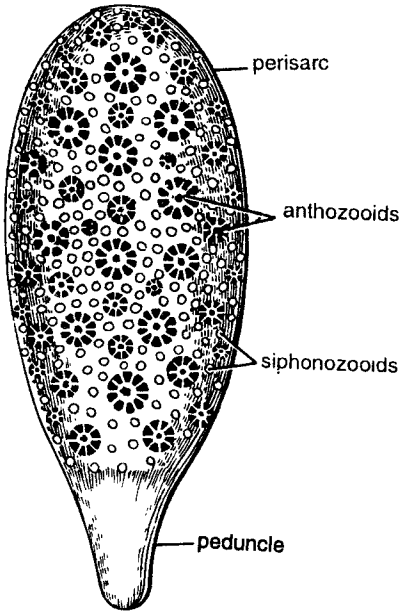


Fig. 51. ***Cavernularia***.

52. *Virgularia*

Classification : Same as in ***Pennatula***.
Genus.....*Virgularia*

Habit and habitat : ***Virgularia*** is a marine and colonial Actinozoa.

Distribution : It is distributed along Pacific coast.

Comments :
(1) **Commonly** called as **walking stick**.
(2) Body is divided into curved proximal and distal rachis.
(3) Rachis is elongated like walking stick.
(4) **Anthocodia** or polyps are grouped and slightly fused into transverse or oblique rows spaced at regular intervals along the stem.
(5) **Siphonozooids** are found just below each row of polyps.

Special features : ***Virgularia*** is bioluminescent.

Identification : Since the specimen is like walking stick and contains all above parts, hence it is ***Virgularia***.

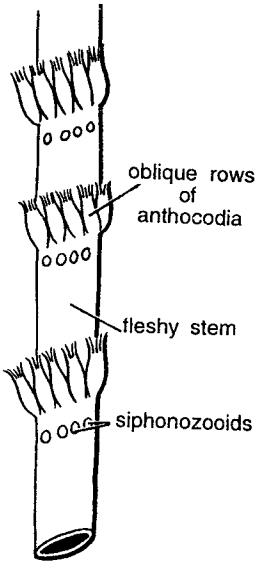


Fig. 52. ***Virgularia***.

53. *Metridium*

Classification :

Phylum..... Coelenterata	→	Tissue grade, diploblastic and acoelomate.
Class..... Anthozoa	→	Only polypoid generation, sedentary, solitary or colonial.
Sub-class..... Hexacorallia	→	Tentacles and mesenteries in multiple of five or six.
Order..... Actiniaria	→	Sea anemones, without skeleton with mesenteries of septa in multiple of six. Basal disc present.

Genus..... ***Metridium*** **(Common sea anemone)**

Habit and habitat : ***Metridium*** is a large sessile, brightly coloured, solitary, flower-like or polyp-like marine coelenterate.

Distribution : It is largest and one of the commonest, **sea anemones** on the Atlantic coast, New Jersey to Labrador from low water mark to approximately 90 fathoms, Pacific coast and Europe.

Comments :

(1) **Commonly** called as **Sea-anemone**.
(2) **Body** is short cylindrical, radially symmetrical and longer than broad.
(3) Body of the animal is divided into 3 regions-Oral **disk**, **column** and **pedal disk**.
(4) Oral disk is expanded as **flat disk** called as **capitulum** which is crowned with several **marginal tentacles around mouth**.
(5) **Column** forms major part of the body and is differentiated into 2 parts (i) **upper delicate thin walled capitulum** and (ii) **lower thick walled scapus**.
(6) Capitulum and scapus are separated by a prominent fold called **collar** and a shallow grove called as **fossa**.
(7) Wall of the **scapus** is perforated by small openings called as **cinclides**.
(8) **Pedal disk :** It is broad disk attached to substratum and is separated from scapus by **limbus**.
(9) **Dioecious :** Sexes separate.
(10) Asexual reproduction by budding and fragmentation.

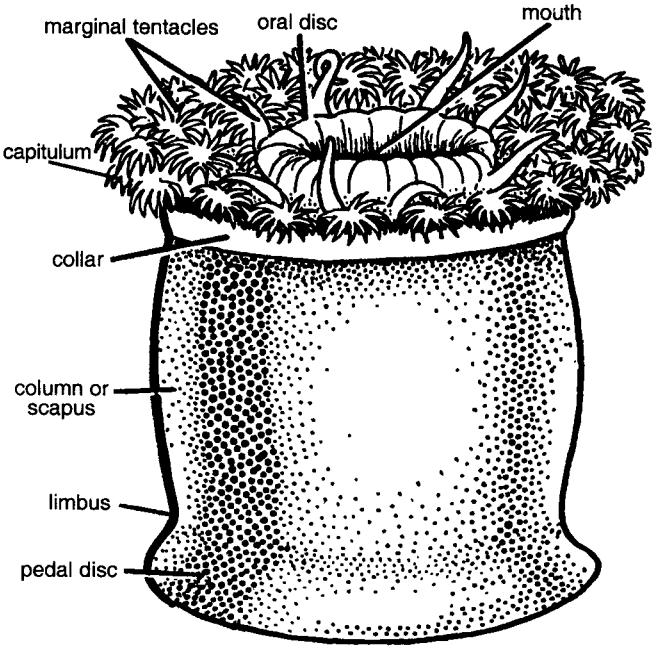


Fig. 53. *Metridium.* Entire.

Identification : Since the specimen contains **base**, **scapus**, **collar**, **capitulum** and all above parts and hence it is ***Metridium***.

54. *Metridium* in V.S.

Comments :

(1) Vertical section shows its internal organization (Fig. 54).
(2) In sections different regions of the body such as **capitulum**, **collar**, **fossa**, **scapus**, **limbus** and **pedal disk**, crown of nematocyst bearing tentacles, sphincter and basilar muscles are seen.
(3) **Mouth** opens into gastrovascular cavity through **actinopharynx** or **siphonoglyp**.

(4) **Gastrovascular cavity** is divided into vertical partitions by six pairs of **mesenteric filaments**.
(5) Posteriorly mesenteric filaments form coiled structures called as **aconcia**.
(6) In sections **gonads** are seen on **mesenteric filaments** or **septal filaments**.
(7) Other structures seen are marginal **stoma, oral stoma, parietal muscle, retractile muscles, transverse musculature of septum** and **septum**.

Identification : Since section contains 6 pairs of mesenteric filaments and all above features, hence it is **V.S.** ***Metridium***.

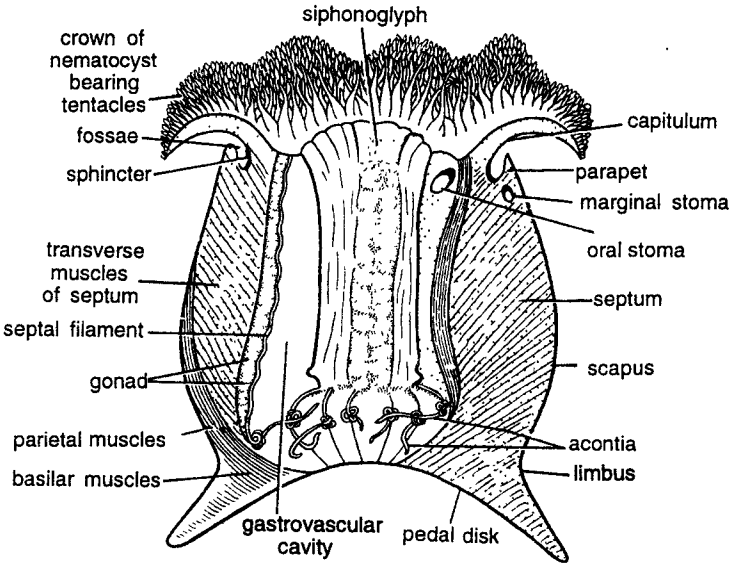


Fig. 54. *Metridium* in vertical section.

55. *Adamsia* : Showing Commensalism

Classification : Same as in ***Metridium***.
Genus.....*Adamsia*

Habit and habitat : ***Adamsia*** is a marine commensal found attached to the empty shells of gastropods occupied by hermit-crab, ***Eupagurus***. It has usual anemone-like structure.

Distribution : It is found in U.S.A. (North Carolina to Florida) in shallow water.

Comments :

(1) **Body** consists of expanded **oral disc, column** and **pedal disc** or base. By pedal disk anemone is attached on the outer surface of the empty mollusc shell.
(2) Oral disc has central mouth encircled by about 500 or more nematocyst bearing **tentacles**.
(3) Column is cylindrical, bearing ciclidial tubercles at its base.
(4) **Siphonoglyphs** and six pairs of mesenteries are present internally.
(5) **Oral disc** has central **mouth** which is encircled by nematocyst-bearing tentacles numbering 500 or more.
(6) These individuals benefit each other.
(7) ***Adamsia*** (Anemone) is carried to different places by hermit crab living inside mollusc shell and it gets variety of food.

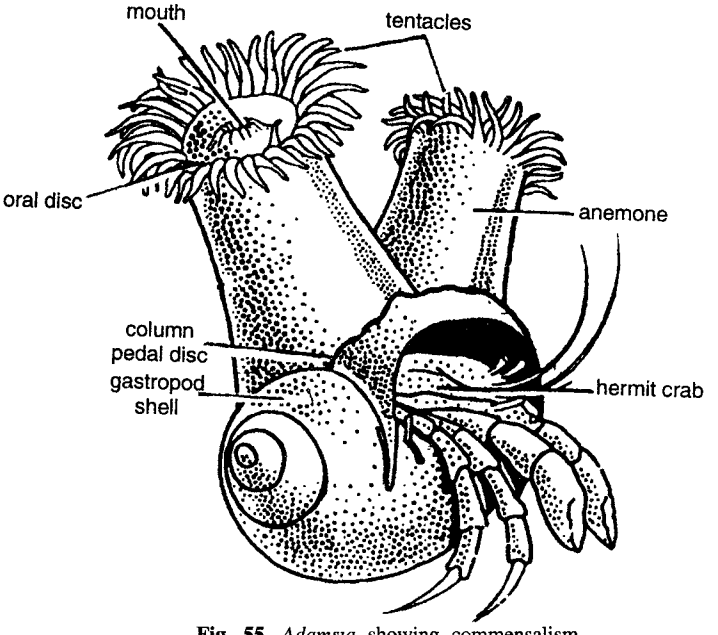


Fig. 55. *Adamsia* showing commensalism.

(8) Hermit-crab is protected from its enemies by retreating into shell, exposing sea anemone, which is protected by poisonous stinging capsules and aconita.

Special features : ***Adamsia*** and Hermit-crab show **commensalism**. In this there is no morphological, physiological and organic relationship between the two associates and there is no metabolic dependency between two.

Identification : Since ***Adamsia*** is found over the mollusc shell and Hermit-crab inside the shell, hence it is ***Adamsia***.

56. *Minyas*

Classification : Same as in ***Metridium***.

Genus.....***Minyas***

Habit and habitat : ***Minyas*** is a small marine, colonial, pelagic and floating sea anemone.

Distribution : It is exclusively found in tropical regions and is most abundant in shallow and coastal water.

Comments :

(1) **Body** divided into 3 parts—**oral disc**, **column** and **basal disc**.
(2) Column is short.
(3) Basal disc contains a float filled with air due to which the animal floats.
(4) Oral disc contains several marginal **tentacles**.
(5) Skeleton is absent.

Identification : Since the base contains a float and all above characters, hence it is ***Minyas***.

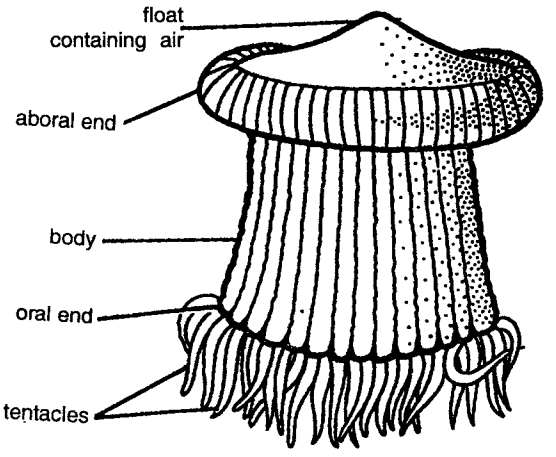


Fig. 56. *Minyas.*

57. *Edwardsia*

Classification : Same as in ***Metridium*** (Fig. 57).

Genus.....***Edwardsia***

Habit and habitat : ***Edwardsia*** is a small, solitary, marine, hexacorallian coelenterate buried in sand with changeable positions.

Distribution : Found in U.S.A., Southern California and North of Cape Cod.

Comments :

(1) **Body** of the preserved specimen is cylindrical and divided into **oral disc**, **column** and **physa**.
(2) **Column** is further differentiated into **capitulum**, **scapulus** and **scapus**. Alive animal appears shorter of contracted condition and **retracted tentacles** arround manubrium.
(3) Oral disc unexpanded contains 16 retractile tentacles. In contracted stage no tentacle is seen.
(4) Body surface has 8 longitudinal ridges and the posterior half of the scapus contains rows of nematocysts called as **nemathybomes**.
(5) Basal part or **physa** is demarcated by **limbus** from **scapus**.
(6) **Siphonoglyphs** and mesenteries eight in number are present.
(7) Septa are in primitive condition consisting of 8 macrosepta and more than 4 **microsepta**.

Special features : The young ***Edwardsia*** leads a parasitic life in the gastrovascular system of medusa and in ctenophores.

Identification : Since the animal contains retractile tentacles and physa, and all above characters, hence it is ***Edwardsia***.

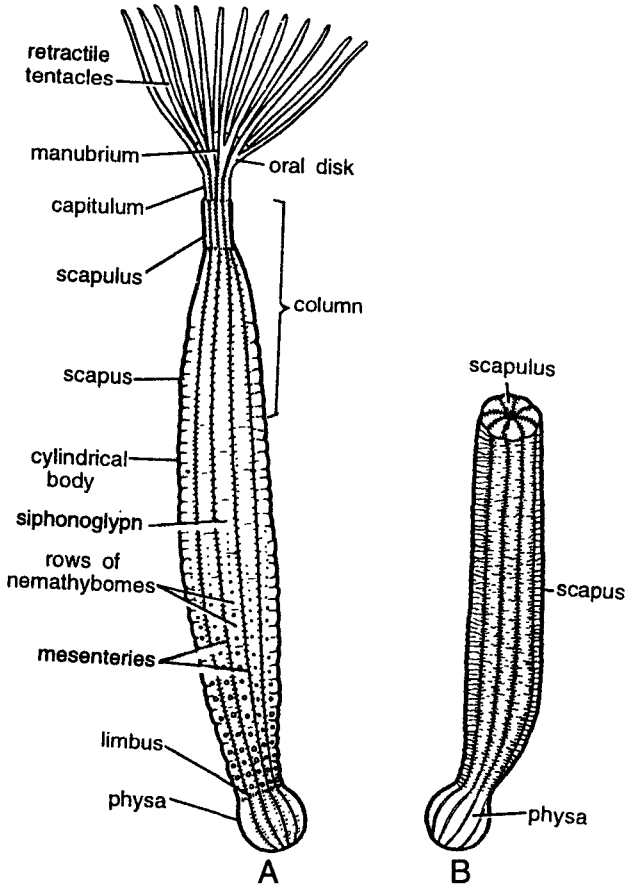


Fig. 57. *Edwardsia.* **A.** Preserved specimen, **B.** Alive specimen contracted.

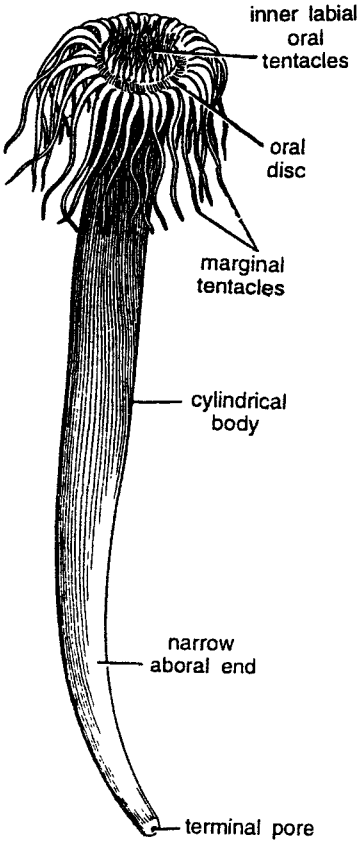


Fig. 58. *Cerianthus.*

58. *Cerianthus*

Classification :

Phylum.....Coelenterate	→	Tissue grade, diploblastic and acoelomate.
Class.....Anthozoa	→	Only polypoid generation, sedentary, solitary or colonial.
Sub-class.....Hexacorallia	→	Tentacles and mesenteries in multiple of five or six.
Order.....Ceriantharia	→	Without skeleton and pedal disc. Mesenteries single.
Genus.....*Cerianthus*		

Habit and habitat : ***Cerianthus*** is a marine Anthozoa, adapted for burrowing life in the sand, living in vertical and cylindrical cavity in sea bottom.

Distribution : Found along the Atlantic and the Pacific Coast, Cape Cod to Florida, Bay of Fundy and Mediterranean.

Comments :

(1) Best known genus of **hexacorallian Anthozoa**. The size varies in different species.

(2) It is anemone-like actinozoan with smooth, muscular, elongated, cylindrical body buried into the sand upto oral disc. The oral disc is exposed.

(3) **Oral disc** bears simple, slender **tentacles** arranged in two sets, an outer **marginal tentacles** and an inner smaller **oral** or **labial** tentacles.

(4) Aboral end is simply rounded and provided with **terminal** pore.
(5) There is one cycle of complete coupled septa.
(6) There is a single dorsal **siphonoglyph.**
(7) There is no true skeleton.

Special features : It is markedly negative to gravity soon resuming an upright position. ***Cerianthus*** has considerable power of regeneration in oral region. ***Cerianthus membranaceous***, an inhabitant of the Mediterranean, is a favourite aquarium animal in European aquaria and has been known to live under such conditions for 10 to 40 years.

Identification : Since the animal contains short and long tentacles in oral disc a terminal pore and all above characters and hence it is ***Cerianthus***.

59. *Zoanthus*

Classification :

Phylum.....**Coelenterata**
Class.....**Actinozoa** } → Characters same as those of ***Cerianthus***.
Subject.....**Hexacorallia**
Order.....**Zoanthidea** → Epizoic. Pedal disc and skeleton absent. Mesenteries paired.
Genus.....***Zoanthus***

Habit and habitat : ***Zoanthus*** is a colonial sea-anemone springing from an incrusting or stolon like base. Many are epizoic in habit being incrusted on hermit crabs, sponges and hydroids.

Distribution : Found in West Indies.

Comments :

(1) **Body** differentiated into **column** and **oral disc** having mouth and **marginal tentacles.**
(2) **Polyps** of colony are united by basal **stolons** attached to **substratum.**
(3) Polyps are clariform, cylindrical, elongated and without foreign bodies on their surfaces.
(4) **Tentacles** 48 to 60.
(5) **Mesenteries** consist of macro and micro-mesenteries differing from all other anthozoans and having characteristic arrangement.
(6) Single siphonoglyph present.
(7) Animals may be colourless or coloured.
(8) Sexes are separate.
(9) A sexual reproduction takes place by simple **budding** from stolon.

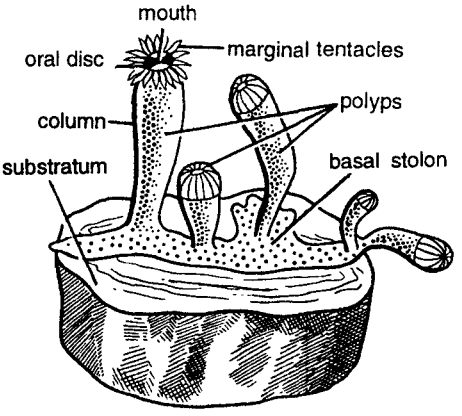


Fig. 59. *Zoanthus* polyps.

Identification : Since the colony is connected by stolons and has all above characters and hence it is ***Zoanthus***.

60. *Madrepora* (= *Acropora*)

Classification :

Phylum.....**Coelenterata** → Tissue grade, diploblastic and acoelomate.
Class.....**Anthozoa** → Only polypoid generation, sedentary, solitary or colonial.
Sub-class.....**Hexacorallia** → Tentacles and mesenteries in multiple of five or six.
Order.....**Madreporaria** → Stony corals with compact calcareous exoskeleton.
Genus.....***Madrepora*** **(Horn coral)**

Habit and habitat : ***Madrepora*** is colonial, symbiotic and marine coral.
Distribution : It is found in West Indies and Florida.
Comments :
(1) **Commonly** called as **Born coral.**
(2) It plays important role in coral-reef formation.
(3) Colony branched, being either flagellate radiate or thick. Branching less towards the periphery. Colony is partly porous or reticulate covered by **perisarc.**
(4) Colony consists of cylindrical cups or **corallites** for **polyps** in **coenosarc.**
(5) The **corallite** is secreted by basal discs of polyps and is composed of calcium carbonate.
(6) Polyps look like flowers. Terminal and lateral polyps possess 6 and 12 tentacles respectively, and are without central columella.
(7) Internally mesenteries are bilaterally arranged and **coenosarc** contains a network of canals.
(8) Sometimes small crustaceans are found in association with horn corals.

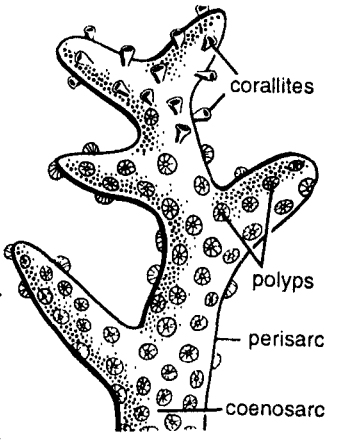


Fig. 60. *Madrepora.*

Special features : The colony increases in size by growth and budding of the polyps.
Identification : Since the animal contains corallita and all above characters and hence it is ***Madrepora.***

61. *Meandrina*

Classification : Same as in ***Madrepora.***
Genus.....*Meandrina*
Habit and habitat : ***Meandrina*** forms incrusting massive, gigantic colony consisting of round masses of limestone measuring approximately 25 meters in diameter and weighing several tons in sea.
Distribution : It is found in West Indies and Florida.
Comments :
(1) ***Meandrina*** or ***Meandra*** is called as **brain coral.** The long, curved grooves running parallel with each other resemble convolutions of **human brain** and hence the name brain coral.
(2) Each mass if formed as a result of accumulation of several generations of polyp.
(3) Surface of the colony is made up of numerous sinous **ridges** which are the septa and **grooves.**
(4) During living condition, the polyps remain confluent, mingled and closely set called as **confluent corallites.**
(5) Polyps do not occupy separate cups but several of them become mixed, having a common fringe of tentacles and rows of septa and mesenteries.
(6) Mouth of mixed polyps remain separate.
(7) Confluent polyps contract in day time, while they remain extended at night.

Identification : Since the specimen contains ridges and grooves like mammalian brain and all above characters and hence it is ***Meandrina.***

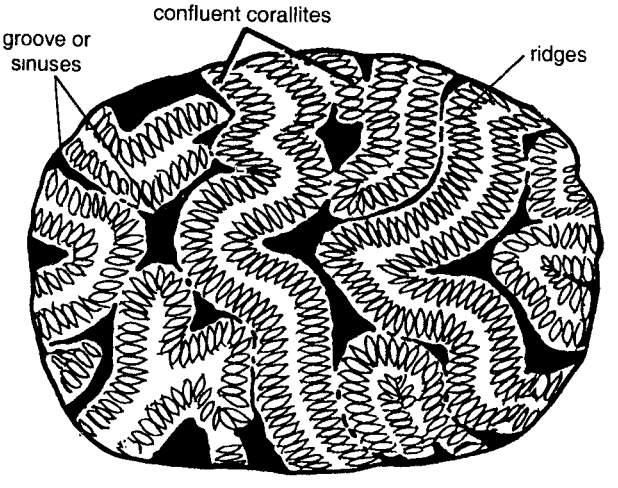


Fig. 61. *Meandrina.*

62. *Astraea*

Classification : Same as in ***Madrepora***.

Genus.....*Astraea*

Habit and habitat : ***Astraea*** is a marine colonial, hexacorallian coelenterate coral.

Distribution : Found in U.S.A.; Florida and California.

Comments :

(1) **Commonly** called as **stony coral**.
(2) Contains ectodermal, calcareous or calcium carbonate skeleton, called as corallium.
(3) **Colony** is compact and massive produced by buds, growing more or less parallel with each other.
(4) Skeleton is very hard like stone.
(5) Surface of the body contains closely-placed cups or corallites containing polyps.
(6) **Zooids** are separated by a solid coenosarc.
(7) **Coenenchyma** is produced by calcification of coenosarc which also gives rise to **corallites**. Corallites lie in close contact with each other.
(8) ***Astraea*** is a poreless coral reproducing by gemmation, fissiparous division and budding.

Identification : Since the specimen contains hardened calcification and closely fitted caps for polyps and all above characters and hence it is ***Astraea***.

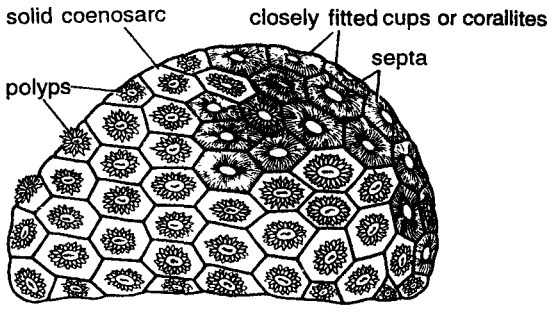


Fig. 62. *Astraea.*

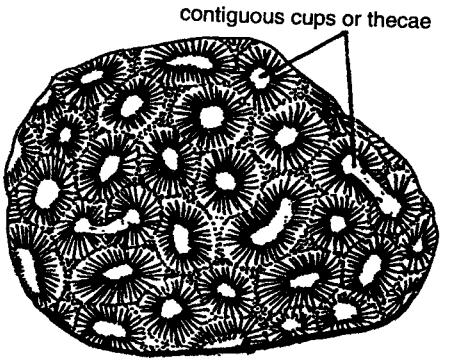


Fig. 63. *Favia.*

63. *Favia*

Classification : Same as in ***Madrepora***.

Genus.....*Favia*

Habit and habitat : ***Favia*** is a marine, colonial reef-building **stony coral**.

Distribution : It is common in West Indies and Florida.

Comments :

(1) Thick stony skeleton is formed by calcareous or calcium carbonate skeleton.
(2) **Coenenchyme** is produced by calcified coenosarc, which also forms corallites or zooids.
(3) Surface of the body contains closely-placed polygonal **cups** or **theca**.
(4) Thecae of the cups are very closed set together having common walls.
(5) It is imperforate or poreless coral, like ***Astraea***.
(6) ***Favia*** has long fossil history. It originated in Jurassic period and is still living successfully.

Identification : Since besides above characters the specimen has characteristic polygonal cups and all above features, hence it is ***Favia***.

64. *Astrangia*

Classification : Same as in ***Madrepora.***

Genus.....*Astrangia*

Habit and habitat : ***Astrangia*** forms small, encrusting colonies, measuring 5 or 8 cm in diameter on rocks and shells in sheltered places.

Distribution : It is found along the coasts of America, Atlantic coasts from North Carolina to North Massachusetts.

Comments :

(1) **Colony** consists of closely placed thecae and protruding polyps.
(2) Polyps (zooids) of the colony are distinct and separated by **sclerasepta** from **theca** skeleton of the colony.
(3) **Polyps** are usually white, pinkish or greenish and remain expanded during day.
(4) Oral disc contains mouth, which is surrounded by a double ring of **tentacles** which are covered with **nematocyst warts** and tipped with a **nematocyst knob**.

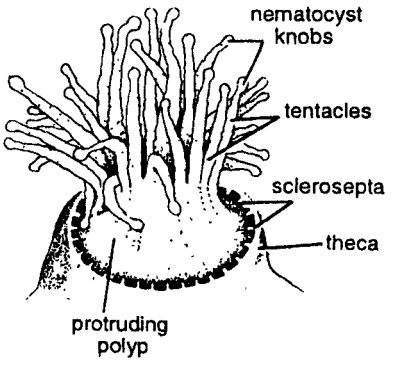


Fig. 64. *Astrangia.* One polyp magnified.

(5) Large polyps have three cycles of tentacles mostly 12 larger tentacles alternating with 12 smaller ones.
(6) ***Astrangia donae*** feeds on crustaceans, small fish, and bits of meat.
(7) Zooxanthellae are absent in the gastrodermis of the polyps.

Identification : Since the colony consists of closely placed thecae, protruding polyps and all above characters, hence it is ***Astrangia.***

65. *Dendrophylia*

Classification : Same as ***Madrepora.***

Genus.....*Dendrophylia*

Habit and habitat : ***Dendrophylia*** is a marine, colonial compound coral.

Distribution : Found in tropical and sub-tropical waters.

Comments :

(1) Animal is **tree-like.**
(2) **Corallites** are not in close contact with one another but tree-like.
(3) Corallites originate from a common calcareous stem.
(4) Stem or coenenchyme is formed by calcification of the coenosarc.
(5) Each corallite or polyp contains a centrally placed mouth, surrounded by whorl of small tentacles.
(6) Reproduction by budding.

Identification : Since the colony has tree-like corallite and all above characters hence it is ***Dendrophylia.***

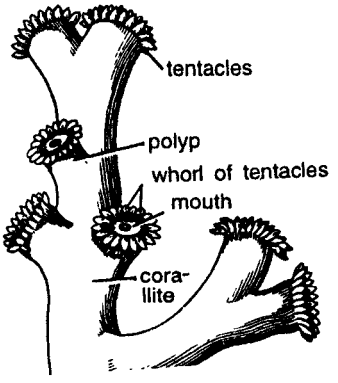


Fig. 65. *Dendrophylia.*

66. *Fungia*

Classification : Same as in ***Madrepora.***

Genus.....*Fungia*

Habit and habitat : ***Fungia*** is a solitary and marine coral (Fig. 66).

Distribution : It is found in warm seas, generally in the Gulf of California.

Comments :

(1) **Commonly** known as **Mushroom coral.**
(2) It is found in sizes from 5 mm to 25 cm in diameter.
(3) It is discoidal, mushroom-shaped, with upper convex and lower concave surfaces having thecae.
(4) Discoidal corallite contains numerous **septa** connected together by a calcareous rod, known as synapticula.
(5) Adult animal contains a single large polyp with numerous tentacles.
(6) Animal lies loose on the bottom of sea or fastened below by a stalk.
(7) Siphonoglyphs are absent.
(8) Life history includes cup-shaped planula which metamorphoses into adult. ***Fungia*** continues to give off ordinary buds throughout life.
(9) It has long fossil history. It originated in tertiary period and is living successfully.

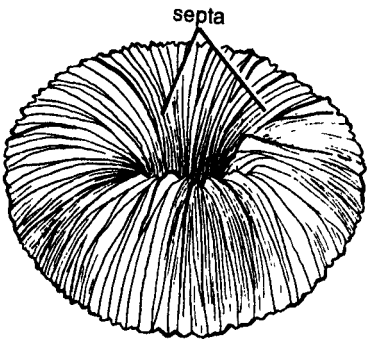


Fig. 66. *Fungia.*

Identification : Since the specimen is mushroom shaped, has whitish septa and all above characters, hence it is ***Fungia***.

Instructions : *Make comparative charts of all the actinozoans studied by you.*

PHYLUM-CTENOPHORA

67. *Cestum*

Classification :

Phylum.....Ctenophora	→	Biradially symmetrical. Radiata without nematocysts.
Class.....Tentaculata	→	With tentacles.
Order.....Cestida	→	Band-like form.
Genus.....*Cestum*		

Habit and habitat : ***Cestum*** is a marine solitary and bioluminescent ctenophore (Fig. 67).

Distribution : It is found in the Mediterranean Sea, occasionally brought to the Gulf-Stream and New England coast.

Comments :

(1) **Commonly** called as '**Venus belt**' or **girdle of venus** among the comb-jellies.
(2) Process of transverse compression is found to such an extent that the body is elongated in the sagittal plane to a flattened transparent, gelatinous band, measuring approximately 1.5 meters in length.
(3) Transparent body shimmers with violet, blue or green colour.
(4) Four sub-tentacular **comb rows** are elongated to run along the entire aboral edge of the band-like body. Tentacles are reduced to tufts of filaments.

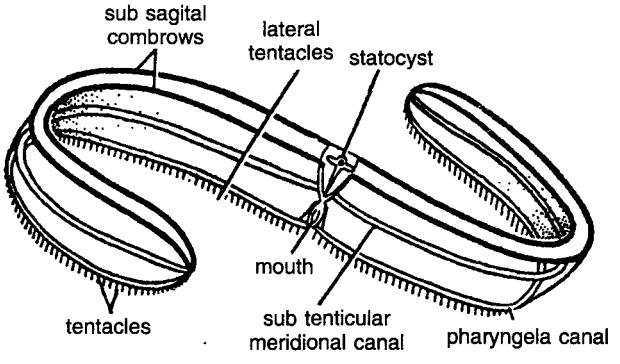


Fig. 67. *Cestum.*

(5) Small **lateral tentacles** line the oral edge.
(6) Four interradial meridional canals arise directly from the stomach.
(7) **Mouth** is found in the mid-oral edge and statocyst on aboral edge. **Sub-tentacular meridional canal** and **pharyngeal canals** are present.
(8) Animal swims by the graceful, muscular undulations of the body and by the beating of comb or swimming plates. Sub-sagittal canals accompany the corresponding comb rows along the entire aboral.

Identification : Since the specimen contains girdle-shaped body comb jaws and all above character and hence it is ***Cestum.***

68. *Coeloplana*

Classification :

Phylum.....Ctenophora	→	Biradially symmetrical. Radiata without nematocysts.
Class.....Tentaculata	→	With tentacles.
Order.....Platyctenea	→	With 2 tentacles and without comb rows.
Genus.....*Coeloplana*		

Habit and habitat : ***Coeloplana*** is a marine solitary ctenophore.

Distribution : It is abundantly found on the coasts of Japan.

Comments :

(1) Flat oval elongated animal in tentacular plan and measuring approximately 60 mm in length.
(2) It is transparent or coloured on the aboral surface in various shades like olive and reddish.
(3) It creeps on some alcyonarians as an **ectocommensal.**
(4) There is a **tentacle** in each notch.
(5) Tentacle arises from tentacle base. Tentacle is enclosed in a **tentacular sheath.**
(6) **Statocyst** is mid-dorsally placed.
(7) Anteriorly tentacle shows branching. **Peripheral network of alimentary canal** are clearly seen.
(8) **Comb rows** are absent. The diagnostic feature of the animal is the presence of 12 to 60 **erectile papillae** depending on species.
(9) **Tentacular canals** and **meridional canals** are present in the middle. **Gonads** present posteriorly.
(10) Gonads (testes and ovary) are found in the wall of 8 meridional canals. The egg gives rise to typical ctenophore **cydippid** larva that develops into the adult.
(11) It reproduces **sexually.**

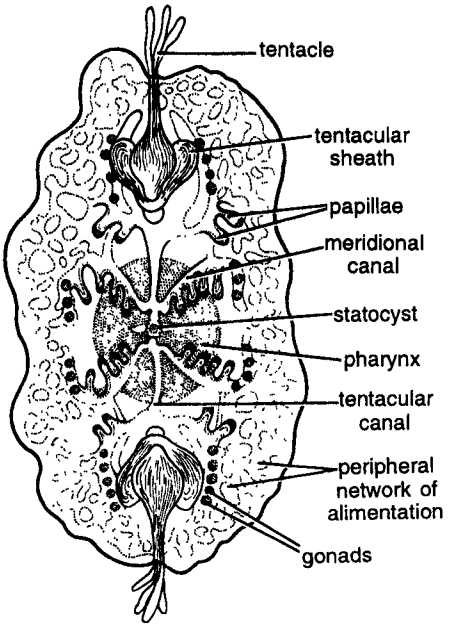


Fig. 68. *Coeloplana.*

Identification : Since the animal has 12 to 60 erectile papillae and all above characters it is ***Coeloplana.***

69. *Ctenoplana*

Classification : Same as in ***Coeloplana***.

Genus.....*Ctenoplana*

Habit and habitat : ***Ctenoplana*** is marine solitary, planktonic ctenophore.

Distribution : It is found along the coasts of Indo-China and Japan.

Comments :

(1) It is an aberrent ctenophore first discovered by Korotneff (1886) and later worked by Willey (1896), Dawyboff (1929) and Komai (1934).

(2) **Body** consists of flattened oval, central thick portion and two rounded, thin lobes in the sagittal plane.

(3) It measures 5 to 8 mm in the tentacular plane and coloured dorsally, mostly olive-green, brown or reddish. It reproduces asexually.

(4) Between the lobes of the anterior notch, there is a **long tentacle** giving **irregular side branches.** Main tentacle arise from base covered by **tentacular sheath.**

(5) There are 8 short **comb rows** of several plates connected to **statocyst** by ciliated furrows.

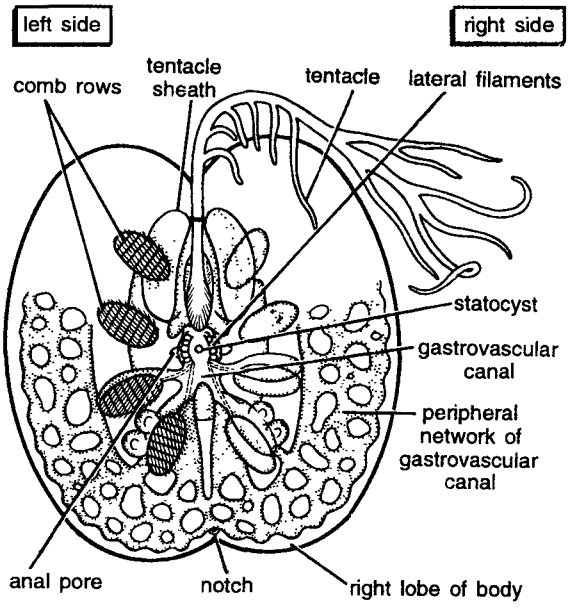


Fig. 69. *Ctenoplana.*

(6) Oral surface is characterised by everted **pharynx, gastrovascular canal and peripheral network of gastrovascular canals.**

(7) **Anus** present on left lobe.

(8) It reproduces asexually.

Special features : At the time of discovery of ***Ctenoplana*** and ***Coeloplana*** they were considered by some zoologists as connecting links between coelenterates and flatworms; but their structural details show that they are simply modified creeping ctenophores.

Identification : Besides above characters, main tentacle has several side branches and hence it is ***Ctenoplana***.

70. *Tjalfiella*

Classification : Same as in ***Coeloplana***.

Genus.....*Tjalfiella*

Habit and habitat : ***Tjalfiella*** is another flattened, creeping, practically sessile ctenophore (Fig. 70).

Distribution : It is found in Greenland on the pennatulid **Umbellula.**

Comments :

(1) **Body** is flattened in the **oral aboral** direction and elongated in the tentacular axis with a simple tentacle with a base.

(2) Each end is upturned and fused at the edges to form a tube or '**chimney**', through tentacle extension.

(3) Chimney is continued with pharyngeal cavity.

(4) **Statocyst** is found on the upper surface.

(5) **Polar fields, ciliated furrows** and **combs rows** are absent.

(6) Gastrovascular canals are continued into the chimney.

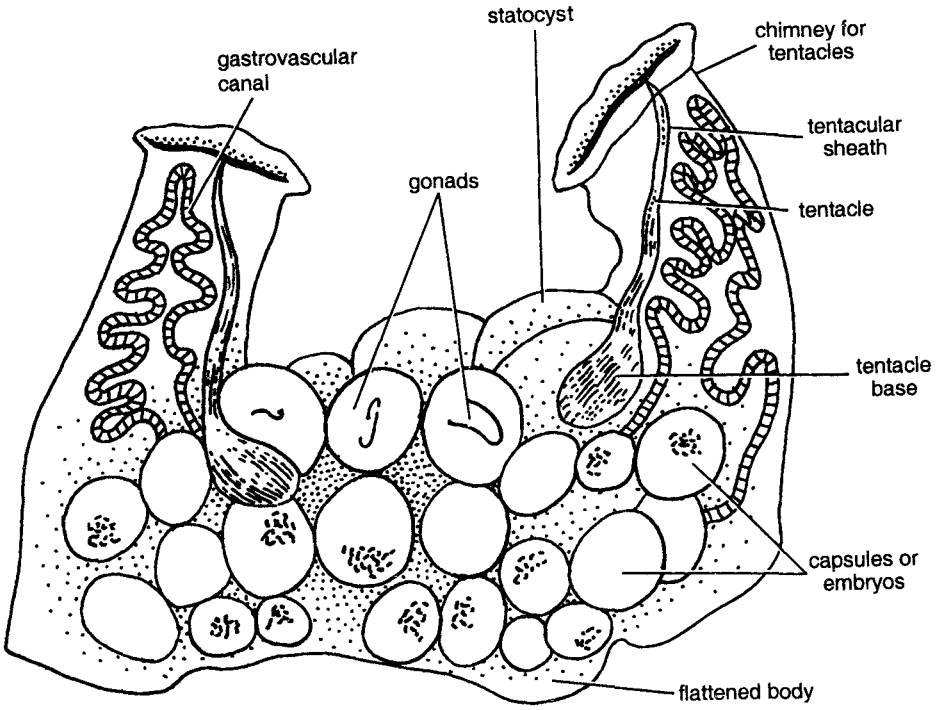


Fig. 70. *Tjalfiella.*

(7) An ovary and a testis occur in each of the eight blind sacs and form eight bulges on the upper surface.
(8) Eggs develop into broad capsules.

Identification : Since the two ends of the body contain chimney like structures and all above characters and hence it is ***Tjalfiella***.

71. *Beroe*

Classification :

Phylum.....Ctenophora → Biradially symmetrical. Radiata without nematocytes.
Class.....Nuda → Without tentacles.
Order.....Beroida → Conical form with wide mouth and pharynx.
Genus.....*Beroe*

Habit and habitat : ***Beroe*** is found in cold sea waters (Fig. 71).

Distribution : It is abundantly found along Pacific coast, Mediterranean and Chesapeake Bay to Florida.

Comments :

(1) **Commonly** called as **Mitre jelly-fish**.
(2) Body is conical or **thimble-shaped**, compressed in the lateral plane with no trace of tentacles or tentacle sheaths.

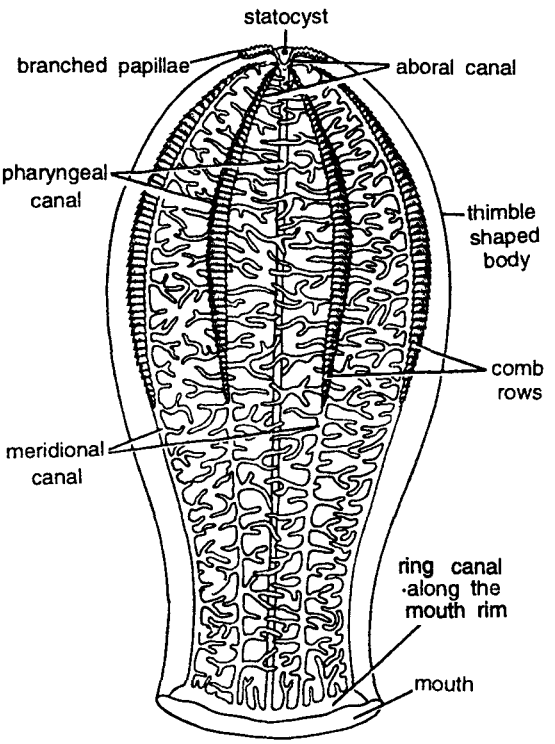


Fig. 71. *Beroe*

(3) **Animal** is of pink colour, measuring approximately 20 cm in height.
(4) Rounded aboral end contains **statocyst** and **branched papillae**.
(5) Major parts in the body consists of **aboral canals, pharyngeal canals, meridional canals** and **comb rows.**
(6) Truncated oral end contains mouth.
(7) **Comb rows** extend up to the middle of the body.
(8) Meridional and pharyngeal canals give off along their lengths numerous branched **lateral diverticulae** forming a network.
(9) Above canals unite to form a **ring canal** along the mouth rim.
(10) There are 4 **comb plates** running whole length or upto half depending on species.
(11) Animal is voracious feeder, swallowing crustaceans and other ctenophores even larger than itself.

Identification : Besides thimble shape, specimen has all above characters, hence it is ***Beroe.***

Instructions : *Study in a comparative manner* ***Coeloplana, Ctenoplana, Tjalfiella and Beroe.***

PHYLUM PLATYHELMINTHES

Natural history

Helminths are the only group of animals having no extinct form and having successful genetic continuity of their population. The word 'parasite' is often added after 'Helminth' but vast animals belonging to this group are free-living. This group is further privileged to have the organs in the body for the first time and also are the first animals to have three germinal layers-ectoderm, mesoderm (mesenchyme) and endoderm. The group is divided into two phyla — Phylum Platyhelminthes and Phylum Nemathelminthes. The latter is included under Phylum Aschelminthes now.

Platyhelminthes are acoelomate, bilaterally symmetrical and dorsoventrally flattened. Their leaf shaped or ribbon shaped body has a high surface area to volume ratio with all regions of the body close to the surface. This allows for the supply of oxygen and the escape of metabolites for diffusion. Phylum Platyhelminthes is divided into 3 classes—Turbellaria, Trematoda and Cestoda. Turbellaria includes free-living flatworms (planarians). Trematodes comprise flukes which are ectoparasite and endoparasite and cestodes are completely endoparasite. Cestodes show best parasitic adaptations. Both trematodes and cestodes are responsible for various diseases in man and his animals.

Diagnostic characters

(1) Flatworms.
(2) Organ grade of organization.
(3) Acoelomate bilateria without definitive anus.
(4) Triploblastic (ectoderm, endoderm and mesoderm).
(5) Mesoderm gives rise to various organs such as excretory, reproductive, etc.
(6) Skeletal, circulatory and respiratory systems absent.
(7) Free-living, or parasitic causing various diseases.

Classification

CLASS I TURBELLARIA

1. Mostly free-living.
2. Body is covered with epidermis.
3. Mouth ventral.

Order 1 Acoela

1. Intestine absent. Mouth directly opens into mesenchyme.
2. Small marine turbellarians.
   Ex. *Convolula, Haplodiscus.*

Order 2 Rhabdocoela

1. Intestine sac-like.
2. Gonads, Yolk gland and protonephridia present.
   Ex. *Stenostomum, Catenula, Microstomum.*

Order 3 Alloeocoela

1. Intestine diverticulated.
2. Protonephridia paired.
   Ex. *Hofstenia, Plagiostomum.*

Order 4 Tricladida

1. Intestine contains 3 branches one anterior and two posterior.
2. Several protonephridia and nephridiopore.
3. Fresh-water, marine or terrestrial.
   Ex. *Dugesia, Planaria, Bipalium.*

Order 5 Polycladida

1. Intestine contains many branches.
2. Male and female gonopores separate.
   Ex. *Stylochus, Thysanozoon, Leptoplana.*

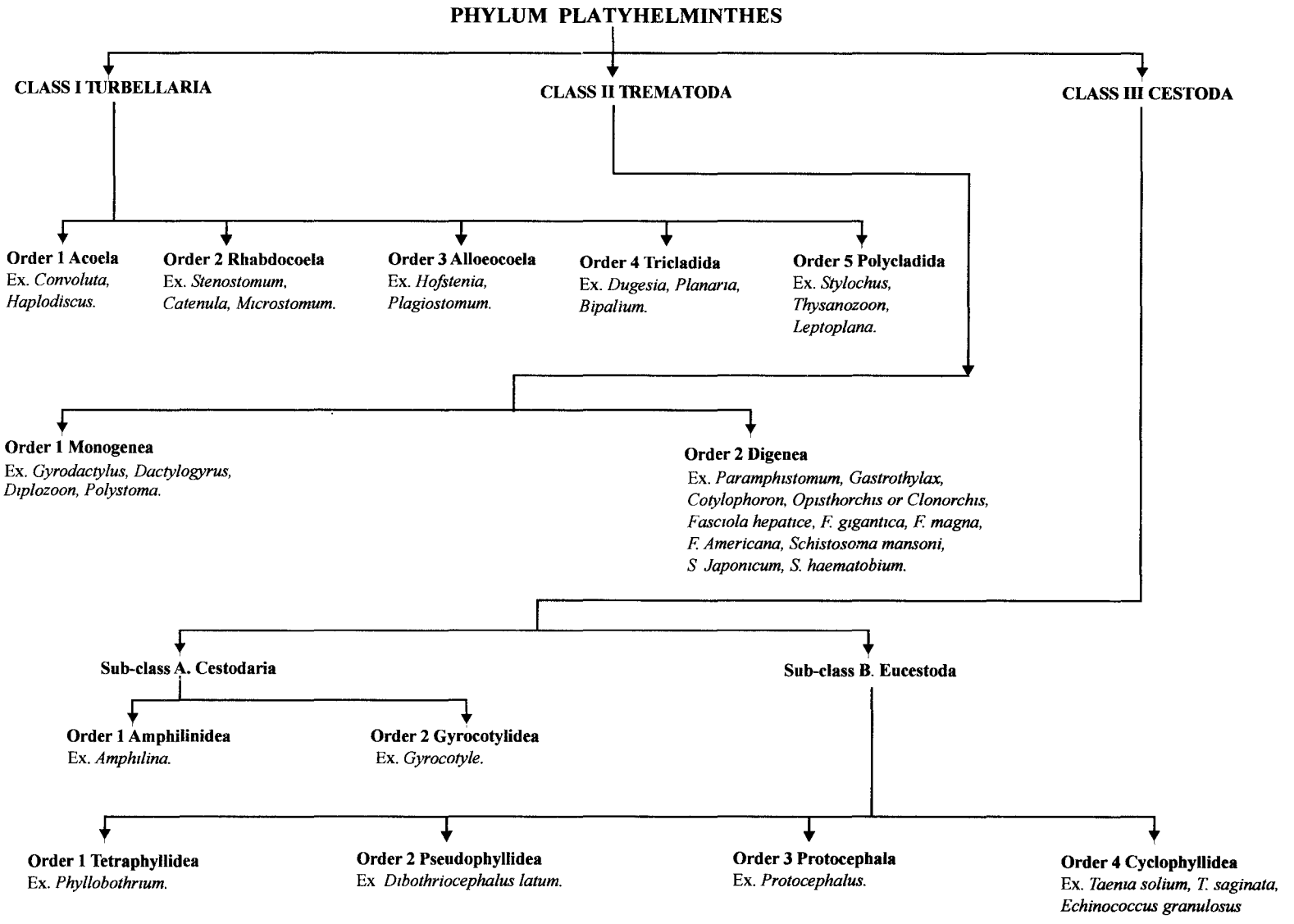
CLASS II TREMATODA

1. Commonly called as flukes.
2. Body dorsoventrally flattened and covered with tegument. (Old name cuticle no longer in use).
3. Ectoparasites or endoparasites. No free-living forms.
4. Life cycle monogenetic or digenetic with or without intermediate hosts.
5. Suckers for adhesion.

Order 1 Monogenea

1. Ecto or endoparasites or commensals.
2. Attachment organ is opisthapter.
3. No intermediate host in life cycle.

(Classification cont. on Page 62)


PHYLUM PLATYHELMINTHES
CLASS I TURBELLARIA
CLASS II TREMATODA
CLASS III CESTODA
Order 1 Acoela
Ex. Convoluta, Haplodiscus.
Order 2 Rhabdocoela
Ex. Stenostomum, Catenula, Microstomum.
Order 3 Alloeocoela
Ex. Hofstenia, Plagiostomum.
Order 4 Tricladida
Ex. Dugesia, Planaria, Bipalium.
Order 5 Polycladida
Ex. Stylochus, Thysanozoon, Leptoplana.
Order 1 Monogenea
Ex. Gyrodactylus, Dactylogyrus, Diplozoon, Polystoma.
Order 2 Digenea
Ex. Paramphistomum, Gastrothylax, Cotylophoron, Opisthorchis or Clonorchis, Fasciola hepatice, F. gigantica, F. magna, F. Americana, Schistosoma mansoni, S Japonicum, S. haematobium.
Sub-class A. Cestodaria
Sub-class B. Eucestoda
Order 1 Amphilinidea
Ex. Amphilina.
Order 2 Gyrocotylidea
Ex. Gyrocotyle.
Order 1 Tetraphyllidea
Ex. Phyllobothrium.
Order 2 Pseudophyllidea
Ex Dibothriocephalus latum.
Order 3 Protocephala
Ex. Protocephalus.
Order 4 Cyclophyllidea
Ex. Taenia solium, T. saginata, Echinococcus granulosus

Sub-order 1 Monopisthocotylea
1. Single opisthator.
2. Oral sucker absent or poorly developed.
   Ex. *Gyrodactylus, Dactylogyrus.*

Sub-order 2 Polyopisthocotylea
1. Opisthaptor contains many suckers.
2. Ecto or endoparasites.
   Ex. *Diplozoon, Polystoma.*

Order 2 Digenea
1. Endoparasitic flukes.
2. Life cycle is completed in two or more hosts hence digenetic.
3. Oral and ventral suckers present. Single excretory pore.

Family 1 Paramphistomidae
1. Acetabulum on posterior end.
2. Parasites of vertebrates.
   Ex. *Paramphistomum, Gastrothylax, Cotylophoron.*

Family 2 Opisthorchidae
1. Found in bile ducts of fish-eating mammals including man.
2. Eggs bulb-shaped.
   Ex. *Opisthorchis* or *Clonorchis.*

Family 3 Fasciolidae
1. Commonly called as liver flukes.
2. Internal organs branched.
   Ex. *Fasciola hepatica, F. gigantica, F. magna, F. americana.*

Family 4 Schistosomatidae
1. Commonly called as blood flukes.
2. Female is carried by male in its gynecophoric canal. Male female separate.
   Ex. *Schistosoma mansoni, S. japonicum* and *S. haematobium.*

CLASS III CESTODA
1. Commonly called as tape worms.
2. Body ribbon or tape like.
3. Exclusively endoparasites.
4. Body covered by tegument.
5. Intestine completely absent.
6. Body segmented and divided into scolex, neck and segments.
7. Vagina has evolved in females.

Sub-class A. Cestodaria
1. Undivided cestodes (Monozoic)
2. Larva has 10 hooks.
3. Scolex absent.

Order 1 Amphilinidea
1. Male pore and vagina posterior. No suckers.
2. Intestinal parasites of fishes.
   Ex. *Amphilina.*

Order 2 Gyrocotylidea
1. Anterior sucker present.
2. Uterus straight.
3. Endoparasites of fishes.
   Ex. *Gyrocotyle.*

Sub-class B. Eucestoda
1. Segmented Tapeworms (Polyzoic).
2. Larva has 6 hooks (hexacanth).

Order 1 Tetraphyllidea
1. Scolex with 4 ear-like bothridia.
2. Intestinal parasites of elasmobranch fishes.
   Ex. *Phyllobothrium.*

Order 2 Pseudophyllidea
1. Scolex with 2 bothria.
2. Intestinal parasites of fishes and vertebrates.
   Ex. *Dibothriocephalus latum.*

Order 3 Protocephala
1. Scolex with 4 cup-shaped suckers.
2. Intestinal parasites of fish and amphibians.
   Ex. *Protocephalus.*

Order 4 Cyclophyllidea or Taenioidea
1. True suckers.
2. Single or double set of genital organs.
3. Intestinal parasites of birds and mammals.
   Ex. *Taenia solium, Taenia saginata, Moniezia expansa, Echinococcus granulosum.*

72. *Dugesia* : Planaria

Classification :

Phylum.....Platyhelminthes	→	Organ grade, acoelomate flatworms.
Class.....Turbellaria	→	Epidermis is partly ciliated containing rhabdites.
Order.....Tricladida	→	Intestine (clad) has three branches.
Family.....Planariidae	→	Adhesive organs absent. Head triangular and truncated.
Genus.....*Dugesia*		

Habit and habitat : ***Dugesia*** is a fresh water, triclad found in streams, springs, ponds, lakes and caves, gliding over stones and debris by the side of the pond or on the bottom (Fig. 72).

Distribution : Cosmopolitan, commonly found in temperate zones, U.S.A., India and U.K.

Comments :

(1) **Commonly** known as **Planaria.**

(2) Dark brown elongated cylindrical animal measuring approximately 15 mm in length.

(3) Body differentiated into **dorsal** and **ventral** surfaces. Ventral surface contains **adhesive** and **ciliated** zones.
(4) Anterior region is called as **head.**
(5) Head is triangular containing 2 ear like **auricles** on side and 2 **semicircular ocelli.**
(6) Body tapers posteriorly as a pointed end.
(7) Digestive system, consists of **mouth, proboscis, oesophagus** and **intestine.**
(8) Intestine is peculiar having three branches, one extending upwards and two backwards and hence the name Tricladida
(9) Mouth encircled by **proboscis pore.** Proboscis is highly muscular and lies in a **proboscis sheath** and is everted through the proboscis pore.
(10) **Gonopore** lies behind proboscis pore. It reproduces **sexually** and **asexually.**

Identification : Since the specimen contains auricles, eyes and all above characters and hence it is ***Dugesia.***

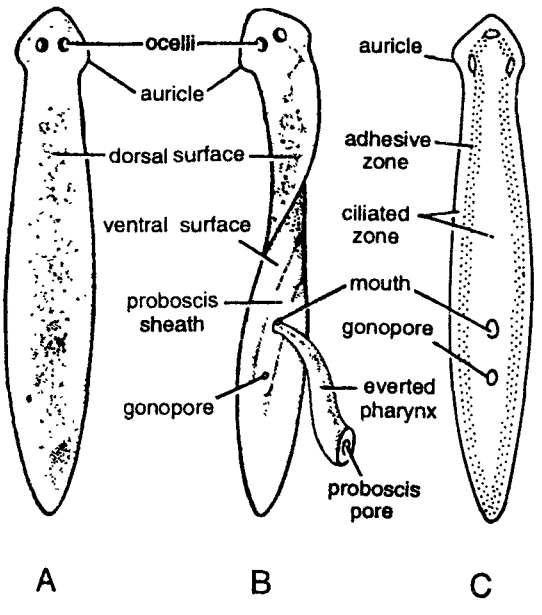


Fig. 72. *Dugesia.* **A.** Dorsal view. **B.** Dorsoventral view. **C.** Ventral view.

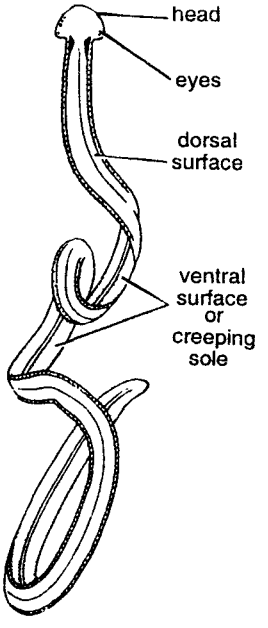


Fig. 73. *Bipalium.*

73. *Bipalium*

Classification :

Phylum.....Platyhelminthes
Class.....Turbellaria
Order.....Tricladida → Characters same as in *Dugesia.*
Family.....Bipaliidae → Expanded lunate head with several eyes.
Genus.....*Bipalium*

Habit and habitat : ***Bipalium*** is a large terrestrial triclad inhabiting the humid soil on the floor of the tropical jungles (Fig. 73).

Distribution : It has cosmopolitan distribution chiefly found in green houses and outdoor regions in Florida, Louisiana and California. It is also found in temperate and tropical countries.

Comments :

(1) It is one of the **largest land planarians** measuring 20 to 50 cm in length. It was discovered in the green houses of the knew gardens in U.K. by Moseley (1878). *(Z–20)*

(2) Animal consists of an expanded lunate **head** and **cylindrical** long body.
(3) Numerous **eyes** are present on the margin of the head and sides of the body.
(4) Purple, black, yellow, olive and grey coloured stripes are very distinct near the neck.
(5) Body remains twisted.
(6) This **Planaria** has **stripes** over the dorsal surface also and a creeping sole on the ventral surface.
(7) Reproduction generally **asexual**. It never becomes sexual in temperate climate and it propagates by fragmentation.
(8) ***Bipalium adventium*** breeds **sexually**.
(9) If subjected to desiccation, it recovers water loss, provided the loss does not exceed 45% of its weight.

Identification : Since the specimen contains a **semi-circular head** and all above features, hence it is ***Bipalium***.

74. *Fasciola hepatica* : Sheep Flukeworm

Classification :

Phylum.....Platyhelminthes	→	Organ grade, acoelomate, bilateral flatworms.
Class.....Trematoda	→	Flukes, endo- or ectoparasites.
Order.....Digenea	→	Two suckers, one or more intermediate hosts.
Family.....Fasciolidae	→	Internal organs branched.
Genus.....*Fasciola*		
Species.....*hepatica*		

Habit and habitat : ***Fasciola hepatica*** is found in the **bile ducts** of **liver** and biliary passages of sheep, ox, horse, dog, elephant, man, monkey, deer and kangaroo. In sites they are seen protruding through bile ducts and liver substance.

Distribution : It has cosmopolitan distribution throughout sheep-raising areas. In U.S.A. and India it is **endemic**. Human Fascioliasis has been reported from Venezuela, Syria, China, Cuba, Argentina, U.S.S.R., Hungary, Rumania and France.

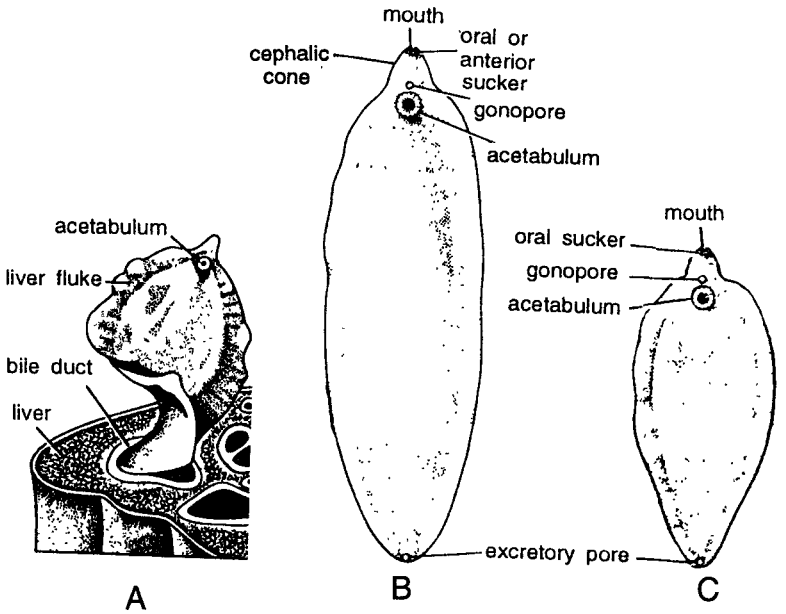


Fig. 74. A. *Fasciola gigantica in situ*, **B.** *Fasciola gigantica*, **C.** *Fasciola hepatica.*

Comments :

(1) **Commonly** known as **sheep liver fluke.**
(2) It is a **polyxenous** and **pathogenic parasite.**
(3) Body is leaf-like, dorsoventrally flattened measuring 18 to 51 mm in length and 4 to 15 mm in breadth. ***Fasciola gigantica*** is larger than ***F. hepatica.***
(4) Anterior end is produced into a conical projection called **cephalic cone.**
(5) There is a small ventrally-placed **mouth** at the anterior extremity, surrounded by **oral sucker.**
(6) In both ***F. gigantica*** and ***F. hepatica***, a little behind the **mouth** and **oral sucker** is an adhesive **acetabulum** or ventral sucker. Between oral sucker and ventral sucker is **gonopore. Excretory pore** is found at posterior extremity.
(7) Life-cycle involves two hosts. Sheep as **definitive** host and ***Limnea*** as **intermediate** host. Life-cycle stages include **zygote, Miracidium** larva, **Sporocyst** larva, **Redia** larva, **Cercaria** larva and encysted **Metacercaria. Metacercaria** after ingestion by sheep changes into adult parasite inside the host.

Special features : The **liver fluke** causes **anaemia, eosinophilia, diarrhoea, dysentery, ulcers, pain, bottle-jaw disease** and **liver rot** in sheep. The **yield** of **wool, leather** and **meat** is greatly **reduced** in infested sheeps causing great loss to animal products industry. It also causes metabolic disturbances in the host.

Preventive measures : The snails in the pond should be collected and destroyed if they are contaminated. The water vegetation near the pond regularly examined for encysted metacercariae. Sheep and goat should not be allowed to graze on such contaminated vegetation and thus infection of liver fluke can be avoided by them.

Identification : Since the specimen contains cephalic cone, acetabulum and all above characters and hence it is ***F. hepatica.***

75. *Taenia solium* : Pork Tapeworm

Classification :

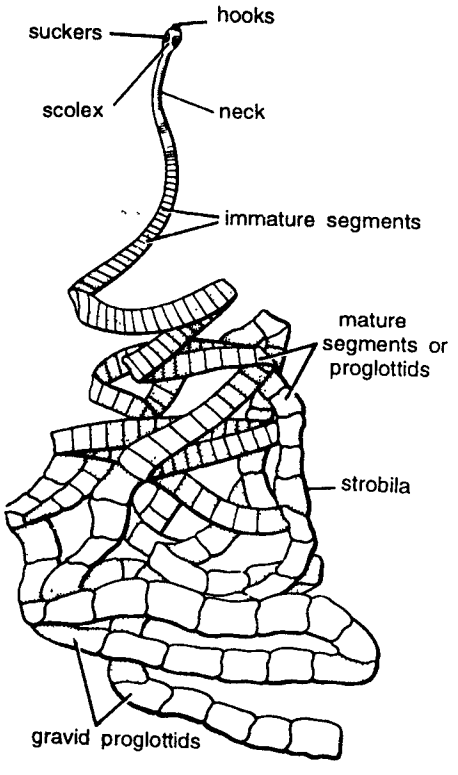
Phylum.....Platyhelminthes	→	Organ grade, acoelomate, bilateral flatworms.
Class.....Cestoda	→	Segmented tapeworms without digestive tube.
Sub-class.....Eucestoda	→	Mesozoic tapeworms, larva with 6 hooks.
Order.....Cyclophyllidea	→	Scolex with four suckers.
Family.....Taeniidae	→	Uterus with lateral branches.
Genus.....*Taenia*		
Species.....*solium*		

Habit and habitat : ***Taenia solium*** is found in the intestine of man. The scolex lies buried in the intestinal mucosa (Fig. 75).

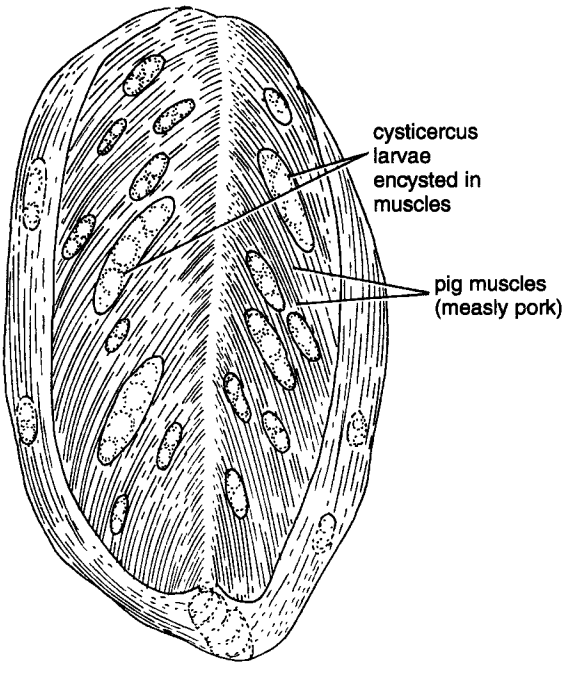
Distribution : The tapeworm is found endemic in the pork consuming areas. Its infection is abundant in India, China, Czechoslovakia, Yogoslavia and Germany.

Comments :

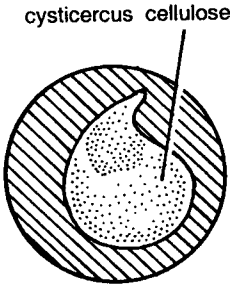
(1) **Commonly** called as **Pork tapeworm.**
(2) Body divided into **scolex, neck, immature, mature** and **gravid** segments.
(3) **Scolex** serves as hold-fast organ. It contains 4 **suckers** and a rounded **rostellum.** Suckers contain radial muscles.
(4) **Rostellum** at its base contains double row of 28 to 32 hooks.
(5) Neck region is area of proliferation.
(6) **Mature segment** contains well developed **hermaphrodite** genital organs. **Gravid** segments contain branched uterus filled with **onchospheres.**
(7) Life-cycle includes two hosts (i) **man** as definitive host and (ii) **pig** as intermediate host. **Longitudinal** and **transverse excretory canals** are seen in all segments.



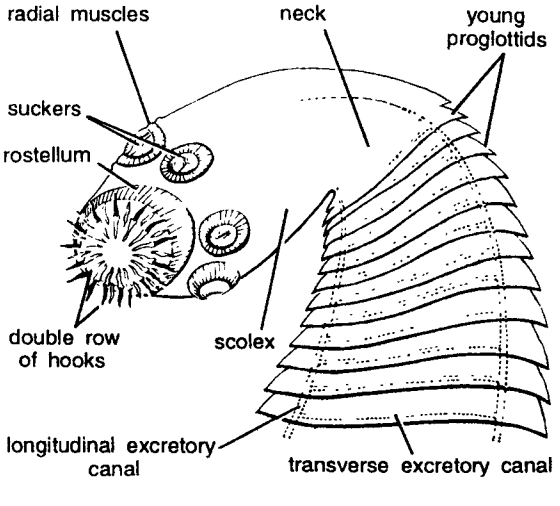
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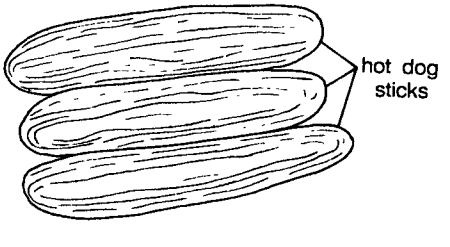
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D



B



E

Fig. 75. *Taenia solium.* **A.** Entire, **B.** Scolex with neck greatly enlarged, **C.** Measly pork. **D.** *Cysticercus cellulose,* **E.** Hotdog.

(8) In villages man deficates in the open field. Pig eats contaminated human faeces containing **onchospheres** and becomes infected.
(9) Onchospheres or hexacanth larvae develop into **Cysticerous larvae or bladder worm** called as **Cysticercus cellulose**, which encyst in thigh, chest, shoulder muscles of the pig. Such muscle is called as **Measly pork.**
(10) When man eats inadequately cooked **hot dog** or **measly pork**, it becomes infected and ***Taenia solium*** develops into adult in the intestine.

Special features : It causes various diseases in man like **anaemia, secondary anaemia, eosinophilia, diarrhoea, haemorrhage, abdominal pain, nausea** and **insomnia**, etc. Upto 13% **eosinophilia** is caused by it. It also causes metabolic disturbances in the host.

Preventive measures : The hot dogs are very common in affluent. Eating of measly pork should be avoided. The pig flesh should be examined for bladder cysts and contaminated flesh should not be allowed for marketing. Inadequately cooked pork should not be allowed and thus infection of Taeniasis can be prevented.

Identification : Since the specimen contains scolex, neck and squarish segments and all above features and hence it is ***Taenia solium***.

76. *Taenia saginata* : Beef Tapeworm

Classification : Same as that of ***T. solium***.

Genus.....***Taenia***
Species.....***saginata***

Habit and habitat : ***T. saginata*** is found in the posterior coils of the intestine (Fig. 76).

Distribution : Same as that of ***T. solium*** and is very common in the beef consuming areas.

Comments :

(1) **Commonly** called as **Beef tape-worm.**
(2) Preserved specimen is whitish in colour and is divided into **scolex, neck** and **segments** or **strobila.**
(3) **Strobila** is dorsoventrally flattened.
(4) **Scolex** contains 4 **suckers.**
(5) **Rostellum** and hooks are absent.
(6) **Segments** are about 1000 in number measuring about 4 to 6 meters.
(7) Segments are of 4 kinds–**immature, mature, gravid** and **malformed.**
(8) Life history includes **man** as **definitive host and buffalo** as **intermediate host.**
(9) Man acquires infection by eating raw and inadequately cooked beef mutton containing **cysticercous** larvae. Buffalo gets infection while grazing on contaminated grasses polluted by human faeces having eggs of ***T. saginata***.

Special features : Infestation of ***Taenia saginata*** causes diarrhoea, dysentery, anaemia, secondary anaemia, eosinophilia, abdominal pain, intestinal pain, haemorrhage, appendicitis and destruction of mucous membrane.

Preventive measures : The infection of ***Taenia saginata*** can be avoided by not eating contaminated beef.

Identification : Since the specimen contains elongated gravid segments and all above features and hence it is ***Taenia saginata***.

Instructions : *Make comparative points between **Fasciola** and **Taenia** and also note various parasitic modifications in them.*

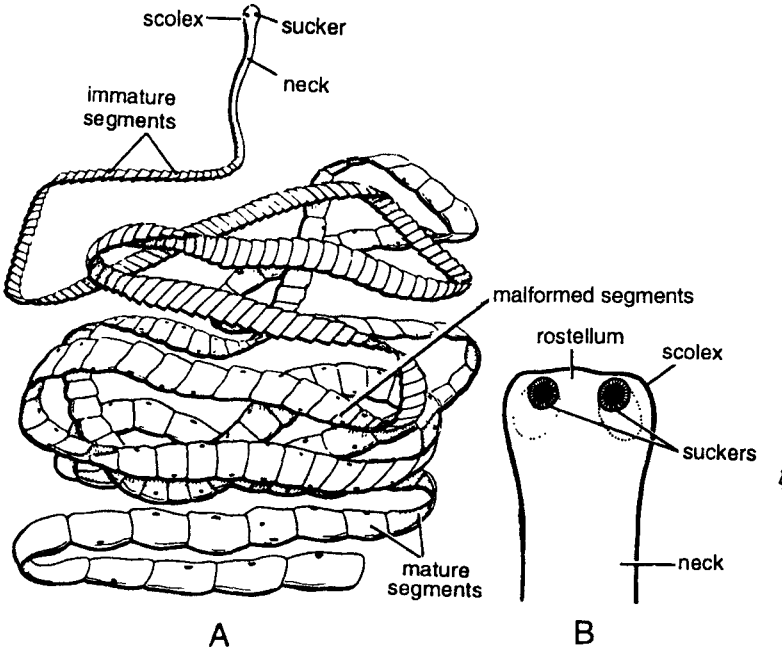


Fig. 76. *Taenia saginata.* **A.** Entire, **B.** Scolex with neck greatly enlarged.

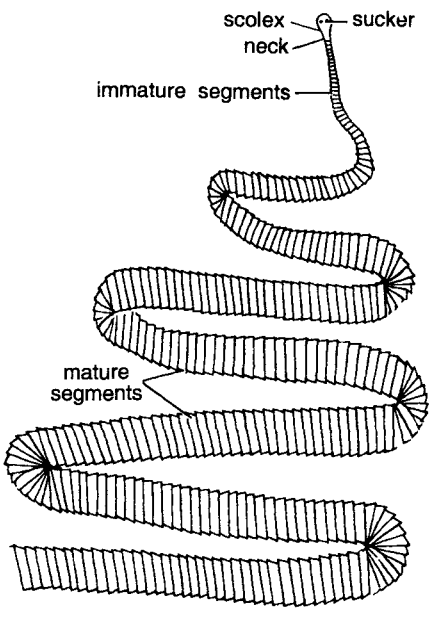


Fig. 77. *Moniezia expansa.*

77. *Moniezia expansa* : Sheep Tapeworm

Classification : Same as that of ***Taenia solium***.

Genus.....***Moniezia***

Species.....***expansa***

Habit and habitat : Commonly found in the small intestine of sheep. Generally 80% sheep are found to be infected by this worm (Fig. 77).

Distribution : All over the world in sheep raising areas.

Comments :

(1) **Commonly** called as **Sheep tapeworms**.

(2) Body divisible into **scolex**, **neck** and **segments**. Tapeworms measure approximately 600 cm.

(3) **Scolex** is adhesive organ and contains **suckers**.

(4) **Neck** is short area for forming new segments.

(5) Segments are much broader than long and contain interproglottidal glands.

(6) Each **mature** segment contains double set of genital organs.

(7) Life-cycle, includes egg cysticercoid in mites (intermediate host) and adults in sheep. Sheep becomes infested when it grazes grasses containing contaminated mites.

(8) ***Moniezia expansa*** causes various histopathological changes in the intestinal mucosa resulting into diarrhoea, dysentry and malabsorption.

Identification : Since the Tapeworm contains, much broader segments than long and all above features and hence it is ***Moniezia expansa***.

PHYLUM ASCHELMINTHES

Aschelminthes include groups of different animals such as Rotifera, Gastrotricha, Kinorhyncha, Nemertinia, Nematomorpha and Nematoda. Nematodes are also included under class Nematoda or Phylum Nemathelminthes.

Diagnostic characters

(1) Commonly called as Round worms.
(2) Body covered with cuticle.
(3) Radial or radiobilateral symmetry.
(4) Sexes separate.
(5) Pseudocoelomate and unsegmented.
(6) Free living, plant parasitic or animal parasitic.
(7) Parasitic nematodes cause various diseases in plants, man and his animals.

Classification

Order 1 Enoploida
1. Free living marine nematodes.
2. Cuticle bears bristles. Amphids present.
   Ex. *Enoplus.*

Order 2 Dorylamoidea
1. Ectophyto nematodes, soil and fresh-water nematodes.
2. Amphids present.
   Ex. *Xiphinema, Dorylaimus.*

Order 3 Rhabditoidea
1. Free living (soil) or parasitic.
2. Pharynx rhabditiform.
   Ex. *Rhabditis, Strongyloides stercoralis, S. papillosus.*

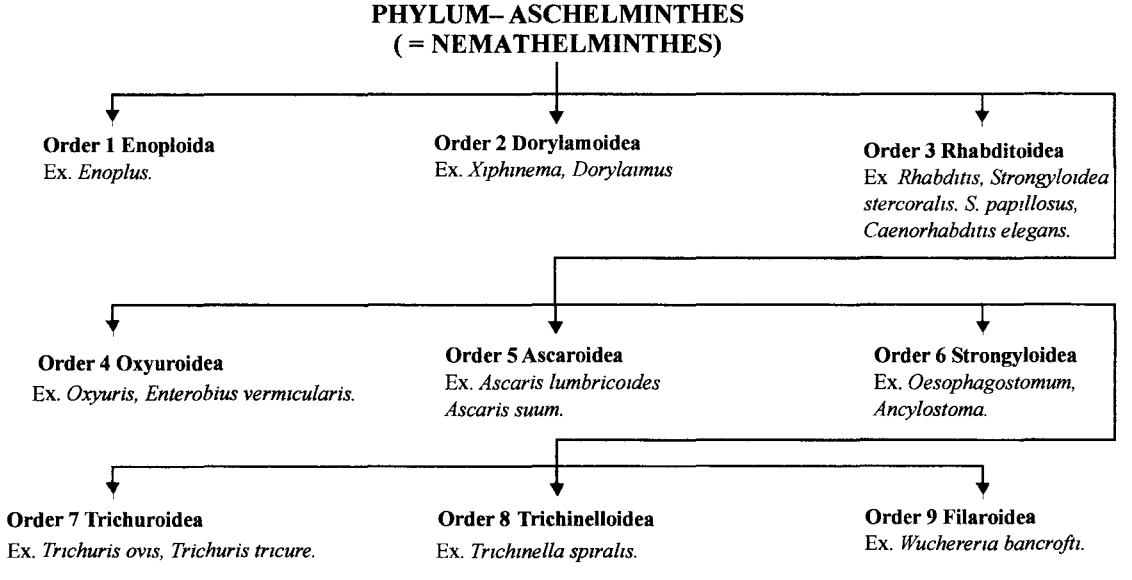
Order 4 Oxyuroidea
1. Small worms.
2. Pharynx contains bulb.
   Ex. *Oxyuris, Enterobius vermicularis.*

Order 5 Ascaroidea
1. Large round worms.
2. Pharynx cylindrical, mouth with 3 lips.
   Ex. *Ascaris Strungyloider* (man) *A. suum* (pig).

Order 6 Strongyloidea
1. Small to moderate size.
2. Presence of copulatory bursa.
   Ex. *Oesophagostomum, Ancylostoma.*

Order 7 Trichuroidea or Trichinelloidea
1. Whip worms.
2. Pharynx contains stichosomes.
   Ex. *Trichuris trichura, Trichuris ovis, Trichinella spiralis.*

Order 8 Filaroidea
1. Filarial worms causing elephantiasis.
2. Pharynx muscular and glandular.
   Ex. *Wuchereria bancrofti.*



78. *Ascaris lumbricoides*

Classification :

Phylum.....Aschelminthes	→	Pseudocoelomate, unsegmented, unisexual nematodes.
Class.....Nematoda	→	Round worms.
Order.....Ascaroidea	→	Buccal capsule absent, mouth with three lips.
Genus.....*Ascaris*		
Species.....*lumbricoides*		

Habit and habitat : ***Ascaris lumbricoides*** is found in the intestine of man and the pig. Both forms are morphologically identical having two different physiological strains. The infective eggs from man's ***Ascaris*** will not develop into the pig and similarly infective eggs obtained from the pig ***Ascaris*** will not develop into the man. However, the two specimens are called as ***Ascaris lumbricoides*** variety ***A. humanis*** (found in man) and ***A. lumbricoides*** (*suum* found in pig).

Distribution : It is one of the most common nematodes found in all parts of the world especially in India, China, Philippines, Korea and Pacific Islands.

Comments :

(1) **Commonly** known as **Round worm**. It causes ascariasis in man especially in children. Infection occurs by eating raw and uncooked vegetables.
(2) Shows sexual dimorphism with separate male and female individuals. **Males** measure 15 to 30 cm in length and **female** 20 to 35 cm.
(3) Tail end of male is ventrally **curved** containing **cloacal** aperture, through which two **equal isospicules** project.
(4) Tail end of female is bluntly pointed. Female genital opening or **vulva** found in anterior one third region.
(5) Anterior ends exhibit same structures in both male and female.
(6) **Mouth** is situated at the anterior extremity which is guarded by **one dorsal** and two **sub-ventral lips**.
(7) **Amphids** are found in the sub-ventral lips.

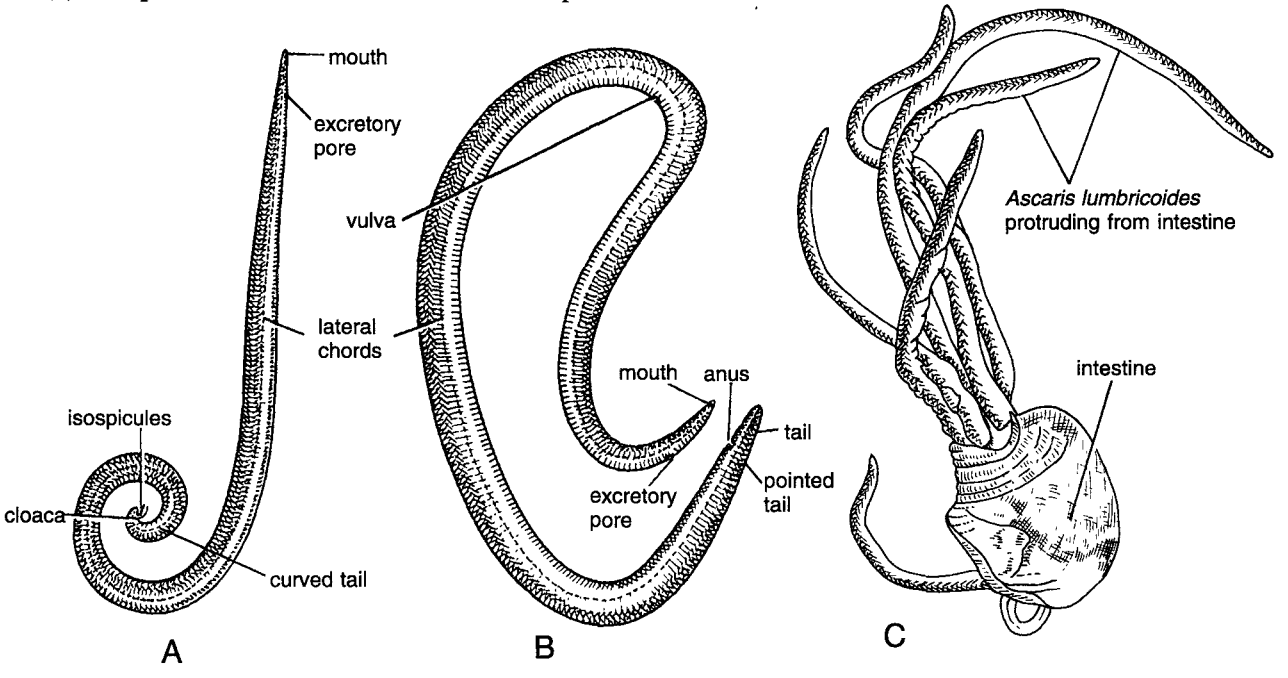


Fig. 78. *Ascaris lumbricoides.* **A.** Male, **B.** Female, **C.** *In situ.*

(8) Body is elongated and cylindrical.
(9) **Two lateral, one mid-dorsal** and **one mid-ventral** longitudinal **chords** extent from anterior to posterior end. **Excretory pore** lies at a distance of about 2 mm from anterior end.
(10) No intermediate host in life history.

Special features : Pathogenic nematode parasite causing **haemorrhage, haemoptysis, appendicitis, peritonitis, tumour, ulcer, diarrhoea, eosinophilia** and death. Its infection can be avoided by not eating raw and uncooked vegetables especially grown on human night soil fertilizer. ***Ascaris*** infection also causes disturbances in the nucleic acid, sugar, protein and fat metabolism of the host. Sometimes intestinal human is blocked by several parasites.

Prevention : Avoid eating raw unwashed and inadequately cooked vegetables and food. Contaminated water should not be taken.

Identification : Since the animal has unsegmented cylindrical body, curved tail in male, pointed tail in female and hence it is *A. **lumbricoides***.

Instructions : *Compare male* and *female **Ascaris***.

PHYLUM ANNELIDA

Natural history

Annelids are truly coelomate animals with metameric segmentation. Capacious coelom and its divisions by septa into separate water tight compartments gives much greater control in the use of the **hydrostatic** skeleton so that changes in shape, shortening, lengthening or bending can be achieved in one segment without unduly influencing the adjacent segments. Phylum includes primitive Archiannelids, Polychaetes and Oligochaetes. Primitive annelids are marine forms which might have given rise to polychaetes and oligochaetes separately. Polychaetes are polyphylectic. Polychaetes represent one line of evolution while Oligochaetes and their related forms second line of evolution. Echiuroids, sipunculids, priapulids and myzostomaria listed as classes of annelids are considered as independent phyla. However the fundamental pattern evolved in Annelids (coelom and segmentation) continue up to man.

Diagnostic characters

(1) Segmented and coelomate animals.
(2) Segmentation metameric.
(3) Closed circulation.
(4) Excretory organs metanephridia.
(5) Exoskeleton absent.
(6) Fresh-water, marine, terrestrial, burrowing or tubicolours.

Classification

CLASS I POLYCHAETA
1. Many setae or hair in each segment.
2. Clitellum absent.
3. Larva trochophore.

Order 1 Errantia
1. Free moving or swimming.
2. Locomotary organs parapodia.
   Ex. *Nereis, Heteronereis, Aphrodite, Polynoe, Eunice, Syllis, Glycera, Tomopteris.*

Order 2 Tubicola
1. Tubicolous animals.
2. Segments greatly modified.
   Ex. *Chaetopterus, Sabella, Parasabella.*

Order 3 Sedentaria
1. Sedentary animals.
2. Body divided into different regions.
   Ex. *Arenicola, Amphitrite, Terebella, Serpula, spirorbis, Sternaspis.*

CLASS II OLIGOCHAETA
1. Few setae in each segment.
2. Citellum present.

Order 1 Archioligochaeta
1. Primitive forms.
2. Small and fresh-water.
   Ex. *Aelosoma, Tubife, Nais, Dero..*

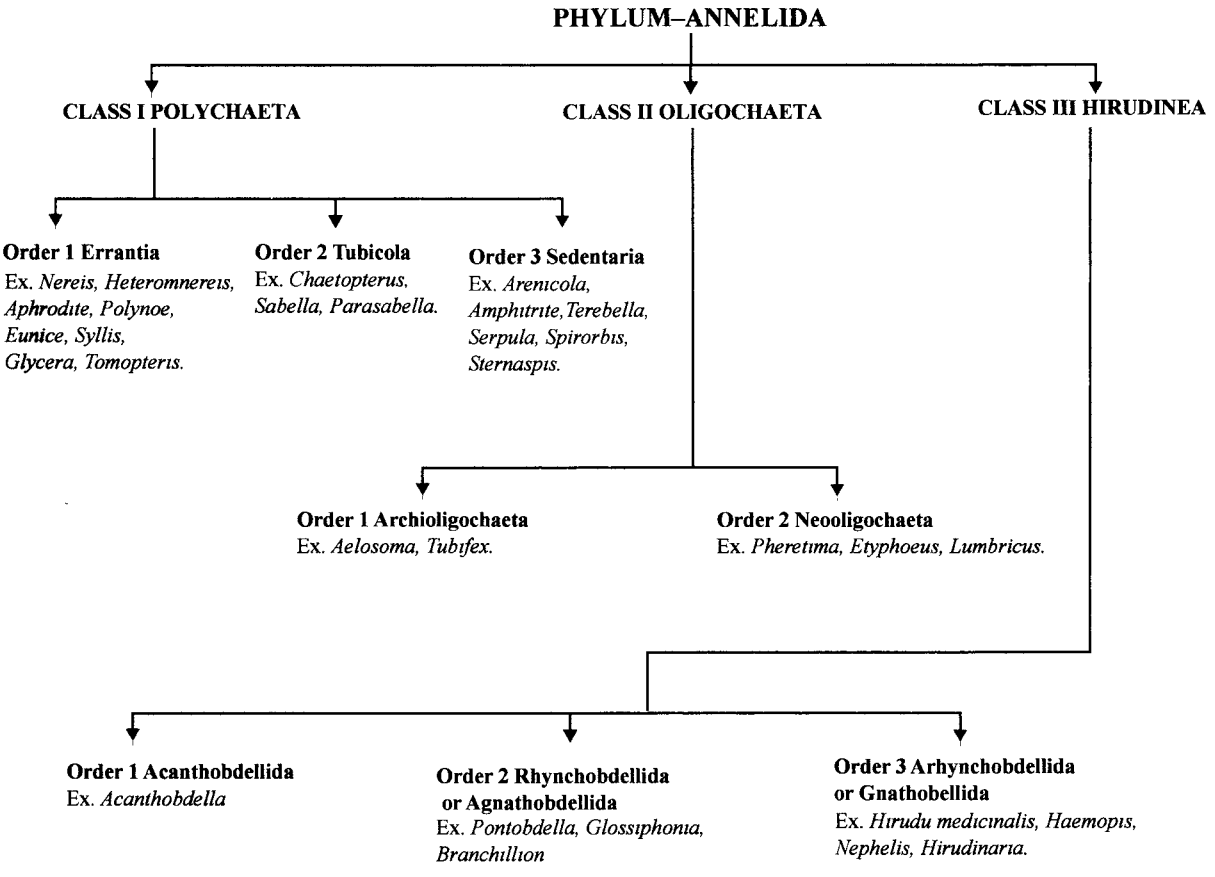
Order 2 Neooligochaeta
1. Modern earthworms.
2. Terrestrial and burrowing.
   Ex. *Pheretima, Etyphoeus, Lumbricus.*

CLASS III HIRUDINEA
1. It includes leeches.
2. Anterior and posterior suckers present. Parapodia absent.
3. Only external segmentation.

Order 1 Acanthobdellida
1. Primitive leeches.
2. Coelom with compartments.
3. Anterior sucker absent.
   Ex. *Acanthobdella.*

Order 2 Rhynchobdellida or Agnathobdellida
1. Ectoparasitic aquatic leeches.
2. Anterior sucker absent.
   Ex. *Pontobdella, Glossiphonia, Branchillion.*

Order 3 Arhynchobdellida or Gnathobellida
1. Ectoparasitic blood sucking leeches.
2. Both anterior and posterior suckers present.
   Ex. *Hirudu medicinalis, Haemopis, Nephelis, Hirudinaria.*



79. *Nereis*

Classification :

Phylum.....Annelida → Metamerically segmented, coelomate and laterally symmetrical.

Class.....Polychaeta → Many setae, clitellum absent.

Order.....Errantia → Free-swimming or burrowing, pharynx protrusible, provided with jaws and teeth.

Genus.....*Nereis* (Rag worm or Clam worm)

Habit and habitat : ***Nereis*** is a marine crawling type, living in temporary burrows in sand, 200 meters deep. They are free-living, predaceous, nocturnal, carnivorous, often found buried in the intertidal sad.

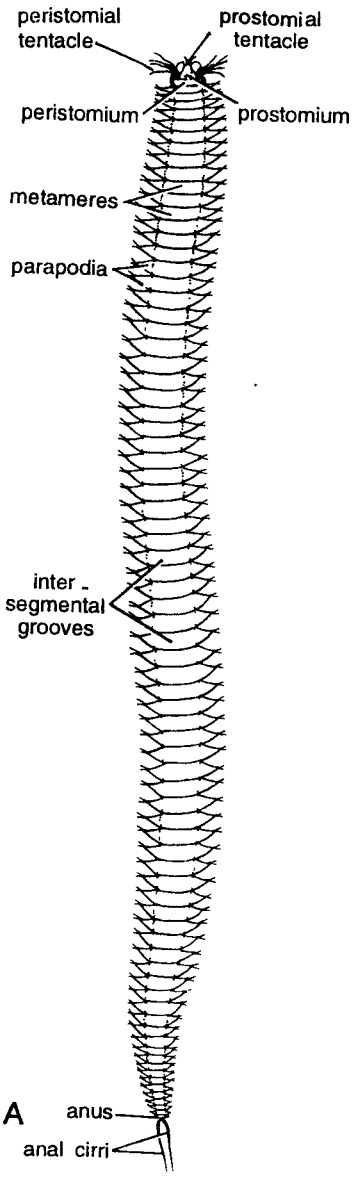
Distribution : It has cosmopolitan distribution found along the North Atlantic coast, Pacific coast, U.S.A. and Europe (Fig. 79).

Comments :

(1) **Commonly** called as **Rag worm** or **Clam worm** and is the simplest annelid.

(2) Examination of preserved specimen shows cylindrical and elongated body form which is divided into similar **metameres** or segments about 200 in number.

(3) First few segments fuse to form head which is composed of (i) **prostomium** or preoral lobe, which carries **prostomial tentacles, palps** and **ocelli;** and (ii) **peristomium** (2 segments fused), which carries antero-laterally 4 pairs of **peristomial tentacles**.



(4) Mouth is found on the anterior surface of the peristomium.
(5) Body segments, except head and anal segment, contain each pair of locomotory **parapodia.**
(6) Segments are also called as **metameres** and between two segments in **intersegmental groove.**
(7) Parapodia also serve as respiratory and circulatory organs. Each parapodium is composed of dorsal **notopodium** and ventral **neuropodium.** Parapodium also possesses aciculum for support and needle like setae for crawling.
(8) Anal segment contains a pair or **anal cirri.**
(9) ***Nereis*** is dioecious, although male and female worms can hardly be recognized.

Identification : Since the animal has prostomium, peristomium, parapodium and all above features and hence it is ***Nereis***.

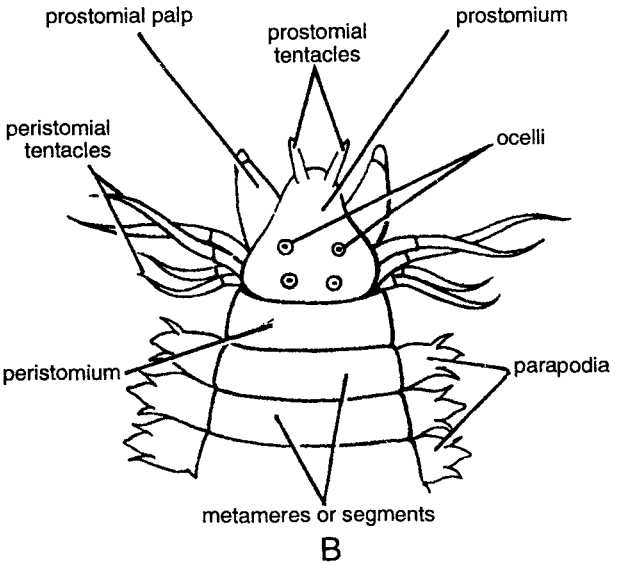


Fig. 79. **A.** *Nereis.* Entire, **B.** *Nereis.* Head magnified.

80. *Heteronereis*

Classification : Same as that of ***Nereis***.

Genus.....*Heteronereis*

Habit and habitat : ***Heteronereis*** is a free-swimming worm found in sea (Fig. 80).

Distribution : Same as that of ***Nereis***.

Comments :

(1) Malmsgren identified that ***Heteronereis*** is the **sexual phase** of ***Nereis*** in which marked modifications occur in the posterior segments of the body which contain gonads.

(2) During breeding season, clam worm leaves its tube and becomes free-swimming.
(3) Body is differentiated into asexual anterior **atoke** and a posterior sexual **epitoke** which contains gametes.
(4) Epitoke or posterior part becomes morphologically modified as the **parapodia** for become swimming.
(5) Parapodia of ***Heteronereis*** contain additional foliaceous lobes and setae become **oar-like**. The **notopodium** and **neuropodium** become large leaf-like and act as **fins** and **gills**.
(6) **Peristomial cirri** become large. Special sensory papillae develop on anal segment.
(7) Prostomium contains **prostomial tentacle**, **prostomial ocelli** and **prostomial palp**. Peristomium contains **peristomial** tentacles.
(8) Muscles and alimentary canal are reduced or become degenerated due to large development of gonads.
(9) There is no marked sexual dimorphism in both sexes but the females tend to become orange or **reddish**.

Special features : ***Heteronereis*** has **swarming habit**. They swim to the surface of the sea water to shed the sperm or ova. Swarming occurs in the night and in some species they perform nuptial dance. ***Heteronereis*** dies after spawning. The development includes **trochophore** larva which metamorphoses into the adult.

Identification : Since the animal has epitoke, atoke and all above features and hence, it is ***Heteronereis***.

Instructions : *Compare and contrast* ***Nereis*** *with* ***Heteronereis***. *Observe various changes in* ***Heteronereis***.

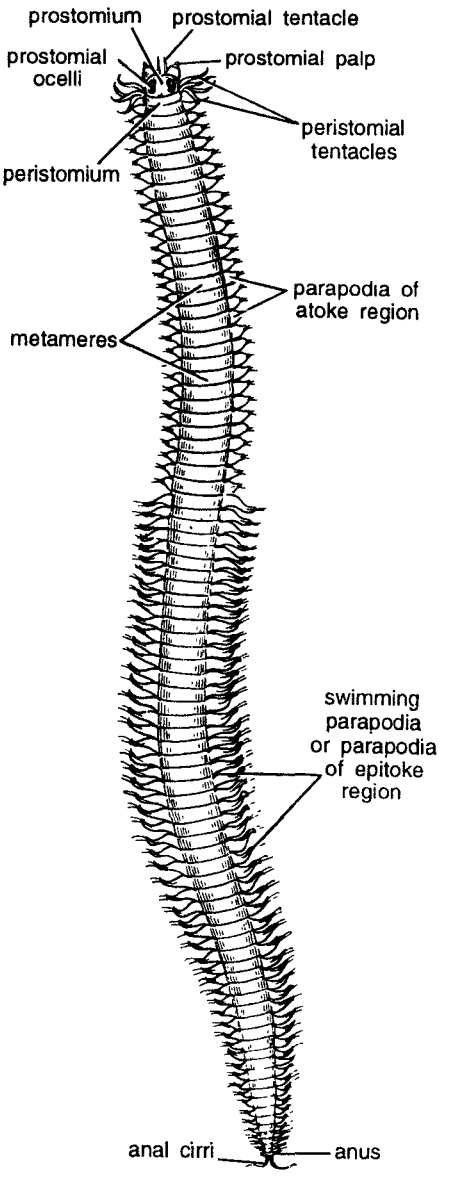


Fig. 80. *Heteronereis.* Entire.

81. *Polynoe*

Classification : Same as that of ***Nereis***.

Genus.....*Polynoe*

Distribution : It is found in Europe and U.S.A. (South Carolina to Massachusetts).

Habit and habitat : ***Polyone*** is a bioluminescent, carnivore, marine, errant polychaete, hidden under stones near tide lines.

Comments :

(1) It is an allied form of ***Aphrodite*** consisting of a short body with parallel sides. The body shows considerable degree of dorso-ventral compression.
(2) Anterior end is distinguished into **head**, which bears three **tentacles**.
(3) **Pharynx** is protrusible containing teeth at protruded end. They eat one another.
(4) Some posterior parapodia bear setae.
(5) Certain parapodia instead of cirri bear broad, flattened and **scale-like elytra**, which constitute protective covering to the back.
(6) Elytra do not contain setae and have rich nerve supply.
(7) Elytra are **bioluminescent** and the illuminating elytra are easily cast off when disturbed or elytra are shed off to deceive the enemy.

(8) Utility of the casting off of elytra is not known but throwing of it frequently may be to deceive the enemies. This is protective device.
(9) Fertilized ova and embryos adhere to masses under each elytra.

Identification : Since the animal contains elytra without setae and all above features and hence it is ***Polynoe***.

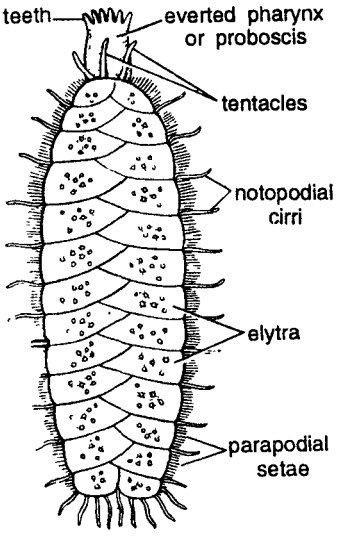


Fig. 81. *Polynoe.*

82. *Eunice*

Classification : Same as that of ***Nereis***.
Genus.....*Eunice*

Habit and habitat : ***Eunice*** is a marine polychaete annelid famous for its **swarming** habits within three days of the fall of the July moon. ***Eunice viridis*** is the peculiar epitoke palolo worm of Samoa and Fiji Islands; swarms in October and November.

Distribution : It is found in West Indies, Gulf of Mexico, Atlantic and Pacific oceans, Samoa and Fiji Island. The worm lives in the cracks and crevices of coral rocks throughout the year, except when swarming.

Comments :

(1) **Commonly** called as **palolo worm**. The body of the animal is differentiated into anterior sexless **atoke** and posterior sexual part, the **epitoke**.
(2) Pigmentation is brownish or yellowish.
(3) Fully mature, gonad-laden epitokes project from the burrow, detach from atokes and swim independently on the surface of the sea, while the atokes regenerate new epitokes.
(4) Body elongated with numerous segments; **peristomium** consists of two segments with 1 pair of cirri, 5 tentacles and a large palp.
(5) **Gills** begin on sixth segments.
(6) During swarming, the ocean becomes full of these frenzied creatures, swimming at high speed with intense agitation.
(7) After spawning, the epitokes sink to bottom.

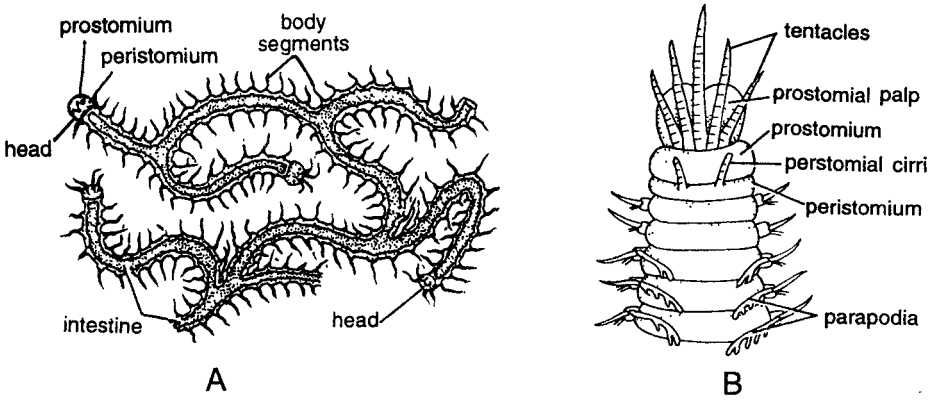


Fig. 82. *Eunice* **A.** Entire worms, **B.** Anterior end.

(8) In some localities the ova and sperms are in such enormous number that the surface of the sea turns into a thick soup.

Special features : Palolo worm exhibits remarkable example of **periodic reproduction**. Over 90% of the population breeds within a single two-hour period of the entire year. The major swarm occurs in November during last quarter of moon when the low tide is unusually low. On the night of breeding posterior half twists counterclockwise, breaks, comes to surface, bursts, sheds sperms and ova and disintegrates. The local population collects them by netting and make into thick soup which tastes like spinach. The natives can predict when palolo would swarm and watch the sea daily.

Identification : Since the animal has one-fourth body atoke, three-fourth epitoke and all above features and hence it is ***Eunice***.

83. *Syllis*

Classification : Same as that of ***Nereis***.

Genus.....*Syllis*

Habit and habitat : ***Syllis*** is marine polycheate, known for its **transverse fission** and abundant in clear, shallow water among hydroids, mussels, tunicates and also in mud, sand and on shells.

Distribution : It is common in U.S.A., Woods Hole regions, Long Island Sound to Bay of Fundy.

Comments :

(1) Animal measures approximately 30 cm in length and divisible into **head** and **body segments**.

(2) Anterior end constitutes **head** which is formed by **prostomium** and **peristomium**.

(3) **Prostomium** contains 2 pairs of **prostomial eyes**, 3 pairs of **prostomial tentacles** and 2 grooved and **jointed palps**.

(4) Each **parapodium** consists of a long jointed **notopodial cirrus** and a well developed neuropodium with normal setae and cirrus. The notopodium is absent.

(5) **Pharynx** contains a conical jaw connected to poison gland by its duct.

(6) During breeding season, body is distinguished into anterior asexual (atoke) and posterior sexual (epitoke) regions.

(7) In ***Syllis hyalina***, the epitoke region separates and regenerates independent head (either male or female).

(8) In ***S. ramosa*** lateral buds are formed giving rise to much branched colony.

(9) Some of the lateral branches develop gonads and heads and later separate to become independent sexual adults.

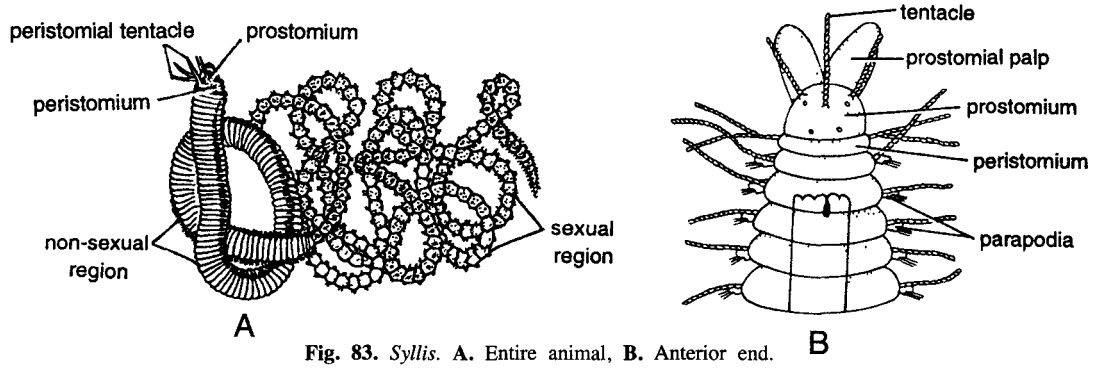


Fig. 83. *Syllis*. **A.** Entire animal, **B.** Anterior end.

Special features : ***Syllis*** shows extensive asexual reproduction by transverse fission.

Identification : Since the animal contains branched body segments and all above characters, hence it is ***Syllis***.

84. *Glycera*

Classification : Same as that of ***Nereis***.

Genus.....*Glycera*

Habit and habitat : ***Glycera*** is marine, polychaet living in cylindrical burrows which are made by their proboscis, in the sand and mud, in shallow water. They burrow very rapidly.

Distribution : It is found in U.S.A., North Carolina to Bay of Fundy and South Carolina to Cape Cod.

Comments :

(1) ***Glycera*** is commonly called as '**Smooth bloodworm**'.
(2) Body is elongated, cylindrical measuring 20 to 25 cm in length and adapted for burrowing life.
(3) **Body** is red coloured with small parapodia and an annulated **prostomium**.
(4) Animal makes cylindrical tunnels by its **proboscis** for dwelling.
(5) **Prostomium** is short, narrow and conical, having four small **tentacles** and two **rudimentary palps**.
(6) Due to burrowing life the parapodia are reduced in size bearing compound chaetae and special retractile gills.
(7) Blood vessels are absent, but the perivisceral fluid functions as circulatory fluid, having red corpuscles containing haemoglobin.
(8) Worm is quickly recognized by its long, tubular proboscis with 4 sharp teeth.
(9) ***Glycera*** is utilized as fish bait.

Identification : Since the specimen contains long proboscis with 4 sharp teeth and all above characters hence it is ***Glycera***.

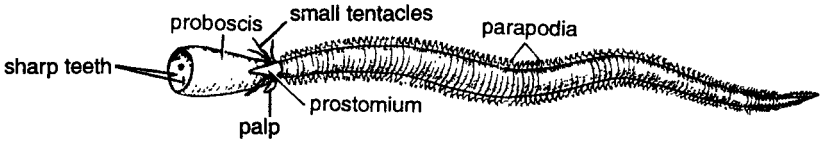


Fig. 84. *Glycera.*

85. *Aphrodite*

Classification : Same as that of ***Nereis***.

Genus.....*Aphrodite*

Habit and habitat : ***Aphrodite*** is marine worm inhabiting the deep water muddy bottoms (Fig. 85).

Distribution : It is found in U.S.A.

Comments :

(1) Commonly called as **sea mouse** measuring approximately 12 cm in length and made up of 30 to 35 segments.
(2) **Body** is covered dorsally by felt-like or blanket-like setae arising from the notopodium.
(3) Shape of the animal is oval, and dorsoventrally flattened. The dorsal surface is convex and is covered with **setae** of different kinds.

(4) Anterior end contains a small **head** or **prostomium**, bearing a small median tentacle and 2 lateral palps. Anus is dorsally situated at the more pointed posterior extremity.

(5) Parapodial structures are greatly modified. **Notopodia** contain 3 kinds of setae—(i) **stiff setae**, (ii) **soft setae**, and (iii) **iridescent setae**.

(6) **Neuropodial** setae are also brown and stiff. The soft **notopodial setae** are modified to form a **felt-like** covering over the back of the animal, while dorsal cirri become plate-like and are called as **elytra**, 15 pairs in number. The elytra obtain dissolved oxygen from the sea water circulating around them.

(7) Ventral surface is flat, segmented and forming a creeping sole. Each ventral segment or **metamere** contains stiff setae.

(8) Pumping action of the dorsal body wall causes the sea water to be filtered through the dorsal felt into the space below.

Special features : Animal rolls itself with erect stiff setae like porcupine to protect itself from enemies when disturbed. During movement of the animal, colour changes from gold to peacock.

Identification : Since the specimen contains distinct stiff setae, iridescent setae and all above characters hence it is ***Aphrodite***.

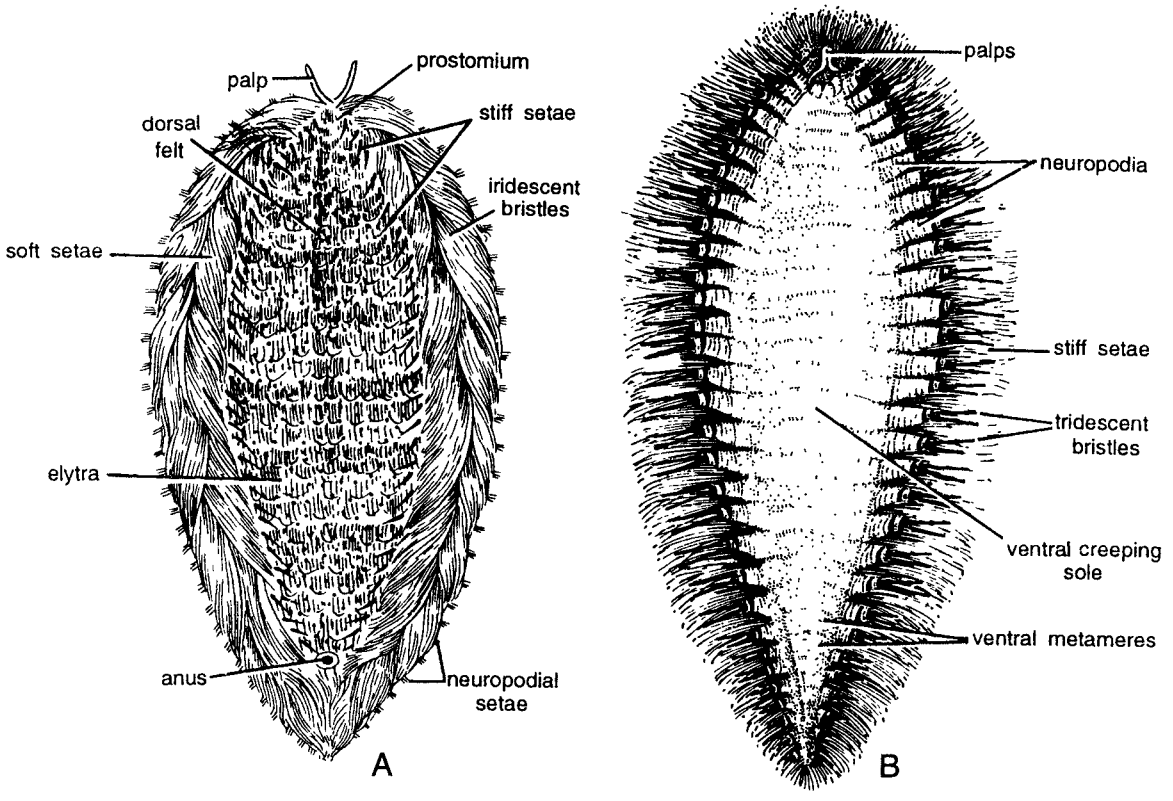


Fig. 85. *Aphrodite.* **A.** dorsal view, **B.** Ventral view.

86. *Tomopteris*

Classification : Same as that of ***Nereis***.

Genus.....*Tomopteris*

Habit and habitat : ***Tomopteris*** is a marine pelagic polychaete.

Distribution : Found in U.S.A. and European countries.

Comments :

(1) Body of the animal is transparent consisting of 18-20 **segments** (Fig. 86).

(2) Anterior end or head is distinct due to the presence of **hammer-shaped prostomium** which contains a pair of eyes and two pairs of **chaetigerous processes** or **tentacular cirri**. The posterior ones are very much elongated while **anterior ones** are short.

(3) Ventral mouth is without proboscis or jaws. Blood vascular system is also absent.

(4) Rest of the body segments possess a pair of parapodia. The parapodia are large biramous with membranous **pinnules** and are without setae.

(5) Each parapodium contains a brightly coloured, yellowish, spherical or rosette-shaped **bioluminescent (photogenic) organ**. The parapodia of the posterior side are reduced.

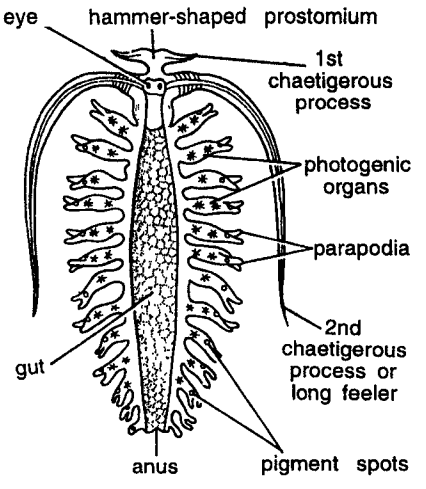


Fig. 86. *Tomopteris.*

(6) Mouth leads into **buccal cavity** which leads into **gut**. Gut opens to outside by **anus**.

Identification : Since the specimen contains hammer shaped prostomium and two large chaetigerous cirri and all above characters, hence it is ***Tomopteris***.

87. *Chaetopterus*

Classification :

Phylum.....Annelida → Metamerically segmented, coelomate and bilaterally symmetrical.

Class.....Polychaeta → Many setae, clitellum absent.

Order..... Tubicola → Tubicolous, sedentary and proboscis non-protrusible, without jaws or teeth.

Genus.....*Chaetopterus* (The paddle worm)

Habit and habitat : ***Chaetopterus*** is a **tubicolous**, marine and **bioluminescent** annelid which lives permanently in a U-tube, made of sand and mucus with incurrent and excurrent openings. The tube is parchment like. Mode of feeding is ciliary.

Distribution : It is commonly found in Europe, U.S.A., North Carolina to Cape Cod.

Comments :

(1) **Commonly** called as **paddel worm** having greatly modified segments.

(2) Tube is opaque, measuring approximately 50 cm long and about 1 cm in diameter.

(3) **Body** is white, delicate, 30 cm long and divided into anterior, middle and posterior regions. The tentacles and palps are absent except a pair of backwardly directed peristomial cirri.

(4) **Parapodia** are variously modified as for **water pumping fans, sucking discs or food ball organs.**

(5) Anterior region comprises of 15 to 20 segments, having a **funnel-shaped mouth** surrounded by a **collar-like peristomium** and a pair of **peristomial cirri** in the first segment. Rest of the segments have reduced **notopodium**. Tenth segment bears great **aliform wings** like notopodia which collect food.

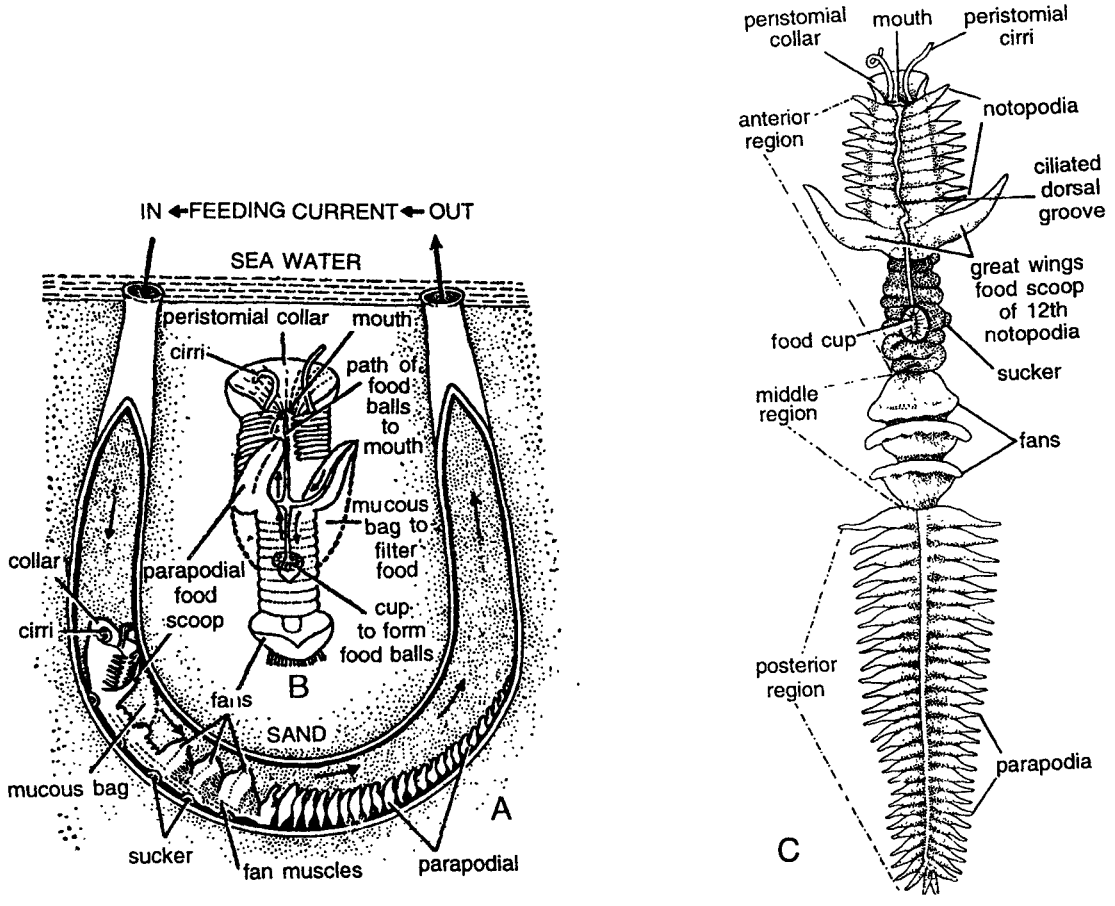


Fig. 87. *Chaetopterus*. **A.** Worm inside burrow, **B.** Anterior end showing feeding mechanism, **C.** Worm outside burrow.

(6) Middle region has fused segments. The notopodia of segments 14 to 16 are fused in mid line to form three **fans**. Notopodia are fused to form **suckers**.

(7) Posterior region is longer with a pair of parapodia in each segment, about 11 to 30 in number.

Special features : The worm is strongly **luminescent** producing bluish-green light without heat. The light is produced by the action of **luciferins** and **luciferase**. Other special feature of the worm is its power of regeneration. The whole body can be regenerated from a single segment.

Identification : Since the specimen has greatly modified segments and all above features, hence it is ***Chaetopterus***.

88. *Sabella* or *Parasabella*

Classification : Same as that of ***Chaetopterus***.

Genus.....*Sabella* or *Parasabella*

Habit and habitat : ***Sabella*** is a marine, tubicolous polychaete present in low tide mark to approximately 100 fathoms deep. It is often incrusted on oyster shells, etc.

Distribution : It is distributed throughout the world but especially U.S.A. (North Carolina to Cope Cod).

Comments :

(1) **Commonly** called as **'peacock worm'** (Fig. 88).

(2) Animal lives in upright tube, made up of sand grains glued together.

(3) **Body** is divided into small **head**, a **trunk** and **abdomen**.

(4) **Head** is constituted by the **prostomium**, which contains several gill filaments or **feathery tentacles** which are modified **palps**. Each tentacle has 2 rows of **small pinnules** having mucus-secreting glands.

(5) Trunk region has 8 segments. First segment is called as peristomium which is collar-like having large ventral gland shield to secrete mucus. **Peristomium** has **notopodium** and **setae**, but no neuropodium. The rest seven segments have normal parapodia, each consisting of a notopodium with normal setae and a neuropodium with small bent setae called crochets or uncini.

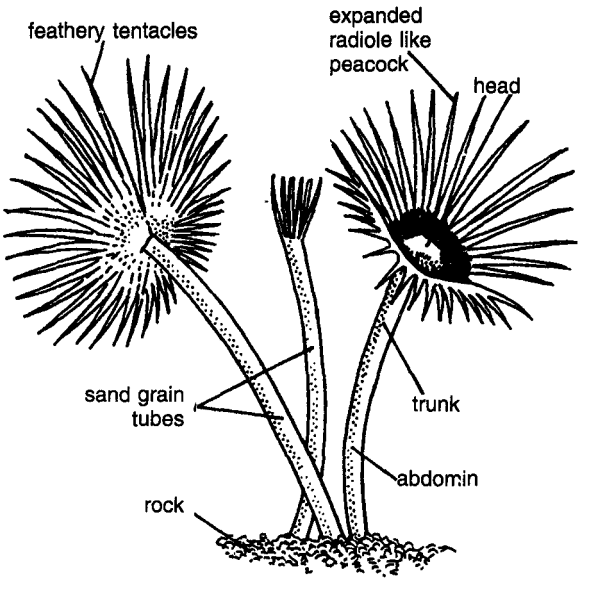


Fig. 88. *Sabella.*

(6) **Abdomen** is the largest part.

(7) A dorsal faecal groove extends from mouth to anus. It curves down in the last trunk segment to ventral side.

(8) ***Parasabella*** is another allied form. In this species gill filaments are long and the slender peristomium is raised and reflexed to form a collar around the gills which is notched dorsally.

Identification : Since the specimen has feathery tentacle and all above characters, hence it is ***Sabella.***

89. *Sabellaria*

Classification : Same as that of ***Chaetopterus.***

Genus.....*Sabellaria*

Habit and habitat : ***Sabellaria*** is a marine, sedentary polychaete, more or less Y-shaped. The animals live in simple tubes in sand formed by them.

Distribution : Found in Europe and U.S.A.

Comments :

(1) **Body** is elongated, segmented and cylindrical with a broad and bifurcated anterior end. The rest of. the body tapers posteriorly.

(2) Animal projects through the sandy tube.

(3) **Head** is constituted by the **prostomium** and **peristomium**. The prostomium contains a pair of **tentacles.**

(4) Peristomium fuses with the **palps** and becomes comparatively larger and branched.

(5) Dorsal cirri are modified as **gill filaments.**

(6) Each metamere except first and last possesses a pair of appendages or podia.

(7) ***Sabellaria*** often occur in large closely set colonies.

Identification : Since the specimen has bifurcated anterior end and all above characters, hence it is ***Sabellaria.***

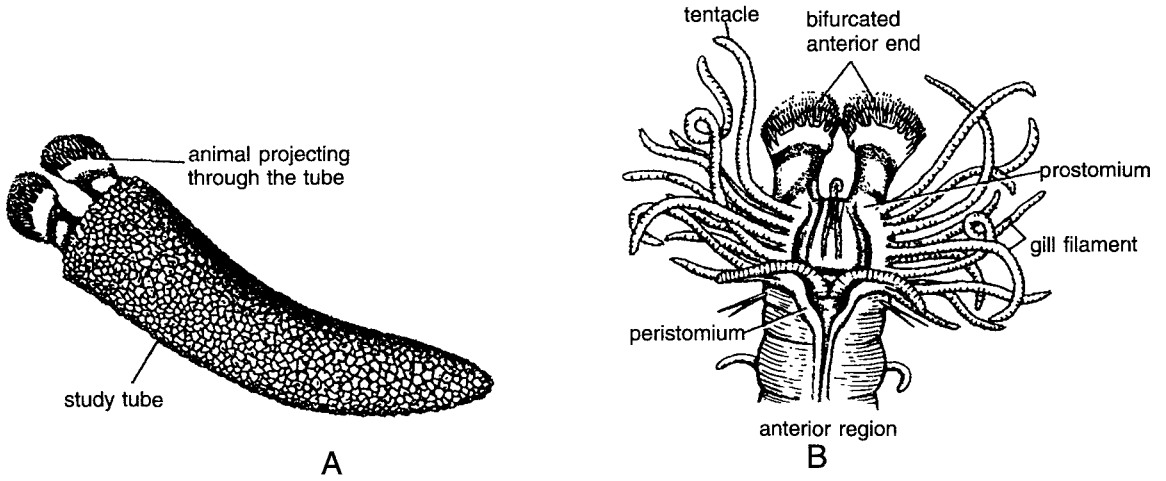


Fig. 89. *Sabellaria.* **A.** Animal projecting through tube, **B.** Anterior region.

90. *Arenicola*

Classification :

Phylum.....Annelida → Metametrically segmented, coelomate and bilaterally symmetrical.
Class.....Polychaeta → Many setae, clitellum absent.
Order.....Sedentaria → Tubicolous, sedentary and proboscis not-protrusible, without jaws or teeth.
Genus.....*Arenicola* (The Lung worm)

Habit and habitat : ***Arenicola*** is also **tubiculous** and **burrowing polychaete**, occurring just below the tide line in sea, where the water is less saline. Animals lives in a J-shaped burrow made of sand and mucus.

Distribution : It is distributed in Europe and U.S.A. (Florida to Cape Cod) (Fig. 90).

Comments :

(1) **Body** is stout, elongated, cylindrical and approximately 15 cm long, brownish or greenish in colour and divided into **metameres**.
(2) **Head** without appendages and with an unarmed proboscis.
(3) Animal is differentiated into an anterior **pre-branchial**, **a middle branchial** and a posterior **post-branchial** region.
(4) Anterior region consists of a small trilobed **prostomium** with no eyes or tentacles, an **achaetus peristomium** and 6 segments bearing rudimentary parapodia.
(5) **Parapodia** contains reduced **notopodium** and **neuropodium**.
(6) Mouth lies ventral to the prostomium. The buccal region and pharynx protrude as proboscis which is covered by chitinized **buccal papillae**.
(7) **Middle region** has 13 segments, each bearing in addition to neuropodia, a pair of extensively branched **gills**. Nephridia six pairs.
(8) **Posterior region** has variable number of segments and devoid of parapodia or gills. Anus opens through last segment.
(9) ***Arenicola*** is generally used as **bait for fishing**.

Identification : Since the specimen has pre-branchial, branchial and post-branchial regions and all above features, hence it is ***Arenicola***.

Instructions : *Compare the characters of* ***Aphrodite***, ***Chaetopterus*** and ***Arenicola***.

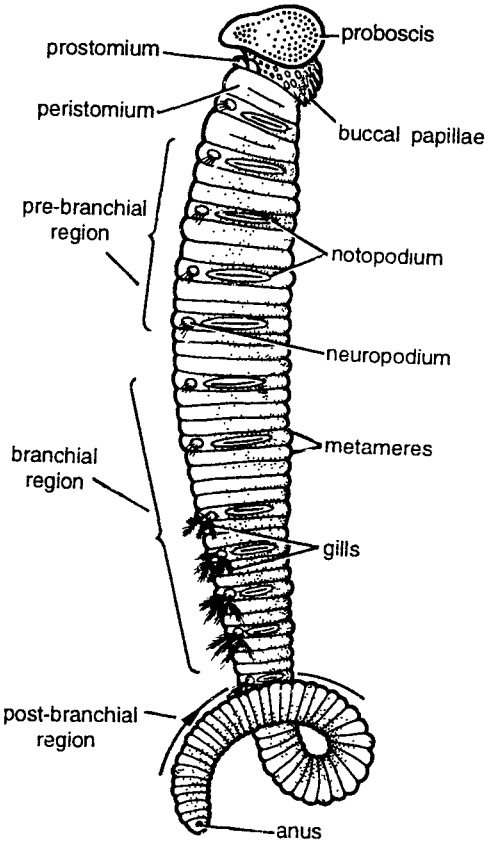


Fig. 90. *Arenicola.*

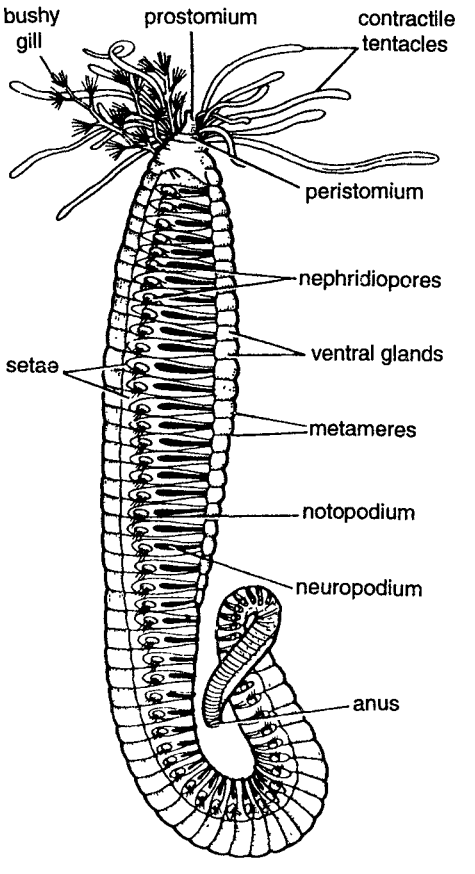


Fig. 91. *Amphitrite.*

91. *Amphitrite*

Classification : Same as that of ***Arenicola***.

Genus.....*Amphitrite*

Habit and habitat : ***Amphitrite*** is a marine, sedentary polychaete, very common along the eastern coast of the United States. The animal dwells near the low tide level in tubes lined with mucus and buried in sand or mud.

Distribution : It is found in Europe and U.S.A. (North Carolina to Cape Cod).

Comments :

(1) **Animal** is long cylindrical, and pinkish in colour measuring 20 to 30 cm in length (Fig. 91).

(2) **Body** is divided into **metameres** and regionated into somewhat thickened anterior region **(head)**, middle region **(trunk)** and posterior narrow region.

(3) **Prostomium** forms the upper lip and **peristomium** lower lip of the mouth. No eyes and palps in prostomium. Peristomium is also without appendages. Prostomium forms **proboscis**.

(4) Just behind the head is a transverse ridge crowned with several, long hollow, yellowish and contractile **tentacles** having coelomic extension. They are feeding organs and have poor vascularization having a ciliated groove on one side.

(5) **Branchial** region consists of many segments bearing **notopodia** with setae and **neuropodia** with uncini. The first three segments of the middle region contain three pairs of **bushy gills** placed dorso-laterally.
(6) Gills contract rhythmically. Ventrally few thoracic segments have **shield glands** or ventral glands for mucus secretion.
(7) **Abdomen** is long and each segment contains **notopodia** and **neuropodia** (uncini).
(8) Caudal segments lack notopodia and anus is found terminally in the last segment as elongated aperture.

Special features : Generally ***Lepidometria*** a symbiont lives in the same tube with ***Amphitrite***.

Identification : Since the specimen contains anterior feathery tentacles and all above characters and hence it is ***Amphitrite***.

92. *Terebella*

Classification : Same as that of ***Arenicola***.

Genus.....*Terebella*

Habit and habitat : ***Terebella*** is a marine, burrowing, sedentary annelid. The animal burrows in tubes in sand. Some species live 10 to 230 fathoms deep.

Distribution : It is found in Europe, U.S.A., Woods Hole region and Vineyard Sound to Bay of Fundy.

Comments :

(1) **Body** is elongated, cylindrical and divided into **head** and **trunk**.
(2) **Head** is horseshoe-shaped, made up of **prostomium** and **peristomium**.
(3) **Prostomium** contains number of long **filliform bushy tentacles**.
(4) Trunk contains about 60 segments reddish in colour and divided into anterior region or **cirri**, middle region with **cirri** and posterior region without **cirri**.
(5) Gills or branchiae are found on the dorsal surface of few anterior segments and they form 4 wide comb like branches on a single peduncle.
(6) Anterior 1/3 body is thickened while major part of the posterior body tapers narrowly.
(7) Setae of anterior segments are well developed while reduced in posterior segments.

Identification : Since the head contains bushy tentacles and all above characters and hence it is ***Terebella***.

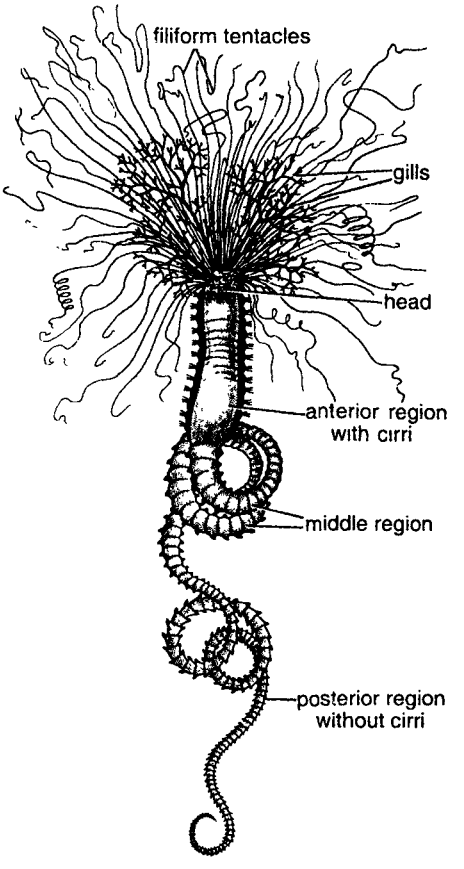


Fig. 92. *Terebella.*

93. *Serpula*

Classification : Same as that of ***Arenicola***.

Genus.....*Serpula*

Habit and habitat : ***Serpula*** lives in a hard, shelly, calcareous and twisted tube, attached to shells and other marine objects. Several animals live together.

Distribution : It is found in Europe and U.S.A (Fig. 93).

Comments :

(1) **Body** is elongated and cylindrical but contractile.
(2) Anterior end forms **head** consisting of **prostomium** and **peristomium**.
(3) Posterior end remains attached with **mass** of **calcareous tubes**.
(4) Prostomium contains a pair of incomplete circlets of feathered gills or **branchian** which are elongated and pinnately branched.
(5) **Gills** are modified palps, sometimes supported by cartilaginous skeleton and are richly supplied with blood and besides **respiration** serve to collect microscopic food particles.
(6) Each gill consists of an elongated branch, having two rows of short filaments.
(7) Tip of one of the dorsal filaments enlarges to form stopper or **operculum**, often armed with plates and spines for the closure of the tube in which the annelid lives.
(8) Peristome is extended forward as paired membrane to form a **collar** which is employed in smoothing the inside of the shell.
(9) Nephridia of posterior segments act as genital ducts.

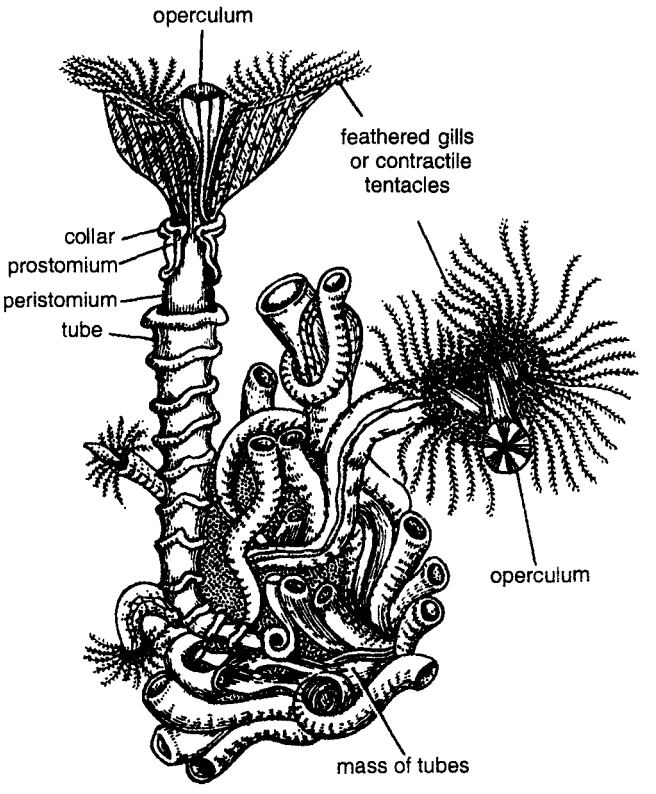


Fig. 93. *Serpula.*

Identification : Since the animal contains a pair of feathered gill and all above characters, hence it is ***Serpula***.

94. *Spirorbis*

Classification : Same as that of ***Arenicola***.

Genus.....*Spirorbis*

Habit and habitat : ***Spirorbis*** is minute, **tubicolous, sedentary polychaete** living in a small calcareous tube, coiled in a flat spiral manner which is incrusted on seaweeds, stones, shells and any hard calcareous object of the sea (Fig. 94).

Distribution : Commonly found in U.S.A., Long Island to Bay of Fundy and northwards.

Comments :

(1) Animal measures about 3 mm in length and tube diameter is also nearly 3 mm.
(2) **Body** is divided into anterior and posterior regions.
(3) Anterior end is constituted by **prostomium** and **peristomium**.
(4) Prostomium contains pinnately branched gills.
(5) One of the gill filaments is enlarged to form stopper or **operculum**. There are 9 greenish **gill filaments**.
(6) Operculum is grooved on one side to serve as **brood punch** for the developing **eggs**.

(7) Peristome is similar to other segments of the thorax, but it forms a **collar** which secretes the tube.
(8) Abdominal segments are hermaphroditic. The anterior abdominal segments produce eggs while posterior segments sperms.

Special features : ***Spirorbis*** has long **fossil history**. It was abundantly found in Silurian Paleozoic and strata.

Identification : Since the specimen contains pinnately branched tentacles and all above characters and hence it is ***Spirorbis***.

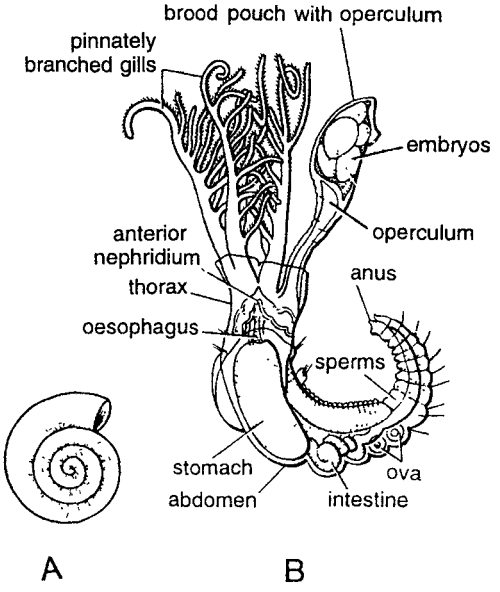


Fig. 94. *Spirorbis.* **A.** Calcareous tube, **B.** Entire worm.

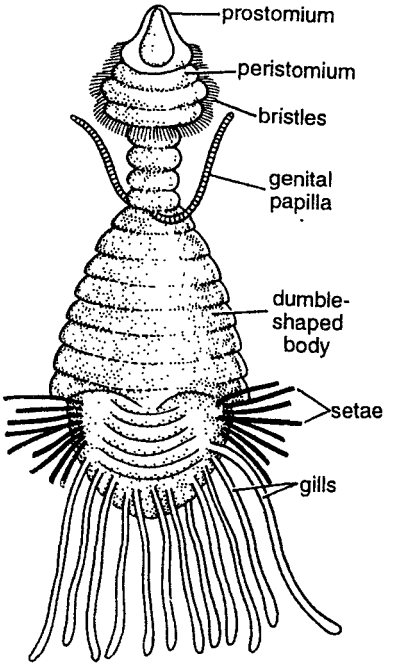


Fig. 95. *Sternaspis.*

95. *Sternaspis*

Classification : Same as that of ***Arenicola***.

Genus.....*Sternaspis*

Habit and habitat : ***Sternaspis*** is a marine, tubicolous polychaete (Fig. 95).

Distribution : It is found in U.S.A. (Florida).

Comments :

(1) Body is short and made up of about 30 segments.
(2) **Head** is formed by **prostomium** and **peristomium**.
(3) Prostomium is elongated and without any appendages.
(4) Peristomium is knob like and contains mouth.
(5) First three segments have **incomplete bristles**, segments 8 to 15 have setae while segments 5th, 6th, 7th and 16th to 24th are devoid of setae.
(6) Just below 7th segment is a pair of **genital papilla**.

(7) In ***Sternaspis spinosa***, the prostomium is elongated and bifurcated like the proboscis of the ***Echiurida***.
(8) Intestine is coiled and the anus is terminal and surrounded by **gills**.
(9) Below 7th segment body is **durable shaped** and posteriorly a cuticular thickening is present ventrally called as ventral shield. Ventral shield contains number of setae around its edge.

Identification : Since the animal has bifurcated proboscis like prostomium and all above features hence it is ***Sternaspis***.

96. *Pheretima* : Earthworm

Classification :

Phylum.....Annelida	→	Metamerically segmented, coelomate and bilaterally symmetrical.
Class.....Oligochaeta	→	Few setae.
Order.....Neo-oligochaeta	→	Modern and terrestrial forms.
Genus.....*Pheretima*		

Habit and habitat : ***Pheretima*** is found in the soil but absent in sandy and humus deficient soil. They are found in mountains, clayey and acidic soils. They live usually in the upper layers of slightly damp soils, lawns, gardens and up to the depth of 30 to 45 cm in burrows for protection against enemies and under unfavourable condition. According to Darwin one acre of land may contain 63,000 earthworms. It is nocturnal. The earthworm is hermaphroditic (monoecious).

Distribution : Cosmopolitan.

Comments :

(1) **Commonly** called as **Earthworm**.
(2) Body consists of 100 to 120 ring like segments depicting true **metamerism** and measuring approximately 150 mm.
(3) Both external and internal segmentations are distinct. The worm is glistening deep brown or clay-coloured.
(4) Anterior end is somewhat narrowly pointed, while posterior end is bluntly pointed.
(5) Except the first and last segment, each segment contains a **row of setae** in the ventral body wall.
(6) Dorsal surface is dark brown in colour and it is easily recognized by dark median line of dorsal blood vessel.
(7) First segment is called as prostomium which contains **ventral mouth**. The last segments is called as **anal** segment containing **anus**.
(8) A portion of the body is thickened and is called as **clitellum** around 14 to 16 segments.
(9) **Spermathecal** pores are found in the inter-segmental grooves of 5/6, 6/7, 7/8 and 8/9 segments. The **female-genital** pore on the 14th segment and **male-genital pores** on the 18th segment. Two pairs of **genital papillae** lie on the ventral surface in the 17th and 19th segments.
(10) **Cross-fertilization**, but copulation has not been studied in ***P. posthuma***. Development takes place in cocoons.

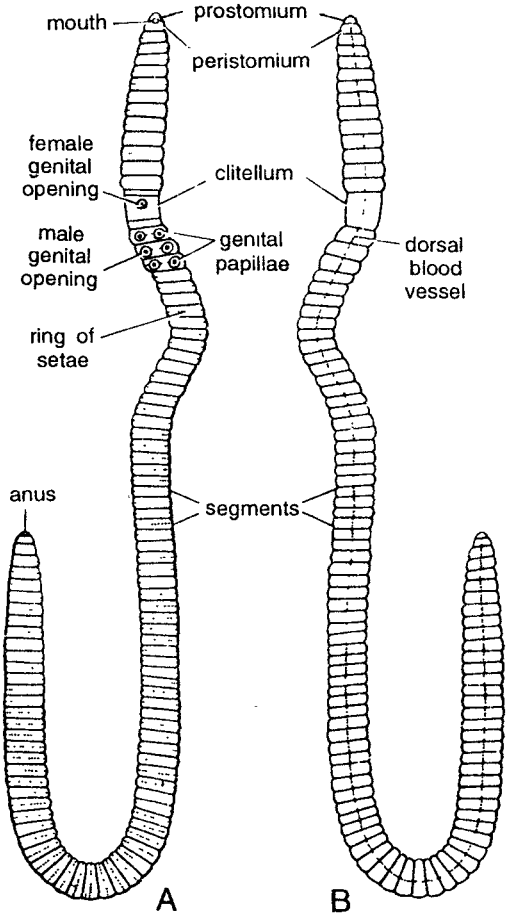


Fig. 96. ***Pheretima.*** **A.** Ventral view, **B.** Dorsal view.

Special features : Earthworm is **economically** very important as (i) It is used as fishing bait, (ii) It has medicinal, educational and experimental value, (iii) The **earthworms are beneficial to agriculture.** They are important agent in the conditioning of soil and permit water to enter easily during rain. The constant mixing of soild and organic debris contributes to development of good humus. Earthworms are very good fertilizers and are cultured.

Identification : Since the specimen contains clitellum in 14 to 16 mm segments and all above features, hence, it is ***Pheretima***.

97. *Lumbricus*

Classification : Same as that of ***Pheretima.***

Genus.....*Lumbricus*

Habit and habitat : ***Lumbricus*** is found abundantly in moist soil (Fig. 97).

Distribution : It is common earthworm of Europe and U.S.A.

Comments :

(1) Commonly called as **Earthworm**.
(2) Earthworm is a common and favourite classroom animal in European countries.
(3) It remains wholly in burrow during daytime because of light and humidity.
(4) Cylindrical body measures 15 to 30 cm in length and consisting of about 100 **metameric** segments.
(5) Each segment, except the first and the last bears **S-shaped setae** on **ventral surface** as black dots.
(6) Lobular **prostomium** divides **peristomium** into two parts.
(7) A permanent **clitellum** develops in segments 33 to 37 only on dorsal and lateral sides, remains **incomplete** ventrally. Clitellum contains **tuberacle**. **Tail** is flattened.

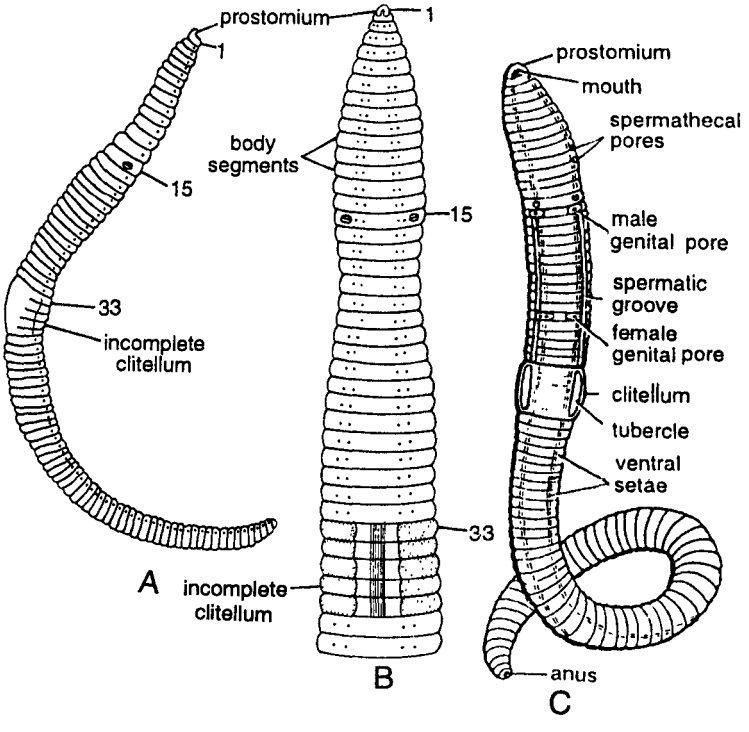


Fig. 97. *Lumbricus.* **A.** Entire worm, **B.** Incomplete clitellum, **C.** Block dots-state pore.

(8) **Dorsal** and **ventral surfaces** well differentiated.
(9) **Hermaphroditic** (monoecious), **female-genital pores** lie ventrally on 15th segment while **male-genital openings** on 14th segment. **Genital papillae** are absent. Reproduction is sexual.
(10) **Dorsal pores** are found in the midline of the inter-segmental grooves from the 10th segment onwards.
(11) Coelomic fluid is exuded from these pores on the surface of the worm, when the worm is subjected to some irritation.

Special features : The **peritoneum** surrounding the intestine is modified to form a glandular layer called the **chlorogogen cells**. These extract wastes from the blood and later become detached and float in coelom. Ultimately much of their substances is engulfed by amoeboid cells and carried to the skin where it is deposited as pigment.

Identification : Since the specimen contains incomplete clitellum in 33 to 37 mm segments and all above features, hence it is ***Lumbricus***.

Instructions : *Compare and contrast* ***Pheretima*** *and* ***Lumbricus***.

98. *Tubifex*

Classification :

Phylum.....Annelida	→	Metamerically segmented, coelomate and bilaterally symmetrical.
Class.....Oligochaeta	→	Few setae.
Order.....Archioligochaeta	→	Small and fresh-water forms.
Genus.....*Tubifex*		

Habit and habitat : ***Tubifex*** **is a tubicolous** fresh-water archioligochaete, found abundantly on the bottom of deep lakes. The animal lives in tubes, made up of mud and minerals glued together by mucus.

Distribution : It is found in U.S.A. (Long Island Sound to Maine).

Comments :

(1) **Body** is cylindrical, red coloured, metamerically segmented measuring 4 cm in length (Fig. 98).
(2) First and second segments are **prostomium and peristomium** respectively.
(3) Each segment contains 4 **bundles of setae** on dorsal and ventral sides.
(4) Setae forked and hair-like in the dorsal bundles and only forked ones in ventral bundles.
(5) **Clitellum** is found in llth and 12th segments.
(6) Contractile **heart** is found in 8th segment. **Female-genital pores in the** 11th **segment and male-genital pore in the 12th segment.**
(7) **Hermaphroditic**. It reproduces sexually only.

Special features : ***Tubifex*** is encouraged to grow in filter beds of sewage disposal plants in order to keep the filter open. They have probably purifactory functions.

Identification : Since the animal contains 4-bundles of setae in each segment and all above features hence it is ***Tubifex***.

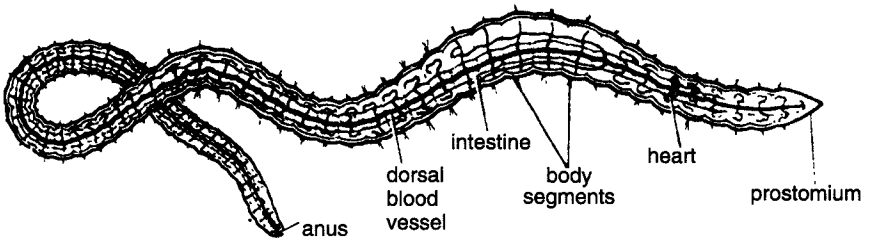


Fig. 98. *Tubifex.* Ventral surface.

99. *Acanthobdella*

Classification :

Phylum.....Annelida	→	Metamerically segmented, coelomate and bilaterally symmetrical.
Class.....Hirudinea	→	Annelids with fixed segments, without parapodia and with anterior and posterior suckers.
Order.....Acanthobdellida	→	Anterior sucker, proboscis and jaws absent.
Genus.....*Acanthobdella*		

Habit and habitat : The order ***Acanthobdella*** includes a single genus ***Acanthobdella*** found as an **ectoparasite** on the caudal and anal fins of the salmon fish ***Salmo salvelinus*** (Fig. 99).

Distribution : Commonly present in West Siberia and N.E. Europe.

Comments :

(1) **Body** consists of about 20 **metameric segments** only.
(2) **Anterior sucker** is absent. **Posterior sucker** is well developed and consists of four segments.
(3) Each ventro-lateral sides of first five segments contain 4 **pairs of setae** embedded in setigerous sacs provided with retractor muscles.
(4) **Body cavity** (perivisceral) is incompletely divided by 20 **transverse septa**.
(5) **Visceral peritoneum** consists of flat globules, containing cells corresponding to **chloragogen cells**.
(6) **Nephridia** with both external and internal openings.
(7) **Blood vascular** system made of a dorsal and a ventral vessel and nervous system consists of 20 ventral ganglia of which the first and the last are composite.

Special features : The external morphology strongly suggests that ***Acanthabdella*** is leech but Michaelson regarded it as oligochaeta due to setae and incomplete septa. However ***Acanthobdella*** represents **good connecting link between earthworms and leeches**.

Identification : Besides absence of anterior sucker, animal shows all above features, hence it is ***Acanthobdella***.

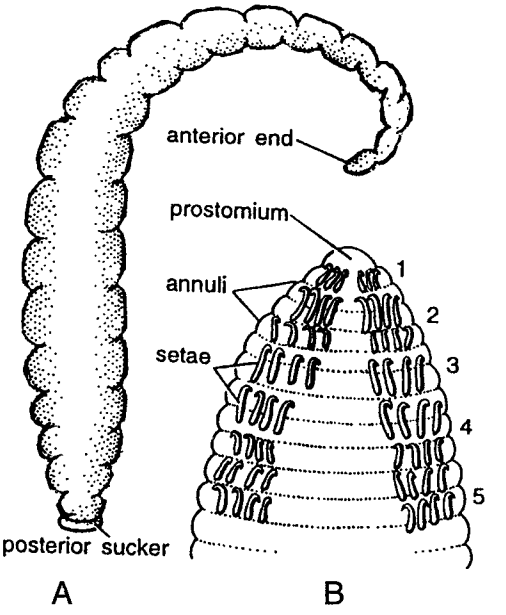


Fig. 99. *Acanthobdella.* **A.** Entire leech, **B.** Anterior end in ventral view.

100. *Pontobdella*

Classification :

Phylum.....Annelida	→	Metamerically segmented, coelomate and bilaterally symmetrical.
Class.....Hirudinea	→	Annelids with fixed segments, without parapodia and with anterior and posterior suckers.
Order.....Rhynchobdellida or Agnathobdellia	→	Proboscis protrusible; jaws and setae absent.
Genus.....*Pontobdella* (The skate sucker)		

Habit and habitat : ***Pontobdella*** leads ectoparasitic life. It is a marine annelid, parasitizing skates and rays.

Distribution : It is found in Europe and U.S.A.

Comments :

(1) **Body** is cylindrical, club-shaped measuring approximately 20 cm in length.
(2) Anterior region is narrow.
(3) **Anterior sucker** is saucer-shaped, firmly applied on the tissues of the host.
(4) **Posterior sucker** is deep and cub-shaped with **serrated margin.**
(5) Body surface is tuberculated having green tubercles or **warts.** It is rough and leathery.
(6) **Metameres** are not very conspicuous.
(7) **Eyes** and **gills** are absent.
(8) **Pharynx** is protrusible without jaws.
(9) **Hermaphroditic.** Reproduction sexual.
(10) **Eggs** are velvety, laid in empty mollusc shells.

Special features : The skate sucker (***P. muricata***) guards over the eggs for about three months till they are hatched.

Identification : Since the specimens contain green tubercles and all above features, hence it is ***Pontobdella***.

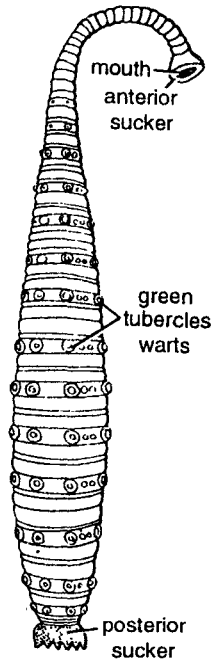


Fig. 100. *Pontobdella.*

101. *Clepsine* : *Glossiphonia*

Classification : Same as that of ***Pontobdella.***

Genus.....*Clepsine*

Habit and habitat : ***Clepsine*** is a fresh-water leech. It feeds on snails, larval stages of ***Chironomus*** and ***Hydrophillus***.

Distribution : It has cosmopolitan distribution. It is very common in India (Nainital, Bengal and Assam).

Comments :

(1) **Body** is greenish, semi-transparent, narrow anteriorly and broadly flattened posteriorly.
(2) Body measuring about 15 mm in length and 5 mm in breadth.
(3) Anterior tapering end bears the **mouth.**
(4) **Anterior sucker** is fused with the body and the posterior sucker is pedunculated.
(5) Each segment contains 3 **rings.**
(6) Three pairs of **eyes, protrusible** proboscis, salivary glands and gut could be observed.
(7) **Crop chambers** are elongated in the middle of the body. The intestine bears 4 pairs of lateral caeca.
(8) Fertilization is by hypodermic impregnation. ***Clepsine*** is notable for carrying its eggs and young attached to the ventral sucker. No cocoon formation.
(9) Animal cannot swim but rolls up when alarmed.

Identification : Since the specimen has narrow anterior end, broad posterior end and all above features hence it is ***Clepsine.***

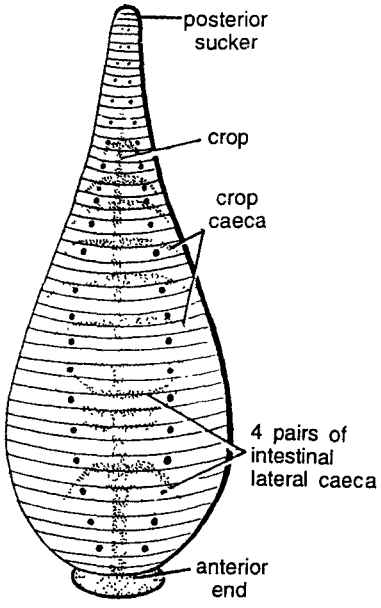


Fig. 101. *Clepsine.*

102. *Branchellion*

Classification : Same as that of ***Pontobdella.***

Genus.....*Branchellion*

Habit and habitat : ***Branchellion*** is a marine leech, found as parasite on torpedo.

Distribution : It is not reported from India.

Comments :

(1) **Body** is small elongated, cylindrical and measuring approximately 10 cm in length.
(2) Animal measures about 10 cm long.
(3) **Body** is differentiated into a narrow **anterior region**, the **neck** or **thorax**, and a wide posterior region, the **trunk** or **abdomen**.
(4) Abdomen contains 11 pairs of lateral, foliaceous outgrowths of the body which form **gills**.
(5) **Gills** are in the form of paired appendages.
(6) Anterior end is everted to form the proboscis.
(7) Suckers are prominent and pedunculate.

Identification : Since the animal contains 11 pairs of gills, hence it is ***Branchellion.***

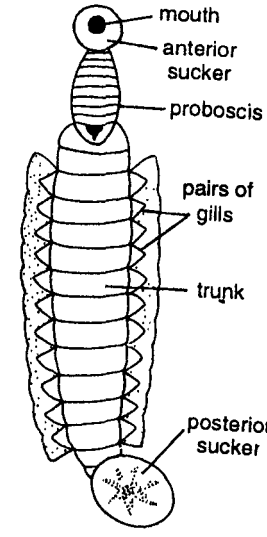


Fig. 102. *Branchellion.*

103. *Hirudo medicinalis*

Classification :

Phylum.....Annelida	→	Metamerically segmented, coelomate and bilaterally symmetrical.
Class.....Hirudinea	→	Annelids with fixed segments, without parapodia and with anterior and posterior suckers.
Order..... Rhynchobdellida or Gnathobdellida	→	Proboscis non-protrusible; jaws present.
Genus.....*Hirudo*		
Species.....*medicinalis*		

Habit and habitat : ***Hirudo medicinalis*** is found in ponds, marshes and streams. They are Sangivorous (blood sucking) ectoparasites on submerged cattles.

Distribution : It has cosmopolitan distribution. Found in India, Myanmar, U.K. and U.S.A.

Comments :

(1) **Commonly** known as Indian **cattle leech.**
(2) **Body** is cylindrically elongated dorsoventrally flattened having variable pigments on dorsal surface, measuring 40 cm.
(3) **Anterior** and **posterior suckers** are well developed and are meant for attachment.
(4) **Anterior sucker** is formed by prostomium and rest of the body contains about 95 superficial segments or annuli and 36 to 37 true segments.
(5) Segments 3, 4 and 5, 6 have 2 and 3 **annuli** each, respectively.
(6) Rest of the segments have 5 **annuli** each. The first 5 segments have 5 pairs of small eyes in the first annulus.
(7) First annulus of each segment contains segmental papillae.
(8) Posterior end contains posterior sucker formed by the union of 7 segments. The entire animal is divided into **cephalic**, **preclitellar**, **clitellar**, **middle**, **caudal** regions and **posterior** sucker.

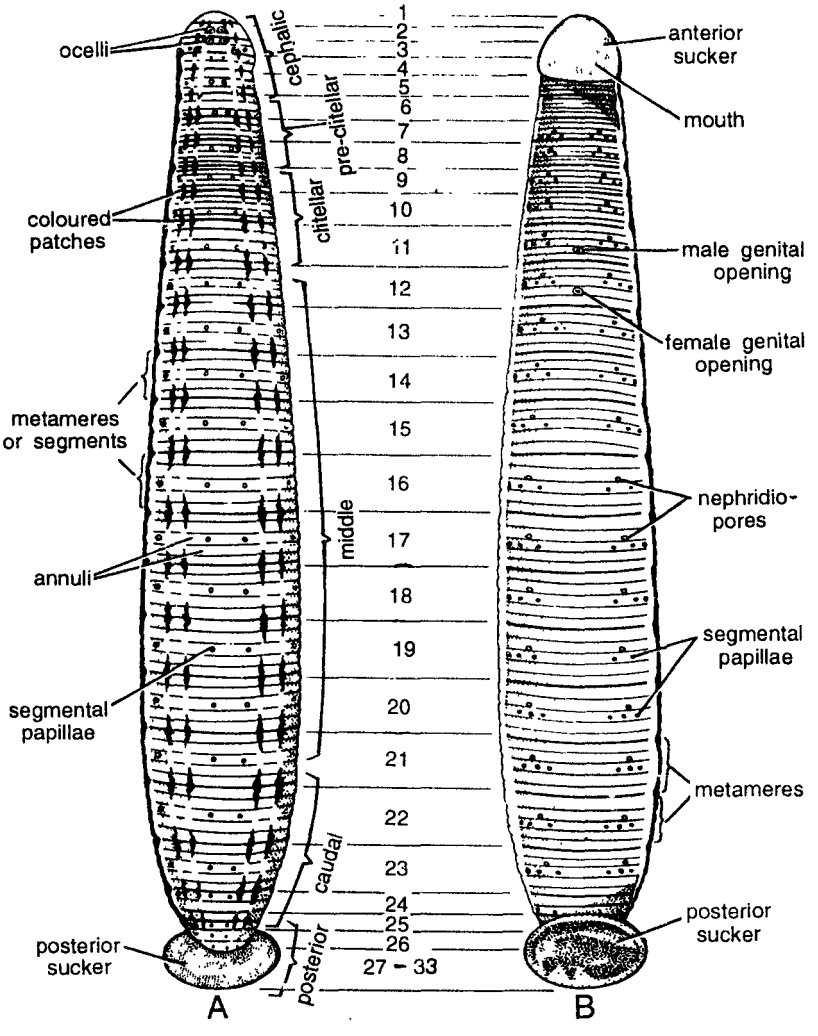


Fig. 103. *Hirudo medicinalis.* **A.** Dorsal surface, **B.** Ventral surface.

(9) **Mouth** is found as a narrow, tri-radiate aperture opening in the pre-oral chamber. **Nephridiopores** are found ventrally on the last annulus of each segment from 6 to 22. The coelom is replaced by spongy botryoidal tissue. The coelom is reduced in the form of 4 channels, called as **haemocoelomic** channels.

(10) **Hermaphroditic**. Development takes place in cocoons or ootheca. Male and female genital pores are on 10th and 11th segments respectively.

Special features : In old days, ***Hirudo*** was used by physicians to suck the blood of some ill persons, because they believed illness was due to some sort of imbalance in body fluids. In the mouth are three cutting teeth that make a Y-shaped incision in the skin. Numerous small salivary glands around the mouth secrete a substance that **prevents the coagulation of blood**. This substance called **Hirudin** is commercially extracted from leeches and used medicinally when anticoagulants are indicated.

Identification : Since specimen contains 36-37 segments, and all above features hence it is ***Hirudo medicinalis***.

104. *Hirudinaria granulosa*

Classification : Same as that of ***Hirudo***.

Genus..... ***Hirudinaria***

Species..... ***granulosa***

Habit and habitat : ***Hirudinaria*** is found in fresh-water ponds, lakes and swamps. It is a blood-sucking or **sanguivorous ectoparasite** feeding and sucking the blood of frog, fishes and men.

Distribution : It has cosmopolitan distribution and specially found in India and Myanmar.

Comments :

(1) **Commonly** called as **Indian cattle leech**.

(2) **Body** is soft, vermiform, elongated dorsoventrally flattened, measuring 30 to 35 cm in length.

(3) Skin is kept moist and slimy due to abundant mucus secretion.

(4) **Anterior** and **posterior suckers** are well developed.

(5) Dorsal surface is olive green, ventral surface orange-yellow or red. Both surfaces have **black stripes**.

(6) Body is divided into **cephalic**, **preclitellar**, **clitellar**, **middle**, **caudal** and **posterior sucker** regions with 33 segments. Each segment is superficially divided into 5 **annuli**.

(7) Anterior sucker is oval and contains ventral tri-radiate mouth. It is formed by the fusion of prostomium and few anterior segments. The posterior sucker is highly muscular and acts as powerful locomotory and adhesive organ.

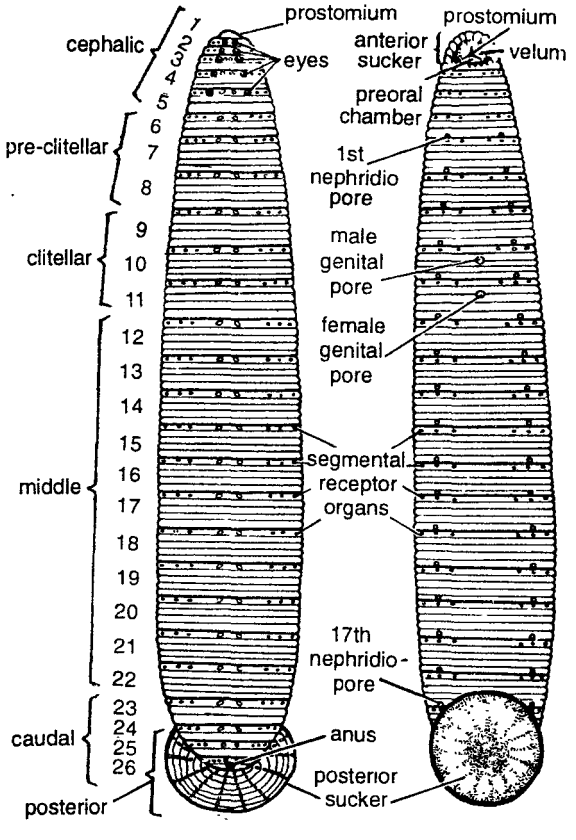


Fig. 104. ***Hirudinaria granulosa.*** **A.** Dorsal view, **B.** Ventral view.

(8) **Eyes** 5 **pairs dorsally**. Segmental receptor organs are 4 pairs (dorsal) and 3 pairs (ventral). Anus is on 26th segment, **nephridiopores** on 6 to 22 segments ventrally, **male-genital pore** on mid-ventral, inter-segmental groove of 2nd and 3rd annuli of 10th segment and **female-genital pore** on 11th segment.

(9) **Hermaphroditic**. Genital organs are like ***Hirudo***. Reproduction sexual. Development takes place on **cocoons**.

Special features : Cattles are often submerged in tanks and lakes. Several leeches attach to their body for blood sucking. It is said that a fully fed leech can live several months without blood-feed.

Identification : Since the leech contains 33 segments and all above features, hence it is ***Hirudinaria granulosa***.

105. *Nepheles* (= *Herpobdella*)

Classification : Same as that of ***Hirudo***.

Genus.....*Nepheles*

Habit and habitat : ***Nepheles*** is found in ponds and streams, under stones and water plants. It is **predaceous** form with indiscriminating appetites, feeding upon insect larvae, planarians, snails and crustaceans.

Distribution : It has cosmopolitan distribution.

Comments :

(1) **Body** is elongated, cylindrical and whitish in colour with distinct **posterior sucker**. The margins of the body are smooth.

(2) Each body segment has 5 **annuli** or rings. The annuli and true segments are not easily demarcated and consist of 19 segments.

(3) **Head** is not prominent but can be recognized by having 2 pairs of eyes.

(4) Setae, parapodia and jaws are absent.

(5) **Genital pores** are separated by 203 rings.

(6) Development takes place in **cocoons**.

Identification : Since the specimen contains 10 segments and all above features, hence it is ***Nepheles***.

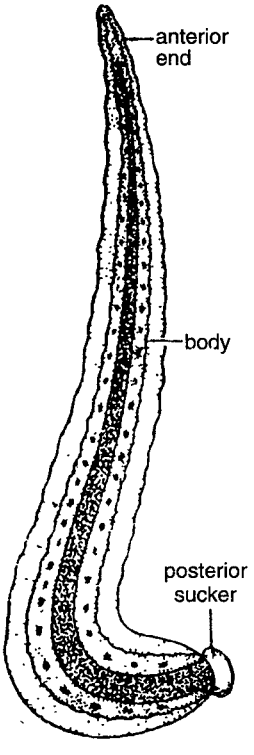


Fig. 105. *Nepheles.*

106. *Haemopis*

Classification : Same as that of ***Hirudo***.

Genus.....*Haemopis*

Habit and habitat : ***Haemopis*** is found in ponds, streams and swampy meadows and leads a lethargic life in autumn by burrowing itself in marshy ground. It is **carnivorous**, swallowing freshwater worms, insects, larvae, tadpoles and small fish. Late Professor K.N. Bahl recorded ***Haemopis*** from Kashmere.

Distribution : Cosmopolitan.

Comments :

(1) **Commonly** called as **hungry horse leech**.

(2) **Body** is elongated and cylindrical with pairs of eyes.

(3) There are 5 **annuli** between gonopores.

(4) Jaws are rounded with large blunt teeth in two rows.

(5) Copulatory glands are absent and crop bears a single caecum.

(6) Development takes place in cocoons.

Identification : Since the specimen contains 5 annuli between gonophores and all above features, hence it is ***Haemopis***.

Instructions : *Make a comparative account of different leeches.*

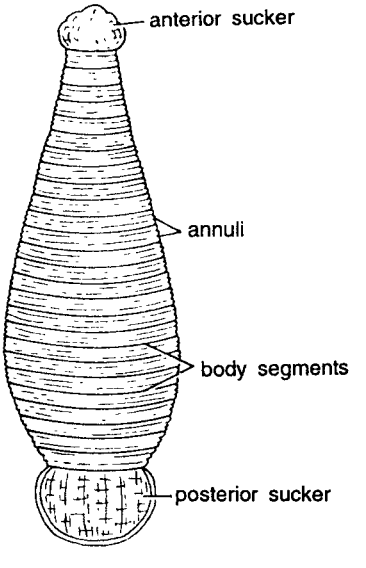


Fig. 106. *Haemopis.*

107. *Polygordius*

Classification :

Phylum.....Annelida	→	Metamerically segmented, coelomate and bilaterally symmetrical.
Class.....Archiannelida	→	Primitive annelids.
Family.....Polygordiidae	→	Short tentacles.
Genus.....*Polygordius lacteus*		

Habit and habitat : ***Polygordius*** is a small, simple, aberrant, marine scavenger worm (Fig. 107).

Distribution : It is found living in the sand of the European seas.

Comments :

(1) **Body** is narrow, elongated, cylindrical and resembles larval polychaetes.
(2) Divisible into head and body segments, measuring 30 to 100 mm.
(3) **Head** comprises of small **prostomium** and large **peristomium**.
(4) Head bears a pair of small **prostomial tentacles**, **ventral mouth** and **ciliated pits**.
(5) External segmentation of the body is faintly marked by grooves in anterior region and clearly marked in posterior region.
(6) **Coelom** is divided by septa, last segment contains anus.
(7) Setae, parapodia, cirri and gills are absent.
(8) Sexes are separate. Gonads develop in posterior segments. There are no reproductive ducts.

Identification : Since the specimen contains small prostomium and large peristomium and all above features, hence it is ***Polygordius***.

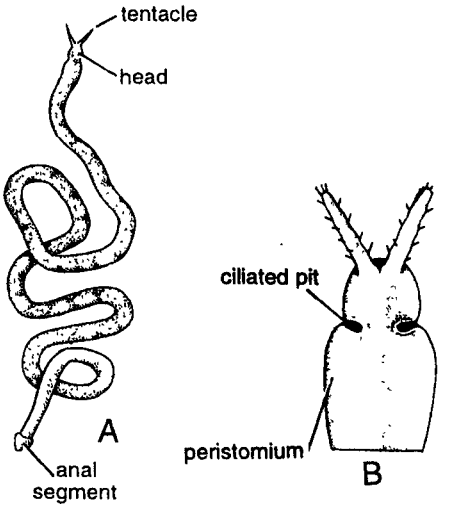


Fig. 107. *Polygordius.* **A.** Entire worm, **B.** Anterior end in dorsal view.

108. *Protodrilus*

Classification :

Phylum.....Annelida	→	Metamerically segmented, coelomate and bilaterally symmetrical.
Class.....Archinnelida	→	Primitive annelids.
Family.....Protodrilidae	→	Long tentacles.
Genus.....*Protodrilus*		

Habit and habitat : ***Protodrilus*** is a small marine worm.

Distribution : It is found in inland sea, lake at Faro near Messina, U.S.A.

Comments :

(1) **Animals** live in sand.
(2) **Body** is narrow, elongated, cylindrical and thread-like.
(3) **Prostomium** of head is small and bears a pair of **long tentacles** called as prostomial ciliated tentacles.
(4) **Peristomium** is large and contains a pair of sensory ciliated pits.
(5) External segmentation is marked by ciliated rings bearing circlet of cilia.

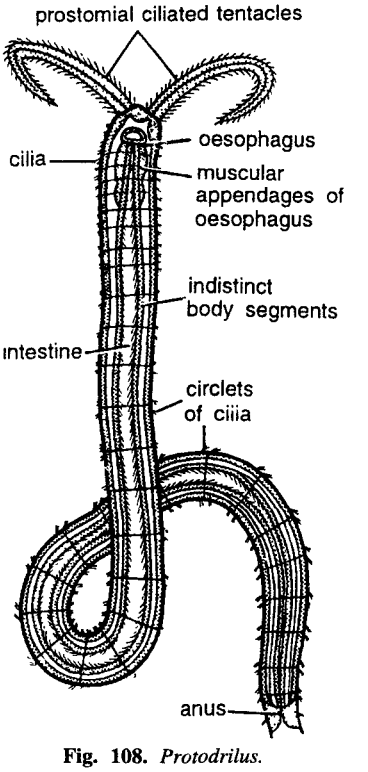


Fig. 108. *Protodrilus.*

(6) Setae, parapodia and gills are absent.
(7) ***Protodrilus*** is **hermaphroditic.**
(8) **Development** is direct.

Identification : Since the specimen contains a pair of ciliated tentacles and all above features, hence it is ***Protodrilus.***

PHYLUM MOLLUSCA

Natural history

Molluscs are successfully living since **Cambrian** time. Presently 500,000 living species besides fossils. For the first time molluscs have acquired hard shell for protection. They are all free-living in fresh water, brackish water and sea water. Clams, oysters, squids serve as human food. Pearl oysters produce pearls for human ornaments. Certain snails serve as intermediate host for helminthic diseases of man and his animals. Gastropod molluscs reveal **torsion** and **detortion**. Molluscs have medical importance. ***Pila globosa*** is the **slowest moving animal.**

Diagnostic characters

(1) Unsegmented (except in Monoplacophora).
(2) Presence of shell mantle, visceral mass and foot.
(3) Circulatory system open.
(4) Excretion by paired metanephridia.

Classification

CLASS I AMPHINEURA
1. Elongated or oval body.
2. Head reduced without eyes and tentacles.

Order 1 Aplacophora
1. Worm like without shell and foot.
2. Integument thick with minute spicules.
   Ex. *Chaetoderma.*

Order 2 Polyplacophora
1. Body oval with large flat foot.
2. Shell of a midorsal row of 8 broad plates.
   Ex. *Chiton, Ischnochiton.*

CLASS II SCAPHOPODA
1. Tooth shells or tusk shells.
2. Shell and mantle tubular, curved and open at both ends.
   Ex. *Dentalium.*

CLASS III GASTROPODA
1. Univalve shell usually spirally coiled due to torsion.
2. Tentacles and eyes present.

Sub-class A Prosobranchiata (= Streptoneura)
1. Nervous system in the form of 8.
2. Gills (Ctenidia) anterior to heart.

Order 1 Aspidobranchiata
1. Two rows of filamentous gills.
2. Two auricles, two nephridia.

Sub-order 1 Docoglassa
1. Nervous system less concentrated.
2. Ctenidium replaced by secondary gills.
   Ex. *Patella Acmea, Lottia.*

Sub-order 2 Rhipidoglossa
1. Shell valves without insertion plates.
2. Few Ctenidia
   Ex. *Lepidioplurus, Haliotes Trochus, Turbo.*

Order 2 Pectinibranchiata
1. Nervous system not concentrated.
2. Single ctenidium.

Sub-order 1 Taenioglossa
1. Gill filaments in single row.
2. Shell spirally coiled or boat shaped.
   Ex. *Cyprea, Triton, Pila.*

Sub-order 2 Rachiglossa
1. Nervous system concentrated.
2. Edge of shell with siphonal notch or canal.
   Ex. *Buccinium, Mure, Conus.*

Sub-class B Euthyneura
1. Shell reduced.
2. Nerves not twisted in the form of 8.

Order 1 Opisthobranchia
1. Viscera and nervous system secondarily unwound.
2. Single nephridium, auricle and gill.

Sub-order 1 Tectibranchia
1. Shell internal, single gill.
2. Parapodial lobes large.
   Ex. *Aplysia, Bulla.*

Sub-order 2 Pteropoda
1. Shell present.
2. Foot modified into wing like parapodia for swimming.
   Ex. *Cavolina.*

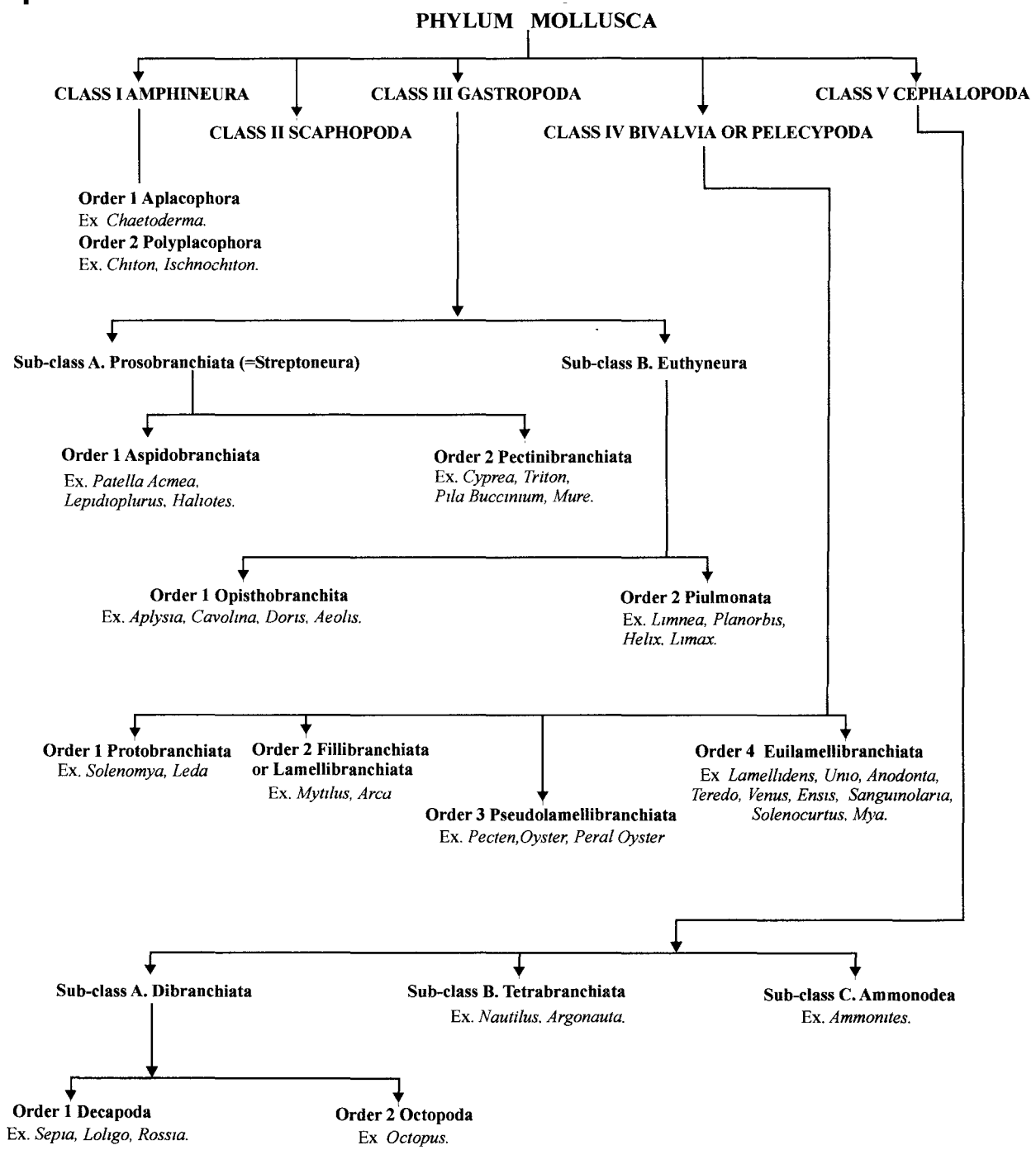
Sub-order 3 Nudibranchia
1. Sea slugs. No external shell.
2. Dorsal surface with extensive projections called cerrata.
   Ex. *Doris, Aeolis.*

Order 2 Pulmonata
1. Fresh-water and land snails and slugs.
2. Shell a simple spire or absent.

Sub-order 1 Basommatophora
1. Fresh-water small limpets.
2. One pair of tentacles and eyes near the tentacle base.
   Ex. *Limnea, Planorbis.*

Sub-order 2 Stylommatophora
1. Land snails.
2. Tentacles 2 pairs. Eyes at the tip of hind pair.
   Ex. *Helix, Climax.*

(Contd..)


PHYLUM MOLLUSCA
CLASS I AMPHINEURA
CLASS II SCAPHOPODA
CLASS III GASTROPODA
CLASS IV BIVALVIA OR PELECYPODA
CLASS V CEPHALOPODA
Order 1 Aplacophora
Ex Chaetoderma.
Order 2 Polyplacophora
Ex. Chiton, Ischnochiton.
Sub-class A. Prosobranchiata (=Streptoneura)
Sub-class B. Euthyneura
Order 1 Aspidobranchiata
Ex. Patella Acmea, Lepidioplurus, Haliotes.
Order 2 Pectinibranchiata
Ex. Cyprea, Triton, Pila Buccinum, Mure.
Order 1 Opisthobranchita
Ex. Aplysia, Cavolina, Doris, Aeolis.
Order 2 Piulmonata
Ex. Limnea, Planorbis, Helix, Limax.
Order 1 Protobranchiata
Ex. Solenomya, Leda
Order 2 Fillibranchiata or Lamellibranchiata
Ex. Mytilus, Arca
Order 3 Pseudolamellibranchiata
Ex. Pecten,Oyster, Peral Oyster
Order 4 Euilamellibranchiata
Ex Lamellidens, Unio, Anodonta, Teredo, Venus, Ensis, Sanguinolaria, Solenocurtus, Mya.
Sub-class A. Dibranchiata
Sub-class B. Tetrabranchiata
Ex. Nautilus, Argonauta.
Sub-class C. Ammonodea
Ex. Ammonites.
Order 1 Decapoda
Ex. Sepia, Loligo, Rossia.
Order 2 Octopoda
Ex Octopus.

CLASS IV BIVALVIA OR PELECYPODA

1. Bivalve shell made of 2 lateral valves.
2. Mantle flattened gills 1 or 2 pairs.

Order 1 Protobranchiata

1. Gill with central axis bearing 2 divergent rows of short filaments.
2. Foot flat ventrally. Two adductor muscles.
   Ex. *Solenomya, Leda.*

Order 2 Fillibranchiata or Lamellibranchiata

1. Gills enlarged, filliform.
2. Often with byssus.
   Ex. *Mytilus, Arca.*

Order 3 Pseudolamellibranchiata

1. Gills from vertical folds.
2. Anterior adductor muscle large. Siphon absent.
   Ex. *Pecten, Oyster, Pearl oyster.*

Order 4 Eulamellibranchiata

1. Gills filaments united by interfilamental and inter lamellar junctions.
2. Equalor sub-equal adductor muscles.
   Ex. *Lamellidens, Unio, Anodonta, Teredo, Venus, Ensis, Sanguinolaria, Solenocurtus, Mya.*

CLASS V CEPHALOPODA

1. Head large, eyes conspicuous and complex.
2. Shell external or internal or absent.

Sub-class A. Dibranchiata

1. Gills 2, Nephridia 2.
2. Shell internal or reduced.

Order 1 Decapoda

1. Ten arms.
2. Internal chambered shell.
   Ex. *Sepia, Loligo, Rossia.*

Order 2 Octopoda

1. Eight arms.
2. Shell absent.
   Ex. *Octopus.*

Sub-class B. Tetrabranchiata

1. Gills, kidneys and auricles each 4 in number.
2. Shell spirally coiled.
   Ex. *Nautilus, Argonauta.*

Sub-class C. Ammonodia

1. Shell external
2. Suturelines irregular
   Ex. *Ammonites.*

109. *Chaetoderma*

Classification :

Phylum.....Mollusca → Unsegmented bilaterally symmetrical and provided with visceral mass, foot and mantle.

Class.....Amphineura → Head reduced, without eyes and tentacles, nervous system without definite ganglia.

Phylum.....Mollusca → Shell absent.

Order.....Aplacophora

Genus.....*Chaetoderma*

Habit and habitat : ***Chaetoderma*** is marine inhabiting modern to abyssal depths, generally found in non-littoral zone. The mollusc is carnivorous, aberrant and specialized.

Distribution : Found in U.S.A. and Europe.

Comments :

(1) **Body** of the animal is elongated, vermiform and almost cylindrical.
(2) **Mantle** well developed and completely covering the body.
(3) **Shell** is absent but cuticle contains numerous **calcareous spicules.**
(4) Animal has anterior **mouth** a constriction, **calcareous cuticular spicules** or epidermal papillae and **anus.**
(5) **Heart** with single auricle.
(6) **Nervous system** is well developed with brain and ganglia.
(7) Gills are reduced to a pair found in the cloacal cavity.
(8) Nephridial ducts act as **coelomoducts.**

Identification : Since the animal has cylindrical body, cuticular spicules and all above features, hence it is ***Chaetoderma.***

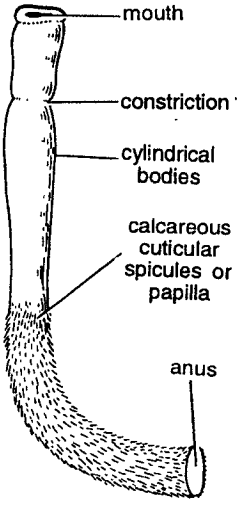


Fig. 109. *Chaetoderma.*

110. *Chiton* or *Ischnochiton*

Classification :

Phylum.....Mollusca	→	Unsegmented bilaterally symmetrical and provided with visceral mass, foot and mantle.
Class.....Amphineura	→	Head reduced, without eyes and tentacles, nervous system without definite ganglia.
Order.....Polyplacophora	→	Foot flat and mantle secretes 8 shell plates.
Genus.....*Chiton* (Sea mouse)		

Habit and habitat : ***Chiton*** is a marine and sluggish slow moving animal, attached to rocks, empty shells, corals and under stones between tidemarks. It is mostly nocturnal and remains concealed under rocks during day-time. It rolls its body when disturbed. It is a vegetable feeder and its food consists of algae and diatoms.

Distribution : ***Chitons*** are found in all parts of the world in shallow waters, few species live in deep sea.

Comments :

(1) **Commonly** called as **sea mouse**, measuring about 1 to 5 cms.

(2) **Body** is elliptical, bilaterally symmetrical and dorsoventrally flattened and is differentiated into a small, indistinct **head**, a large flat **foot** and a dorsal **mantle** forming a roof-like covering.

(3) Head contains ventral mouth and **labial palps**. Below head is sole of **foot** ventrally.

(4) **Eyes** and **tentacles** are absent. **Mouth** and **anus** are opposite ends.

(5) Dorsal side of mantle contains a linear series of 8-**calcareous overlapping plates** marked with lines of growth. Sides of mantle form **mantle girdle**.

(6) Several pairs of bipectinate **ctenidia** are found in a complete rows on either side of the body and lie in a mantle groove between foot and ventral side.

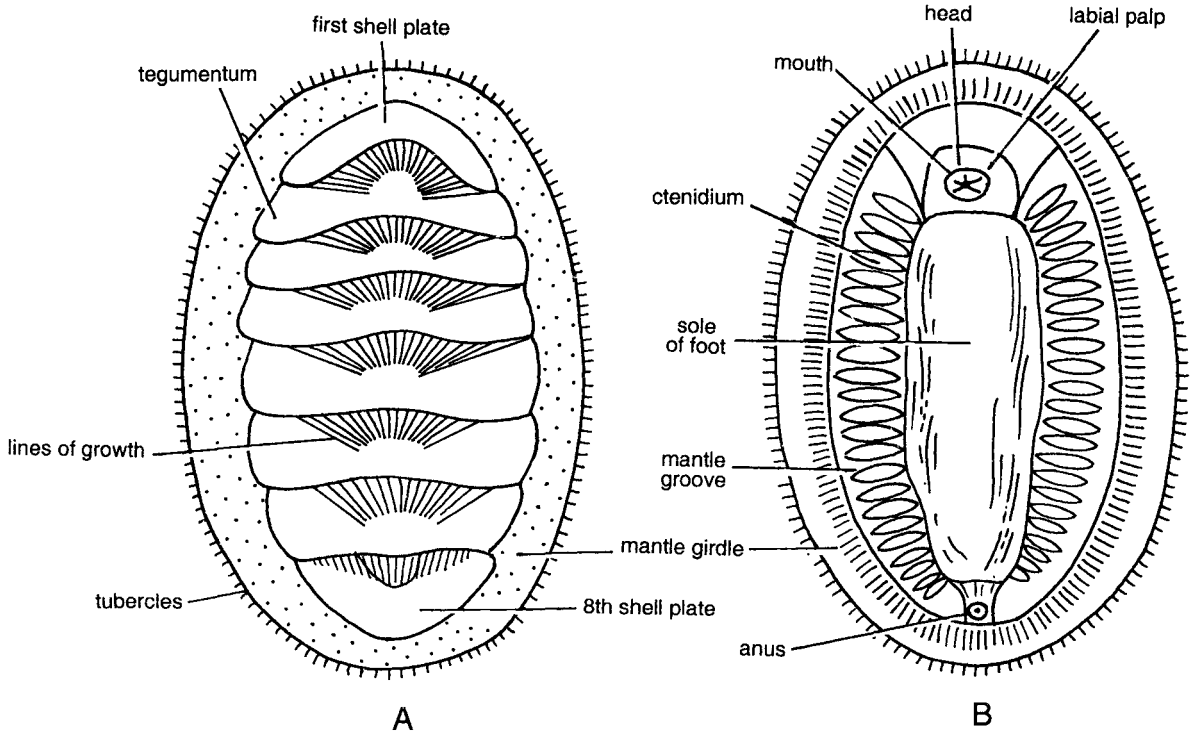


Fig. 110. *Chiton.* **A.** Dorsal view, **B.** Ventral view.

(7) Plates are surrounded and kept in place by a muscular integumental fold called girdle.
(8) Entire periphery of the mantle girdle contain small calcified **tubercle** or **spicule**.
(9) Exposed part of the plate is called as **tegumentum** and overlapping part is called as **articulum**.

Economic importance : Sometimes ***Chiton*** is eaten by man. The foot is called as sea beal.

Identification : Specimen contains 8 calcareous plates dorsally and all above features hence it is ***Chiton***.

111. *Dentalium*

Classification :

Phylum.....Mollusca → Unsegmented, bilaterally symmetrical and provided with visceral mass, food and mantle.

Class.....Scaphopoda → Head indistinct, shell tubular and opened at both ends.

Genus.....*Dentalium* (Tusk shell)

Habit and habitat : ***Dentalium*** is marine, living in clean sand in various depths from shallow water to 2,600 fathoms deep.

Distribution : They are commonly found in Europe, Pacific coast, New England coast (except polar seas).

Comments :

(1) **Body** called as **Elephant's tusk shell.**
(2) Body of the animal lies in a tubular, bilaterally symmetrical, cylindrical and arched shell secreted by mantle, the concave side representing the upper or dorsal side of the body.
(3) Body of the animal has a **vestigial head**, which protrudes as **proboscis** from shell, without eyes.
(4) **Mouth** is surrounded by leaf like **tentacles** called as **captacules** having sucker like tips which are **sensory**, **prehensile** and can **regenerate**.
(5) No **ctenidia** are present, the tentacles being possibly homologous to them.
(6) **Conical foot** also protrudes from shell from anterior end and burrows in sand.
(7) After removing the shell, internal structures, such as **muscles**, **liver and kidneys** are seen. **Radula** is well developed. **Anus** behind the base of the foot. Respiration by transverse folds in the lining of the mantle because gills are absent. Circulatory system is poorly developed. **Nervous system** is simple, consisting of usual cerebral, pleural and pedal ganglia. Eyes are absent.
(8) Circulatory system is very simple and there is **no distinct heart**.
(9) **Sexes separate.**

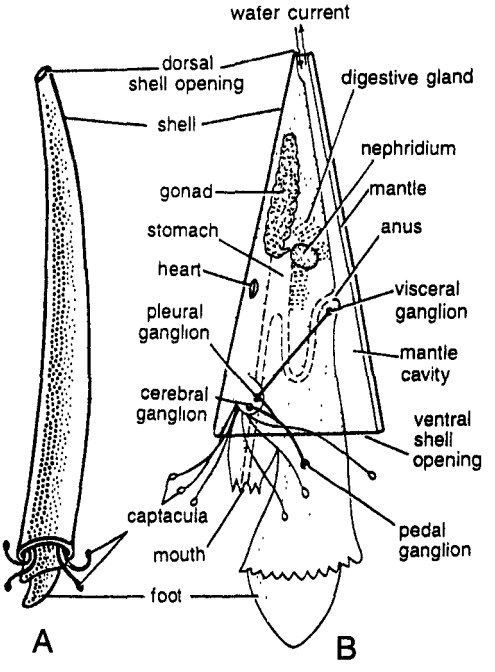


Fig. 111. *Dentalium.* **A.** Shelf, **B.** Animal buried in sand.

Economic importance : The tusk shell was economically very important for Red Indian tribes of America. They used ***Dentalium indianorum*** as Sanampum of money (as currency).

Identification : Since the body is enclosed in a tusk shell and it has all above features hence it is ***Dentalium***.

112. *Patella*

Classification :

Phylum.....Mollusca	→	Soft bodied, non-metameric, shelled and foot-bearing animals.
Class.....Gastropoda	→	Visceral hump twisted.
Sub-class.....Prosobranchiata	→	Gills in front of heart.
Order.....Aspidohranchiata	→	Gills bipectinate.
Sub-order.....Docoglossa	→	Ctenidium replaced by secondary gills.
Genus.....*Patella*		

Habit and habitat : ***Patella*** is found on rocky beaches between tidemarks. It feeds on smaller sea-weeds and other marine vegetation.

Distribution : It is found along Pacific coast, Atlantic coast, Europe and U.S.A. (California).

Comments :

(1) **Commonly** called as true **limpet**.
(2) Small, oval and sluggish creature.
(3) Dorsal side of the body is enclosed by a roundish shell, which is raised into a conical elevation by which it is easily recognized.
(4) **Shell** forms the miniature volcanic cone and dorsally it contains **lines of growth**. Operculum absent.
(5) Underside of the limpet shows a large foot with a broad creeping sole which acts as attachment organ to rocks.
(6) **Head** contains 2 stout, **sensory tentacles**. There are 2 **osphradia**, 2 **nephridia** and a simple heart (1 auricle).

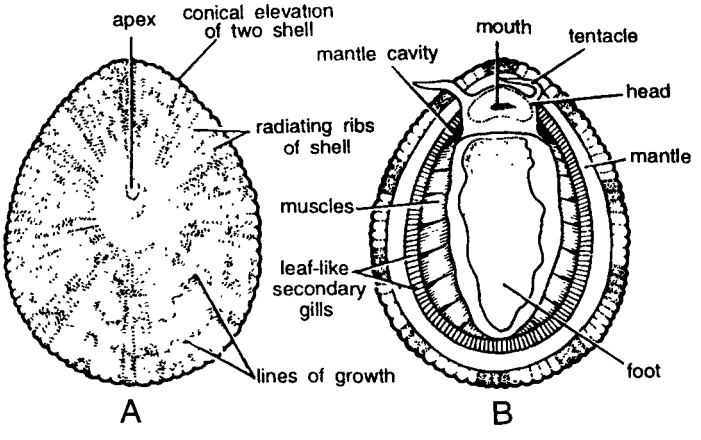


Fig. 112. *Patella.* **A.** Dorsal view, **B.** Ventral view.

(7) True mantle cavity is restricted anteriorly and true ctnidia are replaced by **pseudotenidia** or **secondary gills**.
(8) **Radula docoglossate** with 3 marginals and 3 laterals but no central teeth. There is no siphon.
(9) A secondary pallial cavity extends all round between the **foot** and **mantle**.
(10) **Nervous system** shows little concentration towards the head region.

Economic importance : ***Patella*** has food value as it is generally eaten in France, Italy and Ireland.

Identification : Since the specimen contains radiating ribs and all above features, hence it is ***Patella***.

113. *Fissurella*

Classification :

Phylum.....Mollusca		
Class.....Gastropoda	→	Characters same as those of ***Patella***.
Sub-class.....Prosobranchiata		
Order.....Aspidobranchiata		
Sub-order.....Rhipidoglossa	→	Ctenidia and auricles paired.
Genus.....*Fissurella*		

Habit and habitat : ***Fissurella*** is a marine gastropod found attached with rocks.

Distribution : Found in U.S.A.

Comments :

(1) **Commonly** called as **Key-hole limpet.**
(2) **Shell** is oval, compressed, non-spiral and having a small apical shell aperture which looks little **volcanic crater.**
(3) Shell protects the animal from the impacts of the waves.
(4) **Ventral foot** is large, sole-like and is used as sucker for clinging to rocks.
(5) **Foot** bears on either side an epipodial ridge bearing a row of cirri or **epipodial tentacles.**
(6) **Operculum** is absent.
(7) **Head** contains **mouth** or **apical shell aperture** and **pair of sensory tentacles.**

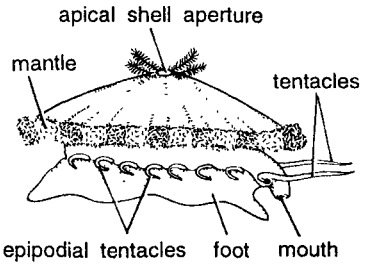


Fig. 113. *Fissurella.*

Identification : Since the animal contains epipodial tentacles and all above features it is ***Fissurella.***

114. *Haliotis*

Classification : Same as that of ***Fissurella.***

Genus.....*Haliotis*

Habit and habitat : ***Haliotis*** is a marine prosobranchiate inhabiting below low-tide level attached to rocks and boulders and feeding upon seaweeds and other dead organic matter (Fig. 114).

Distribution : Commonly found in China, Japan, U.S.A. Pacific coasts and Europe.

Comments :

(1) **Commonly** called as **abalone.**
(2) Shell is flattened ear-shaped and perforated with a series of holes **tentacular processes** emerge. Shell also contains several foramina through which respiratory water current passes.
(3) Large **foot** is provided with **epipodia** containing numerous **sensory tentacles.**
(4) Operculum is absent. **Eyes** are stalked.
(5) Spacious mantle contains a pair of gills.
(6) Anteriorly **siphon** contains a pair of **tentacles** on each side.

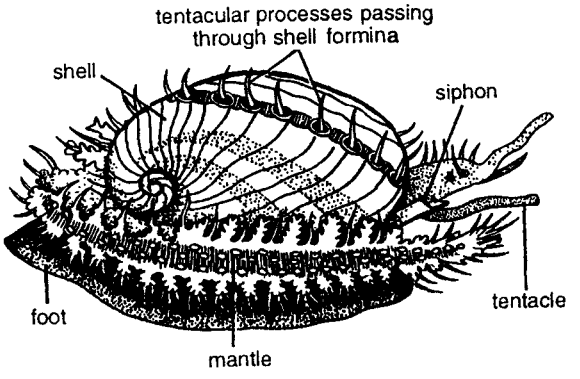


Fig. 114. *Haliotis.*

Economic importance : The colourful pearly iridescent beautiful shells when polished are much sought after in Europe and U.S.A. for the extensive manufacture of buttons, jewellery, souvenirs and buckles. The flesh is considered a delicacy in China, Japan and Europe.

Identification : Since the specimen contains sensory tentacles and all above features, hence it is ***Haliotis.***

115. *Cypraea*

Classification :

Phylum.....Mollusca	→	Soft bodied non-metameric, shelled and foot-bearing animals.
Class.....Gastropoda	→	Visceral hump twisted.
Subclass.....Prosobranchiata	→	Gills in front of heart.
Order.....Pectinibranchiata	→	Ctenidium comb-like or monopectinate.
Genus.....*Cypraea*		

Habit and habitat : ***Cypraea*** lives on rocky ground, in shallow marine water.

Distribution : Tropical and subtropical form. Mostly found in the Indian and Pacific oceans, Africa and U.S.A. (Florida, California).

Comments :

(1) **Commonly** called as **cowry**.

(2) Dorsal side is convex and the ventral side is flat with a narrow longitudinal opening extending along ventral length of the shell in the form of **toothed channel** or **shell aperture**.

(3) Solid shell is very smooth, polished and often highly coloured. Spine often concealed by the last whorl.

(4) **Mantle** and the **foot** are more beautiful.

(5) Lateral folds of mantle are reflected over the shell and may completely cover it.

(6) In entire expanded animal a pair of **eyes, tentacles, pallial tentacles, foot mantle** and **siphon** are easily seen.

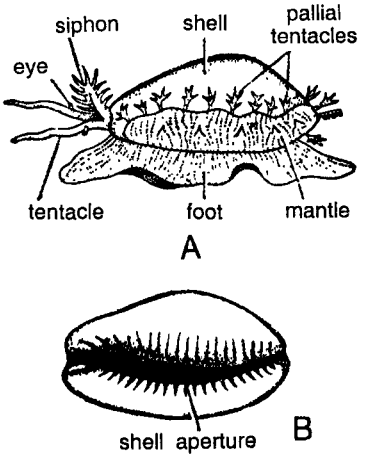


Fig. 115. *Cypraea.* **A.** Entire animal, **B.** Shell in ventral view.

Special features : The cowry shells are much used as ornaments, curious and mantle-piece decorations. The ***Cypraea moneta*** is used as money in the Pacific Islands and Africa. ***Cypraea tigris*** is beautifully engraved with Lord's prayer and sold as curio or used as mantle piece ornament.

Identification : Since the ventral shell contains toothed shell aperture and all above features, hence it is ***Cypraea***.

116. *Pila globosa* : Apple Snail

Classification :

Phylum.....**Mollusca**
Class.....**Gastropoda**
Sub-class.....**Prosobranchiata**
Order.....**Pectinibranchiatal** → Characters same as those of Cypraea.

Sub-order.....**Taenioglossa** → Radula with 7 teeth in each row.

Genus.....***Pila***
Species.....***globosa***

Habit and habitat : ***Pila globosa*** is one of the largest fresh-water gastropod abundantly found in ponds, tanks, rice-fields and in water having succulent vegetation. They are amphibious. In winter they hibernate in the mud by the side of the pond and during prolonged drought they remain dormant.

Distribution : It is most common in India, U.S.A. and Europe.

Comments :

(1) **Commonly** called as fresh-water **apple snail** (Fig. 116).

(2) Body is covered by a thick yellow-coloured or brown globular univalve shell, comprising of **body whorl, penultimate whorl** and **apex**. Each division is separated by **sutures**.

(3) Surface of the shell is marked by **lines of growth**.

(4) **Shell** is **spirally coiled round the axis**, called the **columella**, and opens to the exterior by mouth of aperture.

(5) Type of coiling is right handed and is called as **dextral**.

(6) After removing the shell the soft part contains **head, foot** and **visceral mass**.

(7) **Mouth** of the shell is wide and covered by **operculum**, which is attached to the hinder part of the foot and shows **many concentric rings of growth** around nucleus, **umblicus** and **columellar lip** are closely placed.

(8) **Head** lies on the upper side and contains 1 pair of eyes. Foot is highly muscular and acts as creeping organ. Visceral mass spirally coiled and contains internal organs. It is covered by mantle or pallium. When the foot is protruded during living condition, the head, nuchal lobes, eyes, tentacles, etc. are distinctly seen. These structures are seen after removing the shell.

(9) Sexes are separate but without sexual dimorphism.

Special features : ***Pila*** is the slowest moving animal but it has great medicinal, experimental and study value.

Identification : Since the specimen contains largest body whorl and all above features hence it is ***Pila***.

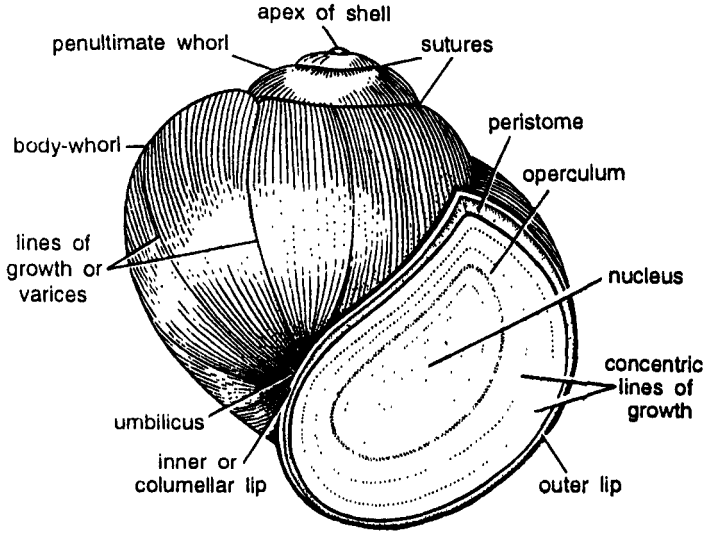


Fig. 116. *Pila.* Entire animal.

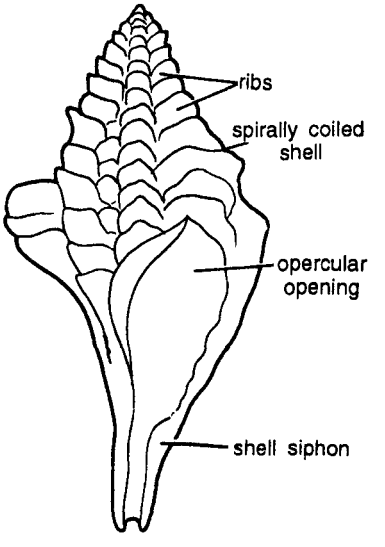


Fig. 117. *Murex.*

117. *Murex angulifer*

Classification :

Phylum.....**Mollusca**
Class.....**Gastropoda**
Sub-class.....**Prosobranchiata**
Order.....**Pectinibranchiata**
→ Characters same as those of ***Cypraea***.

Sub-order.....**Rachiglossa** → Radula with 3 or less teeth in a row.

Genus.....***Murex***

Species.....***angulifer***

Habit and habitat : ***Murex*** is an active, carnivorous and marine gastropod, feeding on living and dead animals in the sea.

Distribution : It is found on the Syrian coast, Greece, Italy, India, West Indies and U.S.A. (California). Found both in tropical and temperate seas.

Comments :

(1) **Shell** is **spirally coiled**, **dextral** with a long and prominent spine bearing 3 or more rows of prominent protuberances or **spines** forming ribs.

(2) Aperture round, ending below in a long canal.

(3) **Peristome** is produced into a long, spout-like prolongation known as the **shell siphon** which leads into the mantle cavity.
(4) **Head** is prolonged anteriorly into a long proboscis, which can be retracted within a proboscis sheath.
(5) **Foot** is large and tough, having flat creeping sole.
(6) Shell is **spirally twisted** with an **operculum**.
(7) **Sexes** are separate. The male has projecting muscular penis. The **visceral hump** is spirally coiled.
(8) **Eyes** are placed at the base of the tentacles. Salivary glands and liver contain proteolytic enzymes.
(9) **Heart** has one **auricle** and kidney is also one.
(10) **Nervous system** is highly concentrated.

Economic importance : Some species of ***Murex*** are destructive to **oyster** industry. It has also ornamental importance and is also used for producing worshipping sound (Shankh). In ancient times the well-known Tyrian or imperial purple dye was obtained from ***M. trunculus*** and ***M. bramdoris***. The dye consisted of a yellowish secretion from a large mucous gland in the mantle.

Identification : Since the specimen has spirally coiled shell rib and all above feature hence it is ***Murex***.

118. *Aplysia*

Classification :

Phylum.....Mollusca	→	Unsegmented, bilaterally symmetrical and provided with visceral mass, foot, shell and mantle.
Class.....Gastropoda	→	Head bearing tentacles, eyes and radula; visceral hump and shell coiled due to torsion.
Sub-class.....Euthyneura	→	Nerve loop not twisted in figure of 8.
Order.....Opisthobranchia	→	Gastropods with detorsion; gills posterior of heart; shell reduced or lacking.
Sub-order.....Tectibranchia		
Genus.....*Aplysia* (The sea hare)		

Habit and habitat : ***Aplysia*** is a marine gastropod found crawling among seaweeds. It has remarkable power of colour changes like the colour of the surroundings. It inhabits upto a depth of 40 fathoms in uncontaminated water.

Distribution : It is found in India, Asia, West Indies and on the Florida coast.

Comments :

(1) **Commonly** called as **sea hare**.
(2) **Body** of the animal is soft, slimy, fleshy and whitish or greenish in colour. Anterior end bears **head** and **neck**.
(3) Animal is slug-like, with the anterior angles of the head extended into two large tentacular folds.
(4) Besides anterior **tentacular folds**, there are pair of eyes and behind eyes another tentacular fold like structure called as **rhinophores**.
(5) **Mantle** cavity is open on the right side with backwardly pointing **ctenidium** through a longitudinal slit. Anus is posteriorly located. **Opening** of **shell sac** and **seminal groove** is also seen.
(6) **Foot** is muscular, and elongated pointed posteriorly.

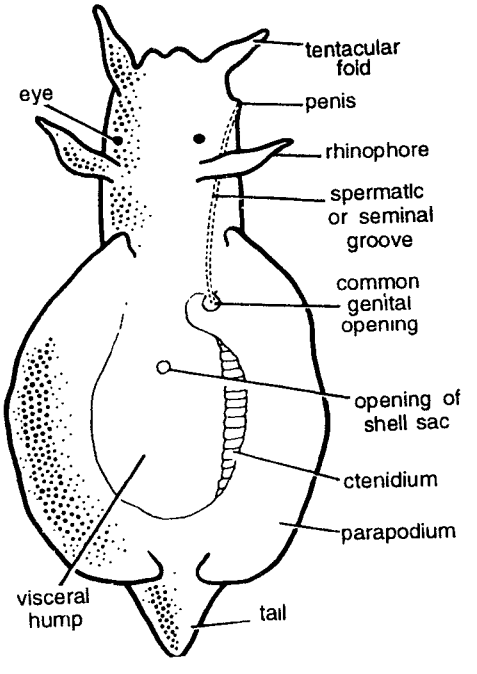


Fig. 118. *Aplysia.*

(7) On the lateral side, there is a pair of large fleshy outgrowths called as **parapodia**, which project upwards and inwards to enclose **visceral hump** and are used as fins for swimming.
(8) **Shell** is internal and rudimentary. Opening of shell sac and spermatic seminal groove also seen.
(9) Animal is bisexual with a single gonoduct and a common **genital opening**.

Special features : ***Aplysia*** when disturbed secretes a purple fluid from the opening shell sac found in the mantle wall and it makes itself invisible to the enemy.

Identification : Since the animal has rhinophores and all above features, hence it is ***Aplysia***.

119. *Doris*

Classification :

Phylum.....**Mollusca**
Class.....**Gastropoda**
Sub-class.....**Euthyneura**
Order.....**Opisthobranchiata** } → Characters same as those of ***Aplysia***.
Sub-order.....**Nudibranchia** → Adults naked without mantle and shell.
Genus.....***Doris*** **(Sea lemon)**

Habit and habitat : ***Doris*** is a sluggish marine and curious gastropod found under stones at low tide mark and between weeds. It feeds on incrusting organisms like sponges (Fig. 119).

Distribution : Cosmopolitan but specially found in the waters of New England.

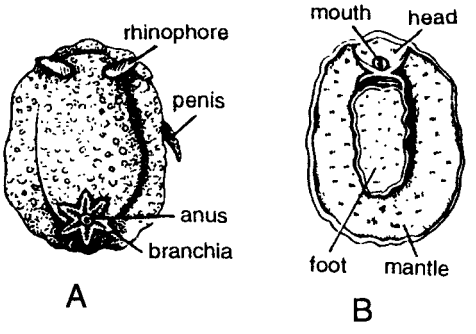


Fig. 119. *Doris*. **A.** Dorsal view, **B.** Ventral view.

Comments :

(1) **Commonly** known as **sea lemon**.
(2) **Body** consists of more or less ovoid mass with a convex warm dorsal side.
(3) Colour is purplish brown.
(4) **Head** bears a pair of short **retractile tentacles** or **rhinophores** beset with calcareous spicules.
(5) **Mantle** is usually pigmented and contains calcareous spicules or dorsal tubercles.
(6) The anus lies mid-posteriorly and is surrounded by a circlet of feathered retractile secondary branchiae.
(7) Ventral surface has **mouth**, **head**, **tentacle** and **mantles**. **Anus** is surrounded by **branchia** or gills.
(8) **Foot** has a large **creeping sole**. Dorsal surface has **protruding penis**.
(9) Digestive gland unbranched compact mass and nervous system of **euthyneurous** type.
(10) **Sexes** are united and the gonopore is asymmetrically placed on the right side of the body.

Identification : Since the animal contains secondary retractile tentacles and all above features hence it is ***Doris***.

120. *Aeolis*

Classification : Same as that of ***Doris***.

Genus.....***Aeolis***

Habit and habitat : ***Aeolis*** is a slug-like, marine gastropod, living among seaweeds and under stones between tide lines.

Distribution : It is found in Europe, U.S.A. and Rhodes Island or Arctic ocean.

Comments :

(1) **Commonly** called as **sea slug** measuring 5 cm.
(2) **Body** is elongated, shell-less, broad, elongated, depressed, tapering behind, gray or orange-coloured with brown or white spots.
(3) **Head** comprises of 2 pairs of cylindrical non-retractile oral **tentacles** and a pair of sessile **eye spot.**
(4) The anterior pair of tentacles is called as **cephalic tentacles,** while posterior pair is designated as **rhinophores.**
(5) **Anus** is seen in mid dorsal position.
(6) True **ctenidia** are replaced by several secondary cylindrical **branchiae** or **cerata,** which are distributed over dorsal surface in 15 to 20 slanting rows.
(7) Dorsal surface has **eyespots, anus** and the ventral surface contains **foot.**
(8) **Hermaphroditic protandrous** form.

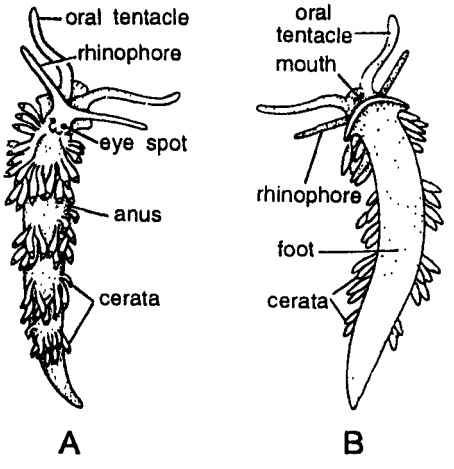


Fig. 120. *Aeolis.* **A.** Dorsal view, **B.** Ventral view.

Special features : It feeds on sea anemones, whose nematocysts are stored in the cerata and discharged on irritation. This is a unique example of an animal using in defence of the offensive organs of another.

Identification : Since the specimen contains cerata and all above features, hence it is ***Aeolis***.

121. *Limnaea*

Classification :

Phylum.....Mollusca	→	Soft bodied, non-metameric, shelled.
Class.....Gastropoda	→	Visceral hump twisted.
Sub-class.....Euthyneura	→	Nerve loop not twisted in figure of 8.
Order.....Pulmonata	→	Air-breathing forms.
Sub-order.....Basommatophora	→	Eyes at the base of tentacles.
Genus.....*Limnaea*		

Habit and habitat : ***Limnaea*** is a typical fresh-water snail, found in ponds, lakes, etc.

Distribution : It is found in the northern states form Atlantic to Pacific, Europe, New England to Kansas, California, and the entire Pacific coast.

Comments :

(1) **Commonly** called as **pond snail.**
(2) **Shell** is thin, horny and fragile with a sharply elongated spire.
(3) **Body whorl** is the largest, while the **penultimate whorl** and **apex** are smaller.
(4) Body whorl opens by a wide aperture which is covered by **operculum.**
(5) **Eyes** are placed at the base of the single pair of **flattened tentacles.** The tentacles cannot be invaginated.
(6) **Foot** is rounded behind. Species of ***Limnaea*** are quite resistant to freezing. They can survive for several weeks in ice.

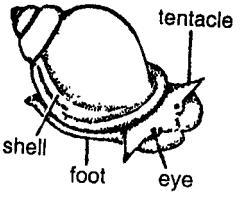


Fig. 121. *Limnaea.*

Special features : ***Limnaea truncatula*** serves as **intermediate host** for the larval stages of the liver fluke. **Sporocyst** and **redia** stages of ***Fasciola hepatica*** are found in ***L. truncatula***. The pond snail and **miracidium** larva of ***F. hepatica*** exhibit strong host specificity.

Identification : Since the animal contains elongated spire and all above features, hence it is ***Limnaea***.

122. *Planorbis*

Classification : Same as that of ***Limnaea.***

Genus.....*Planorbis*

Habit and habitat : ***Planorbis*** is another abundant and most common fresh-water, air-breathing gastropod, found in ponds and lakes in large numbers.

Distribution : It is commonly found in India and Europe.

Comments :

(1) **Animal** is enclosed in black, stout and spirally coiled shell.

(2) **Shell** is **sinistral** and discoidal having a depressed or flattened spire.

(3) **Head** protrudes through the shell opening. It contains **filiform tentacles and a pair of eyes.**

(4) **Mantle** lobe outside pulmonary cavity is transformed into a functional gill.

Special features : ***Planorbis*** also served as intermediate host for larval stages of the flukes.

Identification : Since the specimen contains flattened spirally coiled spire and all above features, hence it is ***Planorbis.***

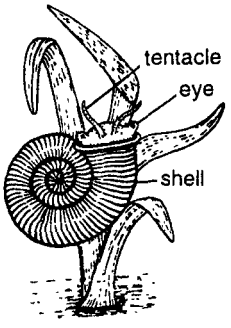


Fig. 122. *Planorbis.*

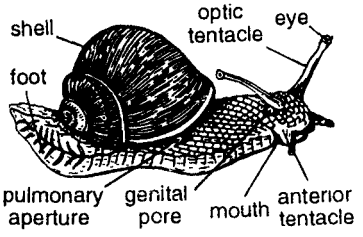


Fig. 123. *Helix.*

123. *Helix*

Classification :

Phylum.....Mollusca
Class.....Gastropoda
Sub-class..... Euthyneura
Order..... Pulmonata
→ Characters same as those of ***Limnaea.***

Sub-order..... Stylommatophora → Eyes at the tips of posterior tentacles.

Genus.....*Helix* (Escargot or Vineyard snail)

Habit and habitat : ***Helix*** is common terrestrial air breathing gastropod, nocturnal hibernating creature (in winter). It feeds on leafy vegetation.

Distribution : Several species are found in Palarctic region; poorly represented in America.

Comments :

(1) **Commonly** called as **garden snail.**

(2) **Shell** is thin, external and heliciform with a low conical **spire**, measuring 4 cm in length.

(3) **Shell** has a smooth aperture and prominent lines of growth.

(4) **Body** consists of **head, foot** and **visceral hump.**

(5) **Head** comprises of two pairs of **tentacles** and mouth. The posterior pair of tentacles **bears eyes** (oculiferous). The mouth is provided with three prominent lips.

(6) **Anterior pair** of **tentacles** small while posterior pair of tentacles are large which bear **oculiferous** eyes.

(7) **Genital aperture** opens above the right lateral lip. The gonads contain 4-angled dart and multified **digitiform** glands.
(8) **Gills** are absent, foot is undivided longitudinally and radula is well developed with several rows of curved teeth.

Economic importance : The French edible snail (***Helix pomatid***) is sold in the markets of America and European countries. It forms delicious dish.

Identification : Since the specimen contains oculiferous tentacles, visceral hump and all above features, hence it is ***Helix***.

124. *Limax*

Classification : Same as that of ***Helix***.
Genus.....*Limax*

Habit and habitat : ***Limax*** is abundantly found in cultivated lands, gar grandens and moist woody regions. It is **nocturnal** and **herbivorous**.

Distribution : It has cosmopolitan distribution but specially found in India, Europe and U.S.A. (California).

Comments :
(1) **Commonly** known as **grey slug**.
(2) **Body** is elongated and differentiated into **head, foot** and **visceral hump**.
(3) Colour may be yellowish or brownish or greyish.
(4) **Head** contains **mouth**, a pair of lateral lips, a pair of **retractile anterior tactile tentacles**, a pair of long **posterior retractile tentacles**, each having a black eye at its tip and a genital pore. Eyes are placed at the tips of the posterior of the two pairs of tentacles. The tentacles cannot be invaginated within the head.
(5) **Foot** is blunt anteriorly and pointed posteriorly and is provided with grooves. It is divided into lateral and median strips.
(6) **Visceral hump** is elongated and flattened and pointed posteriorly.
(7) **Mantle** does not extend back behind the middle of the body.
(8) External shell and ctenidium are absent. A rudimentary **shell** in the form of a thin calcareous plate hidden in the mantle.
(9) **Hermaphroditic**.

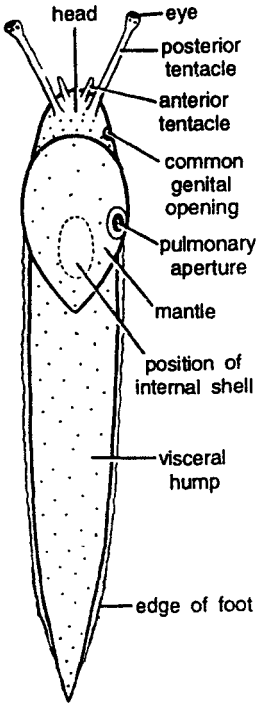


Fig. 124. *Limax.*

Identification : Since the specimen contains anteriorly blunt and posteriorly pointed foot and all above features, hence it is ***Limax***.

Instructions : *Make a comparative account of different gastropods and note peculiar features of each.*

125. *Mytilus*

Classification :

Phylum.....Mollusca	→	Unsegmental, bilaterally symmetrical and provided with foot, shell and mantle.
Class.....Pelecypoda or Bivalvia	→	Bivalve shell.
Order.....Filibranchia	→	Gill filaments incompletely fused, foot small and byssal gland present.
Genus.....*Mytilus* (The sea mussel)		

Habit and habitat : ***Mytilus*** is found at a depth of 2 or 3 fathoms in low tide, attached to rocks or wooden structures by its byssus threads. It is a **sedentary** bivalve mollusc. It is a filter feeder, filtering planktons from incurrent waters (Fig. 125).

Distribution : It has **cosmopolitan** distribution specially found in India, Europe, U.S.A. (California, San Francisco).

Comments :

(1) **Commonly** called as **sea mussel**.
(2) **Shell** is elongated equivalved with **umbo** and marked by **lines of growth**.
(3) Hinge toothless but may bear crenulations.
(4) Postero-ventrally papillated edges of mantle and postero-dorsally lamelliform gills are seen. Foot cylindrical with **byssus**.
(5) Postero-ventrally papillated edges of mantle are seen and postero-dorsally is **exhalent siphon**.
(6) Shell is marked with **lines of growth**.
(7) **Byssal filaments** found in a byssal cavity are formed by byssal gland or **byssogenous apparatus**.
(8) After removing the shell internal structures such as **lamelliform gills**, **foot**, **kidney**, **heart** and alimentary canal enclosed by mantle lobes are visible.
(9) Gills are **lamelliform**, i.e., the filaments are plate-like and united by ciliary junctions.
(10) **Anterior adductor muscle** is smaller and posterior adductor is larger, i.e., it is heteromyrian form. Posterior muscle is large and anterior small (anisomyrian).
(11) **Sexes** are separate. Gonads extend into the mantle.

Economic importance : Used for food in Europe. In India also they are relished as food by poor people living at seacoasts.

Identification : Since the specimen contains umbo, byssus threads and all above features and hence it is ***Mytilus***.

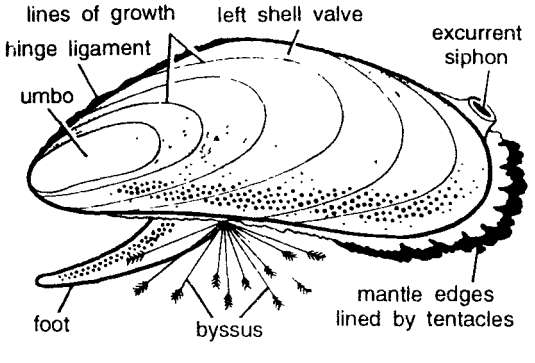


Fig. 125. *Mytilus.*

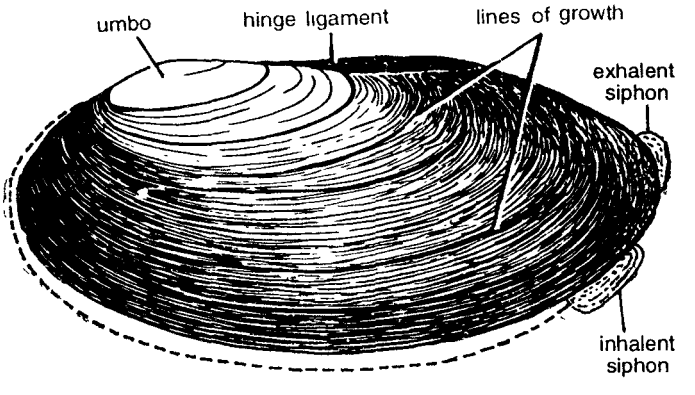


Fig. 126. *Unio.*

126. *Unio*

Classification :

Phylum	**Mollusca**	→	Soft bodied, non-metameric, shelled and foot-bearing animals.
Class	**Pelecypoda**	→	Bivalve shell.
Order	**Eulamellibranchiata**	→	Gill filaments united by inter-filament and inter-lamellar junctions.
Genus	***Unio*** **(The Fresh water Mussel or Clam)**		

Habit and habitat : ***Unio*** is the most familiar and very favourite **pelecypod**, found in ponds, lakes, rivers and streams. The animal is usually buried in the mud.

Distribution : It is commonly found in India, Europe, Atlantic slope and U.S.A.

Comments :

(1) **Commonly** called as fresh water **mussel** or **clam**.
(2) **Body** is dark brown, unsegmented, bilaterally symmetrical and flattened from side to side measuring 5 to 10 cm in length.

(3) Animal is completely enclosed in equal **bivalve shells**. The periostracum is generally smooth and without rays.
(4) Two valves are united together along the dorsal side in a straight **hinge-line** by **hinge-ligament**. Anteriorly, in front of the hinge, there is a whitish, knob-like swelling on each valve, called as **umbo**. Outer surface of each shell contains various **lines of growth**. Hinge is without teeth.
(5) Posteriorly, on lateral margins there are two openings; smaller one is **exhalent siphon**, while the larger one is **inhalent siphon**.
(6) **Mantle** consists of two lobes, corresponding to two valves of the shell. **Ctenidia** are W-shaped and eulamellibranch.
(7) Foot is large, muscular and wedge-shaped and is used for burrowing.
(8) **Adductor muscles** are of same size, *i.e.* **isomyarian.**
(9) **Sexes** are separate but the male and female shells are alike. Development includes **glochidium** larva.

Economic importance : The shells are used in making buttons and animals are largely dissected for understanding nervous system and invertebrate anatomy.

Identification : Since the specimen contains Umbo, hinge and all above characters, hence it is ***Unio.***

127. *Mya*

Classification : Same as that of ***Unio.***
Genus.....*Mya*

Habit and habitat : ***Mya*** is a marine and burrowing eulamellibranchiate, found between lines and in shallow water in mud flats and under stones.

Distribution : It is found in Arctic ocean to Cape Hatteras, San Francisco and Europe.

Comments :
(1) **Commonly** called as **mud-clam.**
(2) **Body** is covered by equal shell valves with hinge ligament resembling ***Unio.***
(3) **Periostracum** wrinkled.
(4) **Umbo** is found on each shell as raised whitish area, while rest of the shell contains lines of growth. Hinge is weak and valves may be separated.

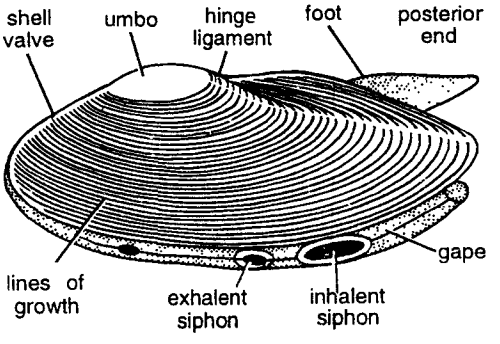


Fig. 127. *Mya.*

(5) **Foot** is reduced and is without byssus threads in adults.
(6) **Exhalent** and **inhalent siphons** are partly retractile and covered with periostracum.
(7) Eyes, tentacles and radula are absent. The **adductor muscles are isomyrian.**
(8) Ligament internal, attached in left valve to prominent shell-like process. **Pallial sinus** is large.

Economic importance : Commonly used as food.

Identification : Since the specimen contains Umbo at a raised area and all above characters hence it is ***Mya.***

128. *Venus*

Classification : Same as that of ***Unio.***
Genus.....*Venus*

Habit and habitat : ***Venus*** is a burrowing form in muddy and sandy flat, near the lower portion of the inter-tidal zone of the Atlantic coast ciliary mode of feeding (Fig. 128).

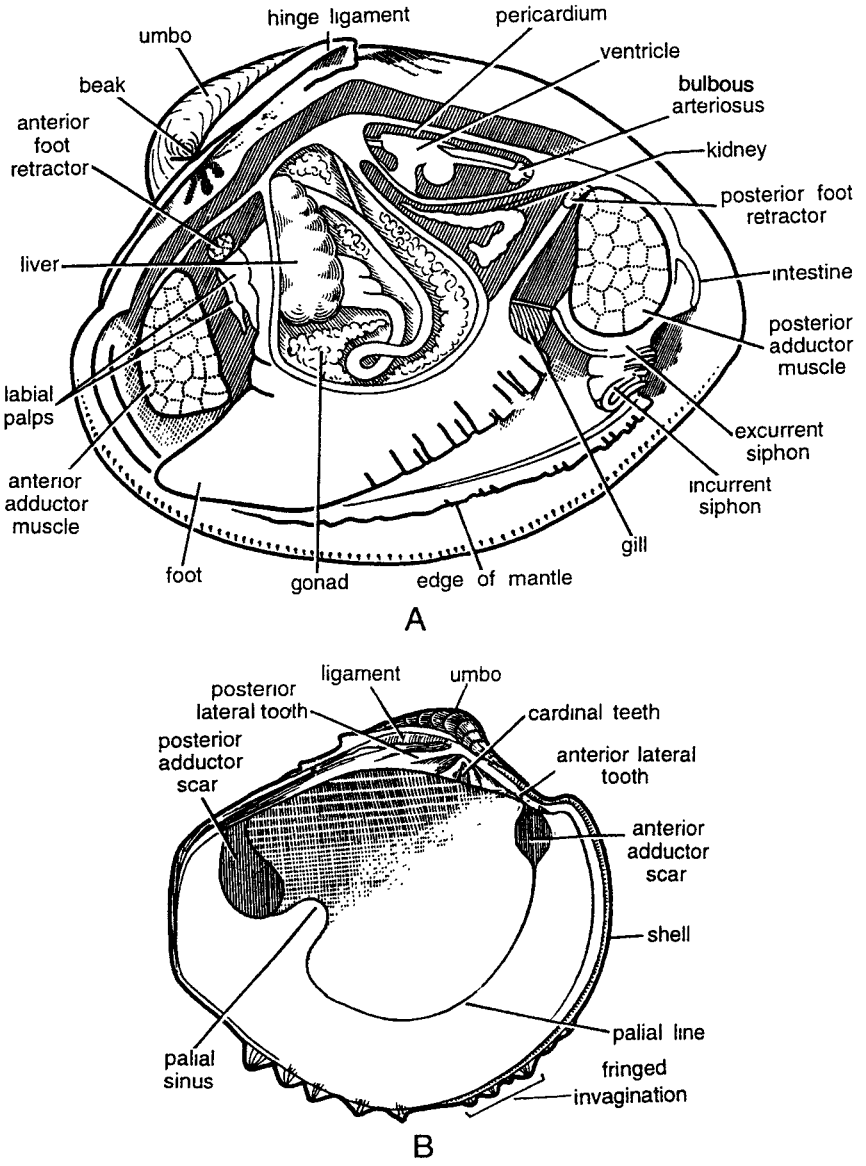


Fig. 128. *Venus.* **A.** Left shell valve removed to show internal anatomy, **B.** Inner surface of left valve.

Distribution : It is found in India, Europe and U.S.A. (Gulf of St. Lawrence to Texas).

Comments :

(1) **Commonly** called as **hard-shelled clam** and **little-neck clam.**

(2) **Shell** is composed of two symmetrical halves covered by equal **shell valves** which are dorsally joined by hinge ligament.

(3) Shell is ovate or heart-shaped, anterior end short, posterior end rounded.

(4) **Umbo** directed forwards, shell surface dirty white with prominent, sharp, concentric ridges.

(5) Small **incurrent siphon** and **large excurrent siphon** separated.

(6) **Inner surface** is smooth dull white with violet or lower granulated margin. Various structures seen are **Umbo, fringed margin, pallial sinus, pallial line, ligament, anterior adductor scar, posterior adductor scar, anterior lateral tooth** and **cardinal tooth.** *(Z–20)*

(7) **Siphons** short, unequal and more or less separated.
(8) After removing the left shell valve various internal structures seen are **beak, anterior foot, retractor muscle, liver, labial palps, anterior adductor muscles, gonad, gill, posterior adductor muscle, kidney bulbous arteriosus, ventricle and pericardium.**
(9) Although it lies buried a few inches, it keeps its siphonal end above the surface of the mud in order to maintain a current of sea-water through its body for feeding.
(10) Lunule is a heart-shaped configuration, which lies anterior and ventral to the beak.
(11) Spawning takes place in rainy season. Millions of eggs and sperms are produced. Young clam lies dormant for 2 years.

Economic importance : Extensively used as food. It is also, used for manufacture of wampum, the violet portion forming the most valuable pieces.

Identification : Since specimen has fringed margin in the shell and all above character hence it is ***Venus***.

129. *Teredo*

Classification : Same as that of ***Unio***.

Genus.....*Teredo*

Habit and habitat : ***Teredo*** burrows inside any wood immersed in sea-water with two siphons emerged for water current and eats cellulose and living microorganisms. The animals live in long burrows in wood or clay, which they form probably by the rasping motion of the shells and then line with the calcareous coating (Fig. 129).

Distribution : The distribution of this boring lamellibranchiate is cosmopolitan because it has been spread every where in the days of specially wooden ships. It is found in India, Europe, Cape Cod to Florida and Massachusetts Bay to Florida.

Comments :

(1) **Commonly** called as **shipworm.**
(2) Highly specialized lamellibranch.
(3) Cylindrical body elongated anteriorly.
(4) There are two **reduced shell valves** which serve as effective cutting and boring organs reducing the wood to saw dust.
(5) Two mantle lobes enclosing a mantle and ctenidia are tubular elongated and produced into **inhalent** and **exhalent siphons**. Two siphons are united for the most part and are separated at a point called **pallet.**

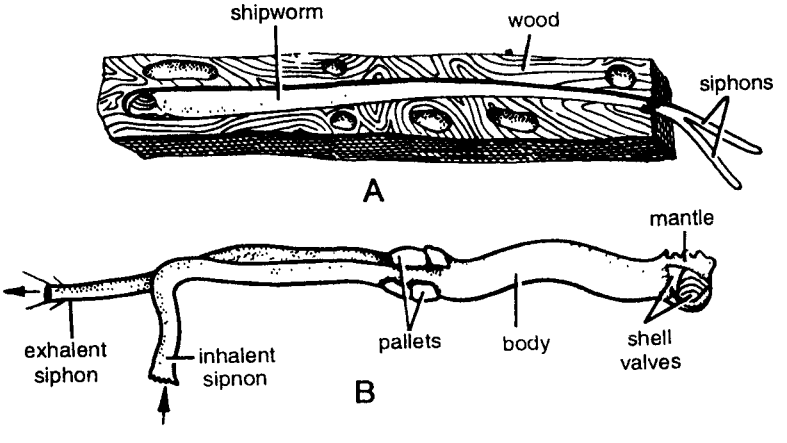


Fig. 129. *Teredo.* **A.** A piece of wood burrowed by *Teredo*, **B.** Entire animal.

(6) **Pallets** act as **operculum**.
(7) **Mantle cavity** contains a pair of **ctenidia**.
(8) Animal feeds on saw dust and planktonic organism through ciliary action of ctenidia.
(9) Animal can digest cellulose and lignin.

Economic importance : ***Teredo*** causes tremendous damage to the ships and the rock. Their burrows usually follow the grains of the wood, but not always, and usually do not run into one another. A Dutch scientist G. Snellius (1773) extensively studied about the damage done by above worm.

Identification : Since the specimen contains shell valves as teeth and all above features, hence, it is ***Teredo***.

130. *Ensis*

Classification : Same as that of ***Unio***.

Genus.....*Ensis*

Habit and habitat : ***Ensis*** is a burrowing animal, found in the sand about low tide mark. It burrows into the sand. It can also swim backwards by jerks of the foot (Fig. 130).

Distribution : It is found in India and U.S.A. (Labrador to West Coast of Florida).

Comments :

(1) **Commonly** called as **razor shell** or **razor clam**.
(2) **Animal** is covered by thin, equivalve shells, which are slightly bent in the middle with concave dorsal and convex ventral sides.
(3) Shells are joined together by 2 hinge teeth in right shell and by 3 hinge teeth in left shell valve.
(4) Shells contain parallel margins and **lines of growth** and have **truncated ends**.
(5) Posteriorly **exhalent** and **inhalent siphons** are present.
(6) Burrowing organ **foot** is muscular, cylindrical and enormously developed. It is capable of swelling out rapidly and becomes very stiff with the flow of blood. It protrudes from anterior end.
(7) **Pallial line is sinupalliate**, i.e. it forms sinuses.
(8) Muscles are **isomyrian**. **Ctenidia** are paired.
(9) ***Sanguinolaria*** and ***Solen*** are the other razor shells having the same features as ***Ensis***. In ***Solen***, shell is very long, subcylindrical straight margins parallel, ends gaping and umbo terminal. The pallial line extending beyond the adductors. The sinus is short and square.

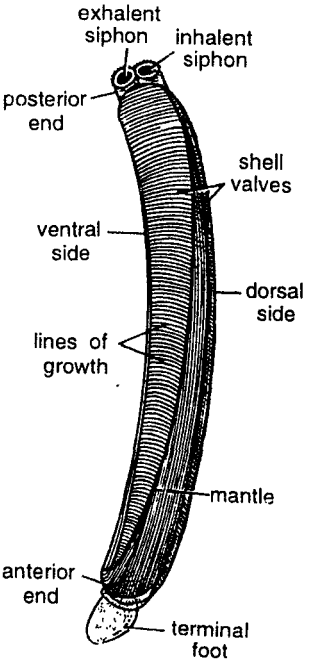


Fig. 130. *Ensis.*

Identification : Since the animal has razor like shell and all above characters, hence it is ***Ensis***.

131. *Solenocurtus*

Classification : Same as that of ***Unio***.

Genus.....*Solenocurtus*

Habit and habitat : ***Solenocurtus*** is also a burrowing pelecypod.

Distribution : Found in India and U.S.A.

Comments :

(1) **Commonly** called as **razor fish** or **razor shell**.
(2) Shell valves are of equal size with parallel margins having lines of growth. Both the shell valves cover part of the body.

(3) **Foot** is strong and muscular boring organ without byssus. It swells with the inflow of blood and protrudes from anterior end.
(4) Two siphones are unequal. **Inhalent siphon** is larger than the **exhalent**.
(5) Muscles are **isomyrian**. Both adductor muscles are of the same size.
(6) Pallial line forms the sinuses.
(7) ***Solenocurtus*** swims backwards by jerking movements of the foot.

Identification : Since the specimen contains unequal inhalent and exhalent **siphon**, hence it is ***Solenocurtus***.

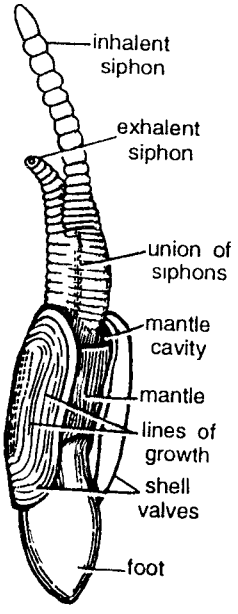


Fig. 131. *Solenocurtus.*

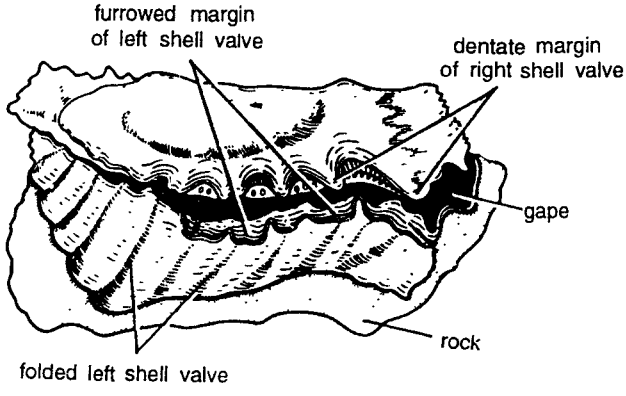


Fig. 132. *Ostrea.*

132. *Ostrea verginiana*

Classification :

Phylum.....Mollusca	→	Soft bodied, non-metameric, shelled.
Class.....Pelecypoda	→	Bivalve shell.
Order.....Pseudolamellibranchiata	→	Gills form vertical folds.
Genus.....*Ostrea*		
Species.....*verginiana*		

Habit and habitat : ***Ostrea*** is a sedentary bivalve attached to rocks or other shells and abundantly found in shallows and brackish marine water and in all seas except colder ones.

Distribution : It is found in Atlantic and Pacific coasts, India and Gulf of Mexico to Massachusetts.

Comments :

(1) **Commonly** called as **edible oyster** (Fig. 132).
(2) **Shell valves** are irregular and variable in shape. Very thick and often with folded layers.
(3) Left valve is large, thick, convex, folded and permanently attached to rocks by **byssus**. Right valve is small and flattened forming lid. Shell surface is rough, irregular and **dextate** with denticles.
(4) **Foot** is totally absent.
(5) There is a single **adductor muscle**, *i.e*, **monomyrian** near the middle just in front of heart.
(6) **Umbo** and **hinge** at anterior end.
(7) **Hermaphroditic** or **unisexual**.

Special features : The **sex** is changeable in **oysters**. Most of the young oysters are male but later on half of them change into female. The egg production (fecundity) is very high. Mortality of eggs is also high. The eggs develop inside the egg and later hatch into veliger larva which settles down and is called as '**spat**'.

Economic importance : The Indian oyster, ***O. virginiana*** is highly valued as food. Oysters are cultivated by men like other animal products industry, such as chickens. Oysters have been a favourite food of man from prehistoric times. In addition to their delicious flesh, they are highly nutritious being rich in vitamins and minerals. The Madras Fisheries Department maintains oyster beds in Pulicate Lake, which supply large quantities of cultivated oysters during the season. The shells of oyster are ground up and used as a source of calcium for poultry.

Identification : Since the specimen contains ruffled shell and all above features, hence it is ***Ostrea***.

133. *Pecten*

Classification : Same as that of ***Ostrea***.

Genus.....*Pecten*

Habit and habitat : ***Pecten*** lives gregariously on the sea bottom of approximately 10 fathoms deep. It feeds on microorganisms caught during respiratory water current. It is abundant among eel grass and over mud flats (Fig. 133).

Distribution : It is found in India and U.S.A. (Santa Barbara to Cape Sam Lucas, Monterary to the Gulf of California and New Jersey to Labrador).

Comments :

(1) **Commonly** called as **scallop**.

(2) **Animal** is enclosed by unequal bivalved shell. Shells are easily recognised by their radiating striations with broad base and two winged ears above.

(3) **Shell** is beautifully sculptured.

(4) **Hinge line** straight and toothless.

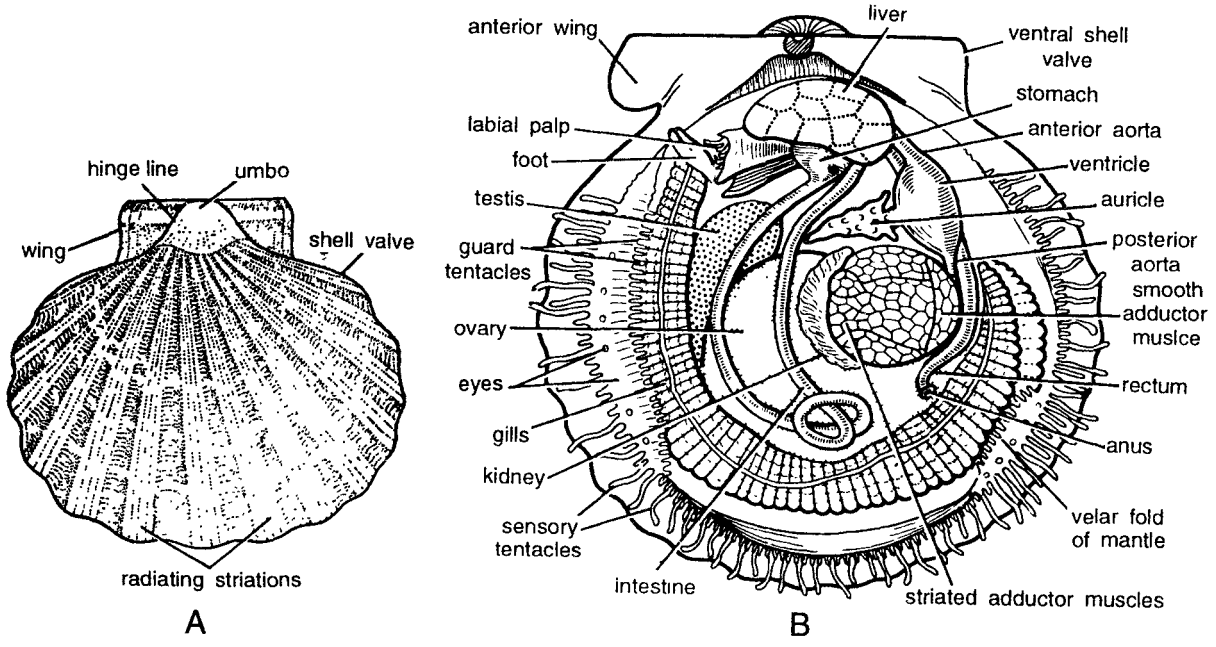


Fig. 133. *Pecten.* **A.** Dorsal view, **B.** After removal of the shell.

(5) Animal rests on the right shell, which is white, clean and convex which has a prominent notch, where the anterior **wing** joins the body of the shell. The left shell is flat dark in colour.
(6) **Shell valves** are thin, light and raised into ridges and grooves, joined by straight, toothless hinge and possess **growth lines**. The concentric lines follow the curvature of the wavy margins. **Umbo** is found near hinge.
(7) **Mantle** is **tentaculiferous** and it enclosed viscera.
(8) After removing the shell **liver, stomach, anterior aorta, ventricle, auricle, posterior aorta, smooth adductor muscle, rectum, anus, velar fold of mantle, striated adductor muscle, intestine, kidney, gills, ovary, guard, tentacles, foot, labial palps, anterior wings, ocelli** and **testes** are seen.
(9) Margin of mantle produces velar folds with numerous sensory tentacles and stalked **eyes** at regular intervals. **Hermaphroditic**.

Special features : Scallops leap and swim by snapping the shell valves together, giving them a zigzag course.

Economic importance. The adductor muscle of scallop is very delicious and scallop-fishing is very important industry. The scallop's adductor muscles soak water and are unfit for preservation. They swell as they absorb moisture and this process is called as 'plumping'.

Identification : Since the specimen contains radiating striations over the shell and all above features, hence it is ***Pecten***.

134. *Pinctada vulgaris*

Classification : Same as that of ***Ostraea***.
Genus.....***Pinctada***
Species.....***vulgaris***

Habit and habitat : ***Pinctada*** lives in the Gulf of California and in West Indian sea water.

Distribution : It has wide distribution except in cold zones. It is very common in the Gulf of Kutch. Tropical and temperate seas, Pacific and Atlantic coast.

Comments :

(1) **Commonly** called as **Indian pearl oyster**.
(2) **Shell** valves are unequal and the hinge line is straight, produced at each end into a short **ear or wing like process**.
(3) **Left shell** is large, convex and permanently attached to rocks by a strong cable of **byssal threads**.
(4) **Right shell** is smaller and thinner and covers viscera.
(5) Surface of the shell is coarse, irregular and ruffled and bears **radiating bands** terminating at the margins into **finger like projections**, which may disappear in order specimens.
(6) Like ***Pecten***, there is a single adductor muscle.
(7) Right and left mantle lobes are quite free.
(8) Pearl oysters feed in the same manner as clams.

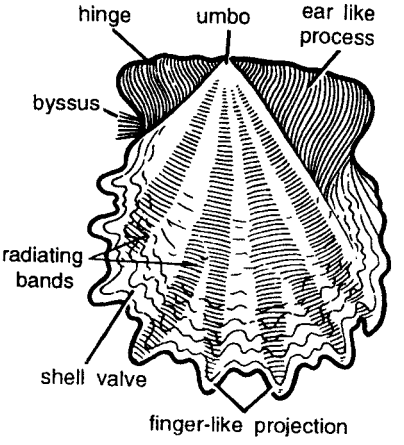


Fig. 134. *Pinctada vulgaris.*

Economic importance : Oyster's shell secretes pearls whenever any insect enters the shell and causes irritation. They are cultivated in pearl oyster industry. Most of our germ pearls are obtained from **pearl oyster**.

Identification : Since the specimen contains ear like processes and all above features, hence it is ***Pinctada vulgaris***.

135. *Loligo*

Classification :

Phylum..... Mollusca	→	Unsegmented, bilaterally symmetrical and provided with visceral mass, foot, shell and mantle.
Class..... Cephalopoda	→	Head well developed with eyes and radula. Foot represented by arms and tentacles.
Sub-class..... Dibranchia	→	Gills, kidneys and hearts, two each.
Order..... Decapoda	→	Shell internal; 8 short and 2 long tentacles.

Genus.....*Loligo* (The Common Squid or Calamary)

Habit and habitat : ***Loligo*** is found in warm seas and in coastal shallow or deep waters. Animal **metachromatic** i.e. colour changing habit. Commonly called as **squid** having dark greyish and reddish spots.

Distribution : It has **cosmopolitan** distribution found along the entire Pacific and Atlantic coast, China, India and U.S.A.

Comments :

(1) **Commonly** called as **squid.**

(2) **Body** is fleshy, dorsoventrally flattened and differentiated into 3 regions (i) anterior head containing 10 **oral arms** and a pair of eyes with olfactory crest, (ii) middle trunk or **visceral hump,** and (iii) Posterior region with lateral fins or parapodia. **Parapodium** is contention of mantle. Head and trunk region are separated by **collar.**

(3) Each one of 8 **oral arms** contain four rows of **pedicellate suckers** ventrally.

(4) Remaining 2 **oral arms** on each side contains six pairs of pedicellate suckers. These arms are used for capturing prey and are called as **hectocotylised arms.**

(5) In males one such arm is also modified as **copulatory organ.** Oral arm are modifications of the foot.

(6) After dissecting the animal, 2 **ctenidia,** 2 **kidneys** and 2 **auricles** are seen.

(7) **Shell, internal** horny and non-chambered and is used in maintenance of **natural buoyancy.**

(8) Ventral siphon is formed by the modification of foot.

(9) Sexes **separate.**

(10) **Eggs** are deposited in long cylindrical jelly masses attached together at one end.

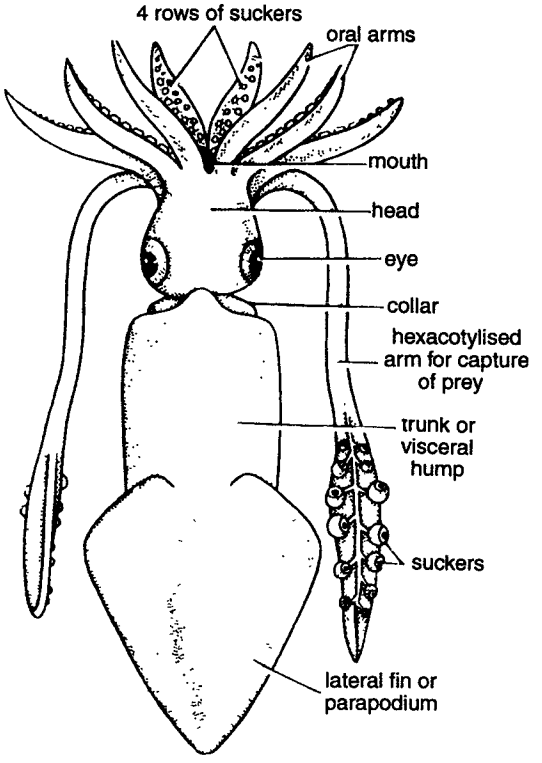


Fig. 135. *Loligo.*

Economic importance : The animal ejects ink called as **loligo ink** in its defence. ***Loligo*** has food value. It is eaten by Chinese and Italians.

Identification : Since the specimen contains all above features and the lateral fin is restricted to posterior part, hence it is ***Loligo.***

136. *Sepia*

Classification : Same as that of ***Loligo***.

Genus.....*Sepia*

Habit and habitat : ***Sepia*** is also a marine cephalopod, found along with ***Loligo*** in coastal waters in coral reefs. It is a good swimmer. It usually swims at night and rest flat at the bottom during daytime. It can also burrow by using fins as shovels. It is **carnivorous**, living on small fishes, crustaceans and other animals. Shallow to mid water forms.

Distribution : It has **cosmopolitan distribution** but specially found in India, Europe and Mediterranean region.

Comments :

(1) **Commonly** called as **cuttle-fish**.

(2) Body is fleshy and differentiated into anterior **head**, middle **collar** and posterior **trunk** or **visceral hump**.

(3) **Colour** is brownish with white spots stripes with violet fins. Chromatophores are present in the deeper layers of integument hence it gives a pigmented appearance.

(4) **Head** contains 10 **oral arms**. 8 **oral arms** are smaller and have several rows of **pedicellate suckers** ventrally encircling around mouth. 2 arms on each side are elongated, each having several pedicellate suckers at its tip and are called as **hectocotylised arms** for capture of prey.

(5) At the base of head is a pair of eyes without olfactory crest.

(6) ***Sepia*** **is luminescent** and **dibranchiate**. It is also a **myopsidan** mollusc, having imperforated cornea and single oviduct.

(7) Internal chambered calcareous shell is well developed and is flat. Shell is used in the maintenance of **neutral buoyancy**.

(8) **Chromatophores** are present in the deeper layers of the integument and hence it gives a pigmented appearance. Sexes are **separate**.

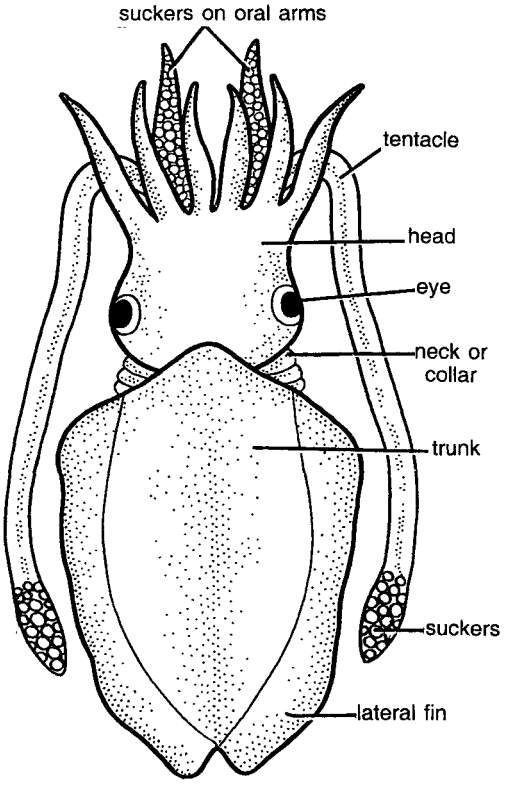


Fig. 136. *Sepia.*

Special features : Animal ejects ink by its ink gland in sea water when irritated. Ink is secreted from a pear-shaped ink sac lying over postero-ventral surface. Ink is called as **Sepia ink** which acts as **defense** mechanism for enemies.

Economic importance : It is used for food in the Mediterranean countries and the sepia ink has medicinal value.

Identification : Since the specimen contains lateral fin all around the visceral hump and all above features, hence it is ***Sepia***.

137. *Octopus*

Classification :

Phylum.....**Mollusca**
Class.....**Cephalopoda** } → Characters same as those of ***Loligo***.
Sub-class.....**Dibranchia**
Order..... **Octopoda** → Shell and tentacles absent. Arms eight.
Genus..... ***Octopus*** **(The devil fish)**

Habit and habitat : ***Octopus*** is a marine, nocturnal deep sea form found at the bottom of the sea. It feeds on crabs, fishes and other molluscs. It has colour changing habit.

Distribution : It has cosmopolitan distribution and is specially found in Europe, India, Atlantic and Pacific coasts, Alaska to lower California and Cape Cod.

Comments :

(1) **Commonly** called as **devil fish**.

(2) Roundish or globose body is differentiated into a **visceral hump** and **head**.

(3) **Head** contains **eyes, siphon** and 8 elongated **arms**, having 2 rows of sessile cupped, suctorial pockets or **suckers** on inner side. One of the arms in male is modified as spoon-shaped intromittent organ or **hectocotylized arm**. The arms are elongated webbed and similar.

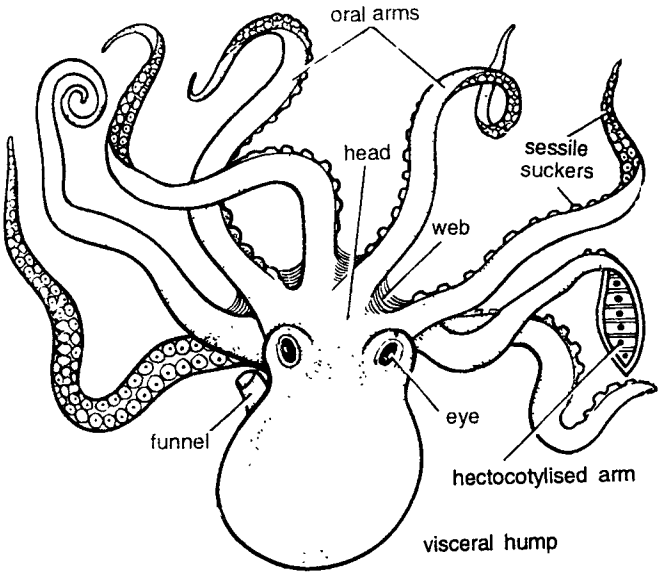


Fig. 137. *Octopus.*

(4) Animal can crawl by its arm and can also swim backwards by ejecting jet of water from the funnel.

(5) Shell and nidamental glands absent.

(6) **Visceral mass** and the mantle cavity are enclosed by mantle.

(7) **Nervous system** is well developed.

(8) ***Octopus*** is **dibranchiate**, having 2 **gills**, 2 **auricles** and 2 **kidneys**.

(9) Colour slaty but varying through all shades from nearly white to nearly black.

Special features : Giant ***Octopus*** can hold a man in its arms. It ejects inky fluid in water to protect itself. The inky fluid forms a sort of **smoke-screen**. The ink not only helps to conceal the ***Octopus*** but also paralyses the sense of smell in the moray eel, a common predatory enemy. It is largely used for studying behavioural sciences. ***Octopus*** is very intelligent and its name devil fish seems justified as displayed by its uncanny cleverness in stocking prey and devilish and cruel capacity in tearing the victim into small pieces once captured.

Identification : Since the specimen has rounded body and all above features, hence it is ***Octopus***.

138. *Nautilus*

Classification :

Phylum.....Mollusca	→	Unsegmented bilaterally symmetrical and provided with visceral mass, foot, shell and mantle.
Class.....Cephalopoda	→	Head well developed with eyes and radula; foot represented by arms and tentacles.
Sub-class.....Tetrabranchiata	→	Gills, kidneys and auricles, 4 each in number.

Genus.....*Nautilus* (The pearly *Nautilus*)

Habit and habitat : ***Nautilus*** is a gregarious, nocturnal deep-sea form crawling over the bottom in troops at night time in search of animal food comprising crabs and shellfish.

Distribution : Commonly found in Indian and Pacific oceans.

Comments :

(1) **Commonly** known as **pearly** ***Nautilus***.

(2) Body of the animal lies in the flat and **spirally coiled** shell in one plane and internally divided into various chambers by **septa** having septal necks.

(3) Shell measures approximately 25 cm.

(4) **Shell** is differentiated into **body chamber** containing **head**, **tentacles** and several coiled chambers with extension of visceral mass called **siphundes**.

(5) Periostracum dark brown or black, **porcellaneous** layer with undulating transverse bands of white and yellowish brown alternately and inner layer pearly.

(6) **Body proper** is lodged in the largest chamber and the other chambers remain either empty of filled up with gas which helps in floatations.

(7) Internal septa are perforated. It is **tetrabranchiate** having 4 **ctenidia**, 4 **kidneys** and 4 **auricles**. Ink gland is absent.

(8) **Sexes** are separate. About 60 to 90 prehensile tentacles are radially arranged around the mouth. Siphonal funnel is formed of two separate folds.

(9) **Eyes** are open vesicles without cornea or lens.

(10) Ink gland and chromatophores absent.

Special features : ***Nautilus*** is the only cephalopod having external shell. It has about 2,000 fossil species which date back to the Cambrian and reaching their maximum in the Silurian and Devonian ages. The body is used for food and the shell is extensively employed for ornamental and useful purposes. Oliver Wendell Holmes in his famous poem, "**Chambered** ***Nautilus***", calls it as "**The ship of pearl**".

Identification : Since the specimen contains spirally coiled shell and all above features, hence it is ***Nautilus***.

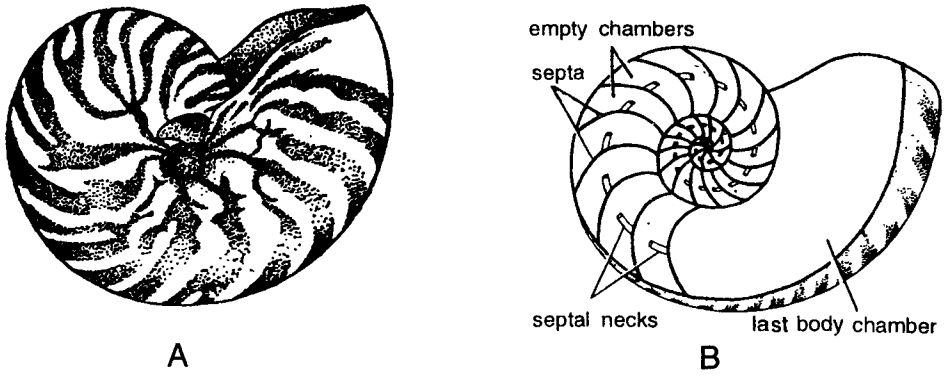


Fig. 138. *Nautilus*. **A.** Shell, **B.** Shell in section.

139. *Argonauta*

Classification : Same as that of ***Nautilus.***

Genus.....*Argonauta*

Habit and habitat : It is a marine cephalopod.

Distribution : It is distributed in Atlantic and Indian oceans and also found in tropical parts of the Pacific ocean.

Comments :

(1) **Commonly** called as '***Paper Nautilus***'. It is actually not a ***Nautilus*** but is more closely related to ***Octopus***.

(2) **Sexual dimorphism** is commendable. Male is approximately 25 cm long and without shell while female is about 25 cm long and possess characteristic **external shell.**

(3) Shell is thin symmetrical, spiral without septa secreted by terminal expansions of two specialized **dorsal arms** called as **Sail** or **Vela.**

(4) **Shell carries eggs,** the name '***Paper Nautilus***' refers to the thinness and fragility of dry shell.

(5) Third arm in the male is **hectocotylised** and used for conveying spermatophores into the mantle cavity of the female. It can be entirely separated from the male and left in the mantle cavity of the female.

(6) **Funnel** protrudes between arms.

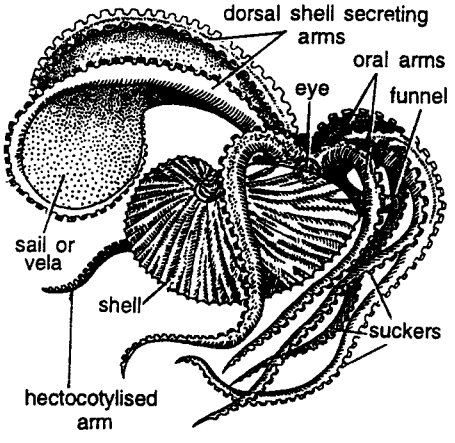


Fig. 139. *Argonauta.*

Identification : Since the specimen contains sail and all above characters, hence it is ***Argonauta.***

PHYLUM ARTHROPODA

Natural history

Although invertebrates evolved 500 million years ago, their fossil record is poor due to lack of hard skeleton. Arthropods were first to have hard exoskeleton made of chitin, a nitrogenous polysaccharide made of hexoses some of which contained amino or acetyl groups and jointed appendages. Coelom evolved in annelids was replaced by haemocoel. It has been suggested that the need for a hydrostatic skeleton disappeared with the advent of jointed exoskeleton and the coelom no longer required for this purpose was replaced by the cavity of blood stream (haemocoel). Dr. S. M. Manton (Zool. J. linn, Soc. 51 : 203-400, 1972) postulates polyphyletic origin of Arthropods Evolutionary and adaptive potentialities of Arthropods have been tremendous.

Arthropods include **crabs, shrimps, barnacles** and other crustaceans in class Crustacea; insects in class Insecta; **spiders, scorpions, ticks** and their allies in class Arachnida; **centipedes** in Chilopoda; **millipedes** in Diplopoda and other less familiar and fossil forms.

Arthropods are adapted for life in air, water and land. Some occur at altitude of 20,000 feet on mountains and crustaceans to depths of more than 32,000 feet in the sea.

Arthropods are free living, parasitic on plants and man and his animals. Some are gregarious. Arthropods are economically very important. Large crustaceans crabs, lobsters, shrimps are eaten by man; small crustaceans are staple foods for fishes. The insects and spiders are eaten by land vertebrates. Insects are friends as well as worst enemy and competitor of man eating his crops, stored food, goods and clothes besides **carrying** and **spreading** several **diseases** like **malaria** and **filaria,** etc. Some important products like honey, lac and silk are derived from insects. It is also a fact that insects have been responsible for evolution of Angiosperms.

Diagnostic characters

(1) Jointed legs (appendages)
(2) Exoskeleton of chitinous cuticle.
(3) Coelom replaced by haemocoel.
(4) Open circulation.

(5) Compound eyes.
(6) Sexes separate.
(7) Largest group.

Classification

CLASS I CRUSTACEA
1. Head and thorax fused to form cephalothorax covered with carapace.
2. Appendages biramous.
3. Antennae 2 pairs.

Sub-class A. Branchiopoda
1. Small freshwater crustaceans.
2. Trunk appendages serve as gills.

Order 1 Anostraca
1. Called as fairy shrimps.
2. Carapace absent. Trunk elongated.
Ex. *Branchipus, Artemia, Eubranchipus.*

Order 2 Notostraca
1. Carapace present.
2. Anterior trunk bears 35 to 70 pairs of appendages.
Ex. *Apus, Lepidurus.*

Order 3 Conchostraca
1. Small crustaceans.
2. Carapace present.
Ex. *Lyneus, Estheria.*

Order 4 Cladocera
1. Includes clamshrimps and water fleas.
2. Body laterally compressed.
Ex. *Cyzicus, Daphnia.*

Sub-class B. Ostracoda
1. Seed shrimps.
2. Body enclosed in a bivalve carapace.
Ex. *Cypris, Eucypris.*

Sub-class C. Copepoda
1. Small crustaceans. Body divided into head thorax and abdomen.
2. 5 pairs of thoracic appendages.
Ex. *Cyclops, Condracanthus, Calanus.*

Sub-class D. Brachiura
1. Ectoparasites of skin and gills.
2. 4 large and biramous thoracic appendages with swimming setae.
Ex. *Argulus, Dalos.*

Sub-class E. Cirripedia
1. Called as Barnacles.
2. Adults sessile or parasitic.

Order 1 Thoracica
1. Sessile forms.
2. Trunk appendages 6 pairs.
Ex. *Lepus, Balanus.*

Order 2 Acrothoracica
1. 4 pairs of trunk appendages.
2. Bore into mollusc shell and soft corals.
Ex. *Alcippe, Cryptothialus.*

Order 3 Ascothoracica
1. 6 pairs of trunk appendages.
2. Parasites on echinoderms and soft corals.
Ex. *Syngoga, Dendrogaster.*

Order 4 Apoda
1. Parasitic trunk appendages absent.
2. Body divided into rings.
Ex. *Proteolepas.*

Order 5 Rhizocephala
1. Parasitic crustaceans.
2. Appendages absent. Stack sends branches into the host.
Ex. *Sacculina.*

Sub-class F. Malacostraca
1. Carapace covers head and thorax.
2. Trunk contains 8 thoracic and 6 abdominal segments.

Order 1 Nebaliacea
1. Carapace bivalved.
2. Abdominal segments 7.
Ex. *Nebalia.*

Order 2 Mysidacea
1. Carapace thin and covers thorax only.
2. Body elongated. Uropod forms fantail.
Ex. *Mysis.*

Order 3 Amphipoda
1. Carapace absent. Gills thoracic.
2. Body elongated and laterally compressed.
Ex. *Gammarus, Caprella, Cerapus.*

Order 4 Isopoda
1. Body dorsoventrally flattened with short abdomen.
2. Carapace absent.
3. Free living or parasitic.
Ex. *Oniscus, Limnoria, Bopyrus.*

Order 5 Stomatopoda
1. Carapace small.
2. Abdomen large and broad.
Ex. *Sauilla, Pseudosquilla.*

Order 6 Decapoda
1. Prawns, shrimps, crayfishes, lobsters and crabs.
2. Carapace on cephalothorax.
3. Legs 5 pairs.

Sub-order 1 Macrura
1. Abdomen well developed and hard.
2. 18 pairs of appendages.
Ex. *Penaeus, Palinurus, Palaemon, Lucifer, Astacus, Homarus.*

Sub-order 2 Anomura
1. Abdomen flexed.
2. Commensal or free living.
Ex. *Eupagurus, Galathea, Hippa.*

Sub-order 3 Brachyura
1. Common crab.
2. Abdomen reduced.
Ex. *Cancer, Carcinus, Mala.*

CLASS II ARACHNIDA
1. Body divided into prosoma and opisthosoma.
2. First pair of appendages are feeding chelicerae.
3. Antennae absent.

Order 1 Xiphisura
1. Cephalothorax horse shoe shaped.
2. Abdomen unsegmented.
Ex. *Limulus.*

Order 2 Scorpionida
1. Body divided into prosoma, mesosoma and metasoma.

2. Respiration by book lungs.
   Ex. *Scorpions, Buthus, Palaeminaeus.*

Order 3 Araneida
1. Prosoma and opisthosoma joined by a narrow stalk.
   Ex. *Spiders, Lycosa, Agelena.*

Order 4 Palprigradi
1. Chelicerae large.
2. Carapace has 2 plates.
   Ex. *Koenema.*

Order 5 Pedipalpi
1. Small arachnids.
2. Pedipalps on legs.
   Ex. *Tarantula, Phrynichus.*

Order 6 Chelonethida
1. Prosoma of 6 fused segments covered with carapace.
2. Opisthosoma with 12 segments without sting.
   Ex. *Chelifer, Garypus.*

Order 7 Phalangida
1. Prosoma joined to abdomen.
2. Chelicerae small 3 jointed.
   Ex. *Phalangium, Leiobonum.*

Order 8 Acarina
1. Body oval compact, with no differentiation of prosoma and opisthosoma.
   Ex. Ticks and mites, *Sarcoptes, Ixodes, Argas.*

Order 9 Solpugida
1. Prosoma divided into large anterior and small posterior part.
2. Chelicerae very large.
   Ex. *Galeodes.*

CLASS III PAUROPODA
1. Body divided into head and trunk.
2. Head has a pair of antennae, one pair of mandibles and maxillae forming lower lip.
   Ex. *Pauropus.*

CLASS IV SYMPHYLA
Head with one pair of antennae, one pair of mandibles and two pairs of maxillae.
Ex. Garden centipedes, *Scolopendrella, Scutigerella.*

CLASS V DIPLOPODA
1. Body divided into head and trunk.
2. Each trunk segment bears 2 pairs of legs.
   Ex. Millepedes, *Julus, Spirobolus.*

CLASS VI CHILOPODA
1. Body divided into head and trunk.
2. Each trunk segment bears 1 pair of legs.
   Ex. Centipedes, *Scolopendra, Theotops.*

CLASS VII ONYCHOPHORA
1. Primitive arthropods.
2. Contain annelidan and arthropodan character.
   Ex. *Peripatus.*

CLASS VIII INSECTA
1. Body divided into head thorax and abdomen.
2. Thorax contains 3 pairs of legs and 1 or 2 pairs of wings.

Sub-class A. Apterygota
1. Wingless insects.
2. Little or no metamorphosis.

Order 1 Thysanura
1. Long antennae.
2. Chewing mouth parts.
   Ex. *Lepisma.*

Order 2 Protura
1. Antennae and compound eye absent.
2. Appendages on abdomen.
   Ex. *Acerentulus.*

Order 3 Collembola
1. Mouth parts chewing or sucking.
2. Furcula (Springing organs on ventral side of 4th abdominal segment).
   Ex. *Achorutes.*

Sub-class B. Pterygota
1. Wings present.
2. Metamorphosis prevalent.

Division I Exopterygota
1. Wings develop externally.

Order 4 Orthoptera
1. Two pairs of wings.
2. Chewing mouth parts.
3. Incomplete metamorphosis.
   Ex. Cockroach (*Periplaneta*), Locust (*Schistocerca*), Grasshopper (*Melanopus*), *Gryllys, Grylotapla* Leaf insect (*Phyllium*) Praying mantis.

Order 5 Dermaptera
1. Fore wings small and leathery Hind wings large and membranous.
2. Mouth parts chewing.
   Ex. Earwigs (*Forficula*).

Order 6 Isoptera
1. Social insects with castes.
2. Wings two parts.
   Ex. Termites or white ants.

Order 7 Placoptera
1. Hind wings usually folded under forewings at rest.
2. Mouth parts chewing.
   Ex. *Isoperla* (Stonefly).

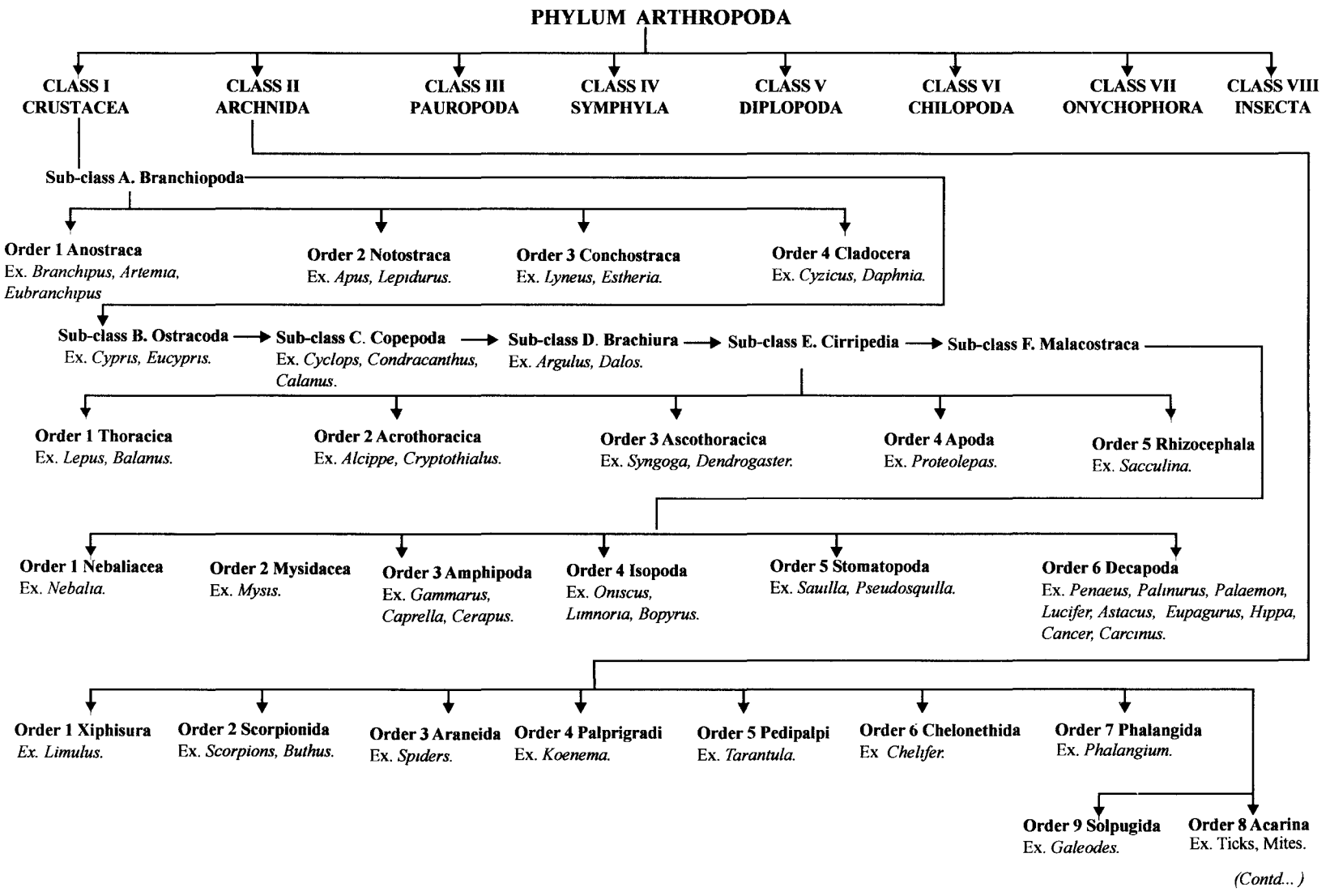
Order 8 Anoplura
1. Wingless ectoparasites.
2. Claws for clinging to hairs.
3. Piercing and sucking mouth parts.
   Ex. *Pediculus.*

Order 9 Ephemeroptera
1. Membranous wings. Forewings larger than hind wings.
2. Two or three abdominal tails.
   Ex. *Ephimera* (May fly).

Order 10 Odonata
1. Wings membranous. Hind wings usually larger than forewings.
2. Body tusk like. Antennae short.
   Ex. *Dragon, Flies, Damselflies.*

Order 11 Hemiptera
1. Wings two pairs.
2. Mouth parts piercing and sucking forming beak like organ.
   Ex. *Cimex* (Bed bug), *Bellostoma, Ranatra, Nepa, Aphids, Cicada.*

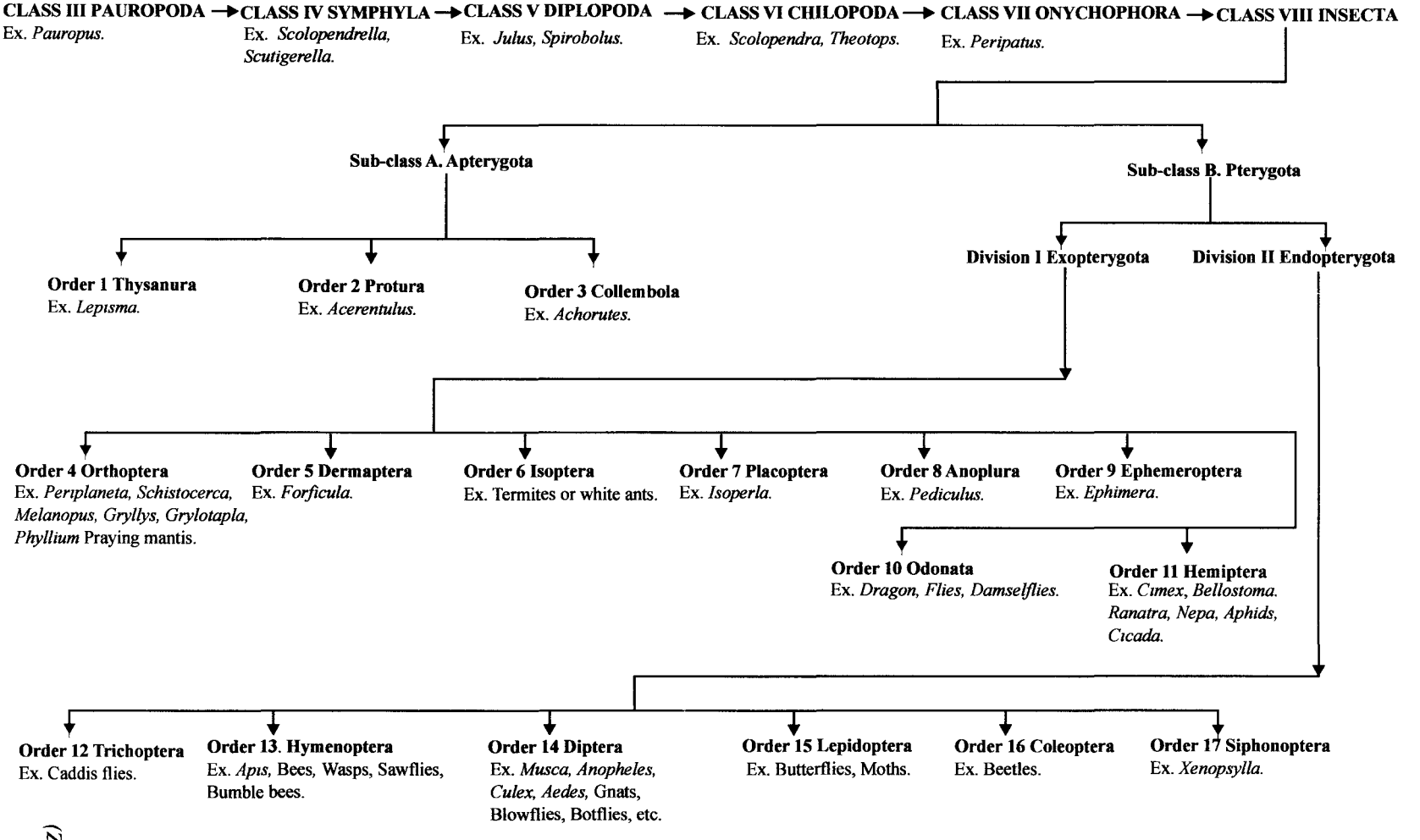
(Classification cont. on Page 128)


PHYLUM ARTHROPODA
CLASS I CRUSTACEA
CLASS II ARCHNIDA
CLASS III PAUROPODA
CLASS IV SYMPHYLA
CLASS V DIPLOPODA
CLASS VI CHILOPODA
CLASS VII ONYCHOPHORA
CLASS VIII INSECTA
Sub-class A. Branchiopoda
Order 1 Anostraca
Ex. Branchipus, Artemia, Eubranchipus
Order 2 Notostraca
Ex. Apus, Lepidurus.
Order 3 Conchostraca
Ex. Lyneus, Estheria.
Order 4 Cladocera
Ex. Cyzicus, Daphnia.
Sub-class B. Ostracoda
Ex. Cypris, Eucypris.
Sub-class C. Copepoda
Ex. Cyclops, Condracanthus, Calanus.
Sub-class D. Brachiura
Ex. Argulus, Dalos.
Sub-class E. Cirripedia
Sub-class F. Malacostraca
Order 1 Thoracica
Ex. Lepus, Balanus.
Order 2 Acrothoracica
Ex. Alcippe, Cryptothialus.
Order 3 Ascothoracica
Ex. Syngoga, Dendrogaster.
Order 4 Apoda
Ex. Proteolepas.
Order 5 Rhizocephala
Ex. Sacculina.
Order 1 Nebaliacea
Ex. Nebalia.
Order 2 Mysidacea
Ex. Mysis.
Order 3 Amphipoda
Ex. Gammarus, Caprella, Cerapus.
Order 4 Isopoda
Ex. Oniscus, Limnoria, Bopyrus.
Order 5 Stomatopoda
Ex. Saulla, Pseudosquilla.
Order 6 Decapoda
Ex. Penaeus, Palinurus, Palaemon, Lucifer, Astacus, Eupagurus, Hippa, Cancer, Carcinus.
Order 1 Xiphisura
Ex. Limulus.
Order 2 Scorpionida
Ex. Scorpions, Buthus.
Order 3 Araneida
Ex. Spiders.
Order 4 Palprigradi
Ex. Koenema.
Order 5 Pedipalpi
Ex. Tarantula.
Order 6 Chelonethida
Ex Chelifer.
Order 7 Phalangida
Ex. Phalangium.
Order 9 Solpugida
Ex. Galeodes.
Order 8 Acarina
Ex. Ticks, Mites.

(Contd...)

contd....

PHYLUM ARTHROPODA



Division II Endopterygota

1. Wings develop internally.

Order 12 Trichoptera

1. Wings membranous, 2 pairs and covered with long hairs.
2. Mouth parts vestigeal.
   Ex. Caddis flies.

Order 13 Hymenoptera

1. Wings same size (2 pairs).
2. Mouth parts chewing-Lapping.
   Ex. *Apis* (Honey bee), Bees, Wasps, Sawflies, Bumble bees.

Order 14 Diptera

1. Wings one pair. Hind wings as halters.
2. Piercing-sucking or sponging mouth parts.
   Ex. Flies (*Musca*), Mosquitoes (*Anopheles, Culex, Aedes*), Gnats, Blowflies, Botflies, etc.

Order 15 Lepidoptera

1. Membranous wings covered with overlapping scales.
2. Mouth parts sucking.
   Ex. Butterflies, moths.

Order 16 Coleoptera

1. Forewing hard, hind wing membranous and folding.
2. Body covering hard and chitinous.
   Ex. Beetles.

Order 17 Siphonoptera

1. Ectoparasite wingless.
2. Piercing-sucking mouth parts.
   Ex. Fleas (*Xenopsylla*).

140. *Apus*

Classification :

Phylum.....Arthropoda	→	Jointed appendages.
Class.....Crustacea	→	Thick exoskeleton, antennae 2 pairs.
Sub-class.....Branchiopoda	→	Trunk appendages act as gills.
Order.....Notostraca	→	Carapace present.
Genus.....*Apus* (Tadpole shrimp)		

Habit and habitat : ***Apus*** is a fresh-water form.

Distribution : It is found in most parts of the world especially in U.S.A., Kansas, Lower California, Texas, Mexico and Nebraska.

Comments :

(1) **Commonly** called as **Tadpole shrimp**.

(2) Body divisible into **head-thorax** (**Cephalothorax**) and **abdomen** measuring 20 to 30 mm in length.

(3) Head is broad, depressed and covered by a horse-shoe shaped **carapace** which bears **eyes** above, **antennules** and **antennae** beneath. The labrum, mouth, antennules, antennae, mandibles, maxillae are present ventrally.

(4) Anterior two-thirds of the dorsal surface is covered by a thin chitinous shell or **carapace**, which covers major part of the body.

(5) Beyond the posterior edge of the carapace a cylindrical and **segmented abdomen** projects.

(6) Last segment bears **anus** and a pair of long **caudal styles**.

(7) On the dorsal surface of the carapace, near its anterior border, are **paired eyes**, **median eye** and **dorsal organ**.

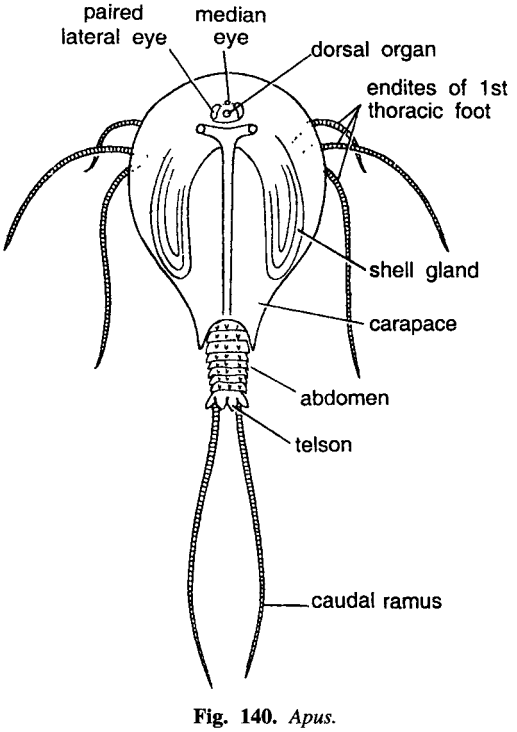


Fig. 140. *Apus.*

(8) Sexes are separate. Males are few. In females few segments are without swimming appendages.

(9) Development includes **nauplius larva**.

Special features : Reproduction is as a rule **parthenogenetic** because the males are rare. How they are able to carry genetic continuity is not clear.

Identification : Since the specimen contains horse-shoe shaped carapace and all above features hence it is ***Apus***.

141. *Lepas*

Classification :

Phylum.....Arthropoda	→	Jointed appendages.
Class.....Crustacea	→	Thick exoskeleton, antennae 2 pairs, jaws 3 pairs.
Sub-class.....Cirripedia	→	Sessile adults without compound eyes and antennae, with carapace and mandibular palps and with 6 pairs of biramous thoracic limbs.
Order.....Thoracica	→	Non-parasitic, carapace of calcareous plates and 6 pairs of thoracic appendages.

Genus.....*Lepas* (The goose barnacle or ship barnacle)

Habit and habitat : ***Lepas*** is the most familiar cirripede found attached to floating seaweeds, logs, turtles and ships between tide-marks. It is a planktonic filter feeder.

Distribution : Cosmopolitan. Specially found on Pacific coast, North of San Francisco, Bay of Fundy.

Comments :

(1) **Commonly** called as goose **barnacle** or **ship barnacle** because barnacle geese were once thought to hatch from them.

(2) Animal is composed of bilaterally compressed vermiform and unsegmented body, the **capitulum**, and a **peduncle**.

(3) Peduncle or stalk is much narrower than the rest of the body and without scales. The peduncle is long and stout and acts a hold-fast organ.

(4) Body is flattened and covered by calcareous plates consisting of a pair of **scuta** at the stalk end, a pair of small **terga** at the opposite end, and a median dorsal **carina** lying along the hinge.

(5) **Capitulum** encloses the viscera and itself is encased in a bivalved carapace in which above plates are embedded.

(6) Six pairs of cirriform many-jointed, **biramous thoracic appendages** fringed with tuft of setae arise from the thorax.

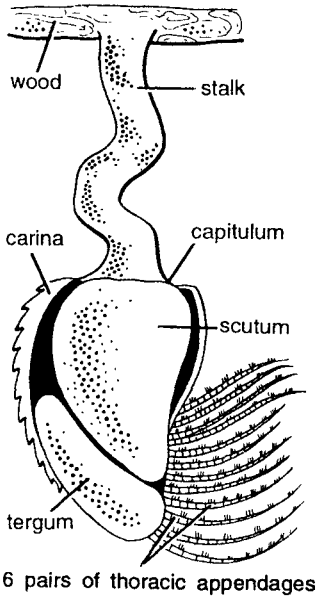


Fig. 141. *Lepas.*

(7) Mouth is ventral and anterior end is provided with mandibles and two pairs of maxillae. Antennae and paired eyes are absent.

(8) The outer plates of mantle are not fused to form a peripheral wall.

(9) ***Lepas*** is **hermaphrodite** but is having cross fertilization.

Identification : Since the specimen contains stalk, body, 6 pairs of thoracic appendages and all above features, hence it is ***Lepas***.

Instructions : *Examine the animal. Try to establish harm caused to the objects to which it attaches.*

142. *Balanus*

Classification : Same as that of ***Lepas***.

Genus.....*Balanus*

Habit and habitat : ***Balanus*** is attached to rocks and molluscan shells in great numbers between tide-marks in shallow water. It may attach to any floating object also (Fig. 142).

Distribution : It has cosmopolitan distribution but especially found along Pacific coast, North Atlantic coast, West Indies and Washington to Alaska.

Comments :

(1) **Commonly** called as **Rock barnacle or Acorn barnacle.**

(2) Stalk is absent to the shell covering the animal is directly attached to the substratum or rocks.

(3) **Head** is short and broad.

(4) Mantle surrounding the body is covered by six calcareous plates, consisting of unpaired **carina, rostrum** and 2 pairs of **carino-lateral plates.** Edges of the plates overlap and fit together forming cylinder. Outer surface of each plate shows 3 divisions, a central portion and two wings.

(5) Opening of the shell is provided with a movable fourfold lid or **operculum**, composed of 2 **scuta** and 2 **terga.**

(6) In water the barnacle protrudes through the opening **six pairs** delicate, curled, fringed and jointed **thoracic legs** to collect food.

(7) **Life cycle** includes **nauplius larva.**

Special features : ***Balanus titinnabulum*** has food value in some countries. Barnacles are highly modified crustaceans in which hermaphroditism is common. Male and female live in permanent association.

Identification : Since the specimen contains carina, scuta, terga and protruding thoracic appendages and all above features, hence it is ***Balanus***.

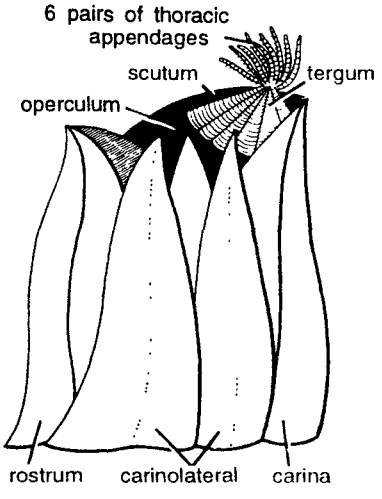


Fig. 142. *Balanus.*

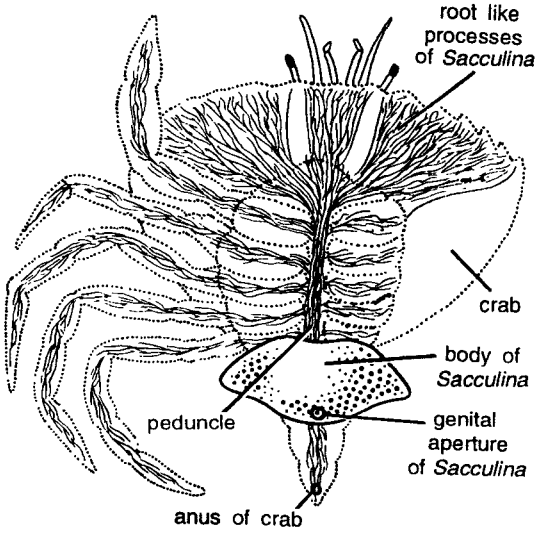


Fig. 143. *Sacculina* at crab's abdomen.

143. *Sacculina*

Classification :

Phylum.....Arthropoda	→	Jointed appandages.
Class.....Crustacea	→	Exoskeleton thick, antennae 2 pairs, jaws 3 pairs.
Sub-class.....Cirripedia	→	Sessile adults without compound eyes and antennae, with carapace and mandibular palps and with 6 pairs of biramous thoracic limbs.
Order.....Rhizocephala	→	Parasitic Cirripedia on decapod Crustacea.

Genus.....*Sacculina* (The root-headed barnacle)

Habit and habitat : ***Sacculina*** is a very interesting animal as it shows extreme case of **degeneration** or **specialization** due to **parasitism** and also it causes **castration** in its host.

Distribution : It has cosmopolitan distribution.

Comments :

(1) **Commonly** called as **root-headed barnacle.**

(2) Parasitizes crabs. Zoologists were able to discover its real crustacean nature by studying its embryology having first stage **nauplius** larva.

(3) Adult loses all arthropodan characters and appears like a fleshy tumour attached to the **abdomen** of the crab on ventral side and lead a parasitic life on decapod crustaceans.

(4) ***Sacculina*** through peduncle sends root like processes like **mycelium of fungus** in each appendages of the crab and in the body to derive nutrition.

(5) Appendages, segmentation, mouth, anus, alimentation absent.

(6) **Hermaphroditic.**

(7) Presence of ***Sacculina*** causes development of many changes in **secondary sexual characters** of the host.

Special features : The nauplius larva resembles that of other crustaceans but without alimentation. Nauplius is free swimming and changes to next larval stage called **Cypris** larva. It attaches itself on decapod crab and then discards its shell and burrows into the host's body. It becomes a mere mass of cells that passes in the crab's blood stream, attaches to host's intestine and grows. When the crab molts, part of parasite protrudes in the abdomen as an ovary packed with egg. The remaining part of ***Sacculina*** becomes branched ramifying throughout the host's body and absorbing nourishment. The host neither grows nor breeds because its sex organs degenerate due to crab. This is called as **parasitic castration.**

Identification : Since the specimen contains round mass of cells and all above characters hence it is ***Sacculina.***

Instructions : *Compare* ***Lepas***, ***Balanus*** and ***Sacculina.*** *Note extreme degree of modifications in* ***Sacculina****, a cirripede.*

144. *Gammarus*

Classification :

Phylum.....Arthropoda	→	Jointed appendages.
Class.....Crustacea	→	Exoskeleton thick, antennae 2 pairs, jaws 3 pairs.
Sub-class.....Malacostraca	→	Free-living Crustacea with compound eyes, biramous antennules, mandibles, 8 thoracic and 6 abdominal segments having appendages.
Order.....Amphipoda	→	Carapace absent, body elongated and laterally compressed.

Genus.....*Gammarus* (The sand flea)

Habit and habitat : ***Gammarus*** is found in salt, brackish and fresh-waters. It is mainly a scavenger, eating dead and decaying animals and vegetation.

Distribution : It is found in Europe, U.S.A., Alaska to California, Long Island Sound to Bay of Fundy.

Comments :

(1) **Commonly** called as **sand-flea or fresh-water shrimp.**

(2) Body is bilaterally compressed and differentiated into **head, thorax** and **abdomen.**

(3) First thoracic segment is fused with head and without carapace.

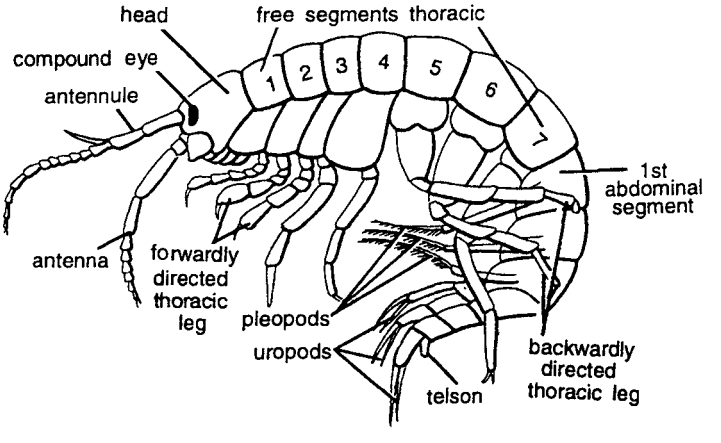


Fig. 144. *Gammarus.*

(4) Head appendages are **antennules, antennae, mandibles, maxillulae, maxillae.**
(5) First fused thoracic segment contains **maxillipedes** without epipodites and 7 free thoracic segments contain **walking legs.** First 2 pairs of legs are subchelate, the remaining are non-chelate, of which the first 2 pairs are **directed forwards** and the **last three backwards.** Second third pairs usually **prehensile.**
(6) Coxopodites of walking legs contain branchiae.
(7) Third and fourth abdominal segments are flexed ventrally. First three and the last three segments bear **swimming pleopods** and **jumping uropods,** respectively. The first three pairs of **pleopods** bear multiarticulate rami.
(8) Last three abdominal segments have bunches of small hairs. Posteriorly abdomen ends in a **telson** having deep cleft.
(9) **Heart** is thoracic.
(10) Sexes are separate. Fertilization is **external.** Eggs and embryos are carried by female which in turn are carried by males.

Identification : Since the specimen has no carapace and contains all above features, hence it is ***Gammarus***.

145. *Caprella*

Classification :

Phylum..... Arthropoda	→	Jointed appendages.
Class..... Crustacea	→	Exoskeleton thick, antennae 2 pairs, jaws 3 pairs.
Sub-class..... Malacostraca	→	Free-living Crustacea with compound eyes, biramous antennules, mandibles, 8 thoracic and 6 abdominal segments having appendages.
Order..... Amphipoda	→	Carapace absent; body elongated and laterally compressed.
Genus..... *Caprella*		

Habit and habitat : ***Caprella*** lives in association of seaweeds, hydroid and polyzoan colonies.
Distribution : It has cosmopolitan distribution. Specially found in U.S.A., Alaska to Santa Barbara.
Comments :

(1) It is a known as **no-body** crab with peculiar and extremely slender body and limbs.
(2) Body has elongated segments, consisting of **cephalothorax** and **abdomen.**
(3) First thoracic segments fuse with head forming cephalothorax containing **eyes, antennules** and **antennae.** Antennae are shorter than antennules.
(4) First antennae longer than the second.
(5) Thorax has six free segments and contains **heart.**
(6) **Gills** confined to third and fourth free thoracic segments on which the legs may be wanting while the rest have sub-chelate walking legs.
(7) **Abdomen reduced** to a small **knob** bearing a pair of rudimentary legs in the male.
(8) **Male** is smaller than the **female.** Structure of male is like female.
(9) It resembles in colour and form with polyzoan hydroid to which it mimics. It holds on by 3 pairs of long posterior prehensile thoracic legs.

Identification : Since the specimen contains elongated cephalothorax and all above features, hence it is ***Caprella***.

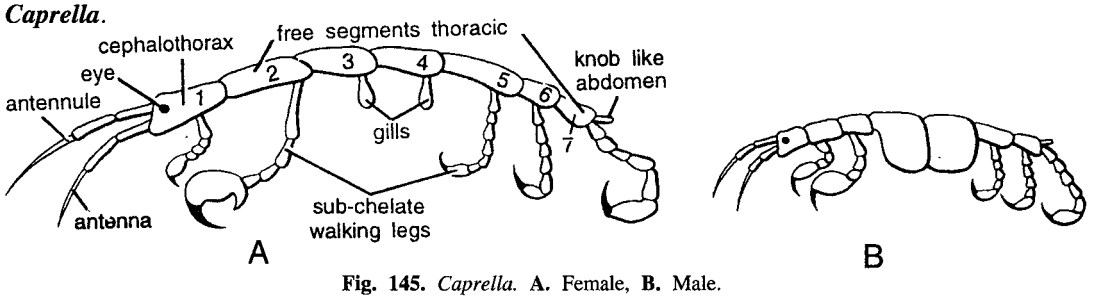


Fig. 145. *Caprella.* **A.** Female, **B.** Male.

146. *Oniscus*

Classification :

Phylum..... Arthropoda	→	Jointed appendages.
Class..... Crustacea	→	Exoskeleton thick, antennae 2 pairs, jaws 3 pairs.
Sub-class..... Malacostraca	→	Free-living Crustacea with compound eyes, biramous antennules, mandibles, 8 thoracic and 6 abdominal segments having appendages.
Order..... Isopoda	→	Carapace absent; body dorsoventrally flattened.

Genus..... *Oniscus* (The wood louse or saw bug)

Habit and habitat : ***Oniscus*** is found in dry places under stones, leaves, dead trees and beneath matted vegetation. It is unique among Crustacea for its perfect adaptation to terrestrial life and it feeds on decaying vegetation.

Distribution : It is found in Europe.

Comments :

(1) **Commonly** called as **wood louse** or **saw bug.**

(2) Body is broad, oval and dorsoventrally compressed with granulated or **tuberculated** surface having deep slate colour and white spots.

(3) Body is divided into **head, thorax** and **abdomen.**

(4) First thoracic segment is fused with head forming **cephalothorax,** which is devoid of dorsal carapace. Compound eyes are sessile.

(5) Appendages are rudimentary **antennules,** uniramous and prominent **antennae, labrum** and **mandibles.**

(6) Fused thoracic segments contain **maxillepedes** visible on ventral side. Rest of the thoracic segments have walking legs.

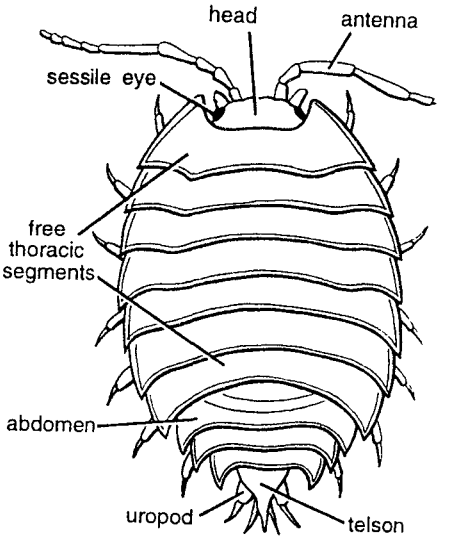


Fig. 146. *Oniscus.*

(7) First 5 abdominal segments contain **pleopods** and the last abdominal segments fused with **telson.**

(8) Thin vascular abdominal pleopods functioning as **gills.**

(9) Pleopods have trachea like respiratory tubes.

(10) It breeds in warm months. The young develop in a brood pouch and emerge in form much like the adults except in size.

Identification : Since the specimen contains two reduced abdomen, reduced pleopods and all above features, hence it is ***Oniscus.***

147. *Bopyrus*

Classification : Same as that of ***Oniscus.***

Genus.....*Bopyrus*

Habit and habitat : ***Bopyrus*** belonging to family Bopyridae inhabits the gill chambers (branchial cavity) of the prawns.

Distribution : It has **cosmopolitan** distribution.

Comments :

(1) **Parasitic isopod** exhibiting extra ordinary **sexual dimorphism** (Fig. 147).

(2) Adult **female** is greatly deformed bopyrid with an asymmetric body and without distinct segmentation. It has following characters :

(i) **Body** is more or less oval.

(ii) It has suctorial mouth parts with simple piercing mandibles.

(iii) **Maxillipedes** are widely expanded covering the head appendages in front.

(iv) Large lamellar or **oostegites** develop from the bases of the thoracic limbs and form a brood pouch. Seven pairs **of thoracic legs are short and hooked for attachment.**

(v) **The abdominal appendages are plate-like functioning as gills.**

(3) **Dwarf male** is usually found attached to the female beneath the last pair of oostegites. It is more isopodian since it normally possesses developed thoracic and abdominal appendages.

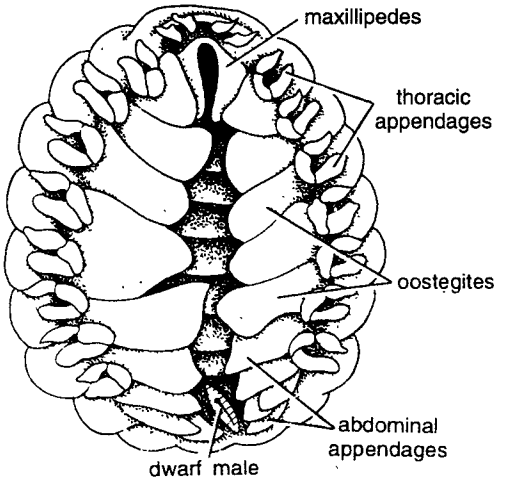


Fig. 147. *Bopyrus.*

Special features : The **life cycle** is completed involving two arthropods. **First host** is copepod and **second decapod** Crustacea. Actually ***Bopyrus*** **is** a **protandric hermaphrodite**. Its larval stage is actually a functional male but when it assumes the parasitic habit, it loses the male organization and becomes a female.

Identification : Since the above parasite has expanded maxillipedes and all above characters, hence it is ***Bopyrus***.

148. *Squilla*

Classification :

Phylum.....Arthropoda	→	Jointed appendages.
Class.....Crustacea	→	Exoskeleton thick, antennae 2 pairs, jaws 3 pairs.
Sub-class.....Malacostraca	→	6 abdominal segments having body distinctly segmented.
Order.....Stomatopoda	→	Abdomen broader than cephalothorax.
Genus.....*Squilla*		

Habit and habitat : ***Squilla*** is a large, marine crustacean, found in burrows in the sand or mud at the bottom of the sea. It is an active predatory form catching prey with powerful maxillipedes (Fig. 148).

Distribution : It is found in India, Gulf of Mexico and Southern coast of Florida.

Comments :

(1) Body is whitish, semi-transparent and is differentiated in **cephalothorax**, **thorax** and **abdomen** measuring 25 cm in length.

(2) **Carapace** is small, flat uncalcified and fused with only three thoracic segments leaving at least four uncovered. Rostrum covers anterior region. There are two free segments in the head bearing **pedunculate eyes** and **antennules** respectively.

(3) **Head** appendages are **bilobed** eyes, **antennules** and **antennae**.

(4) First five pairs of uniramous thoracic appendages serve as **maxillipedes**, the second being the largest, **sub-chelate** and **raptorial**. The dactylus is armed with teeth on the inner margin. There are no oostegites.

(5) Last three thoracic segments bear **walking legs.**

(6) **Abdomen** composed of 6 segments, is broader and elongated than cephalothorax. The first five abdominal segments with longitudinal ridges (carinae).

(7) Abdomen has large and biramous **pleopods**. The first five pleopods have branchiae or gills attached to exopodites while the sixth pair of abdominal limbs form a **tail fan** with the **telson.**

(8) **Heart** is greatly elongated extending through the thoracic and abdominal regions.

(9) Larvae are pelagic and in their general form resemble the **zoaea larva** of crab.

Identification : Since the specimen contains whitish semi-transparent body and all above features, hence it is ***Squilla.***

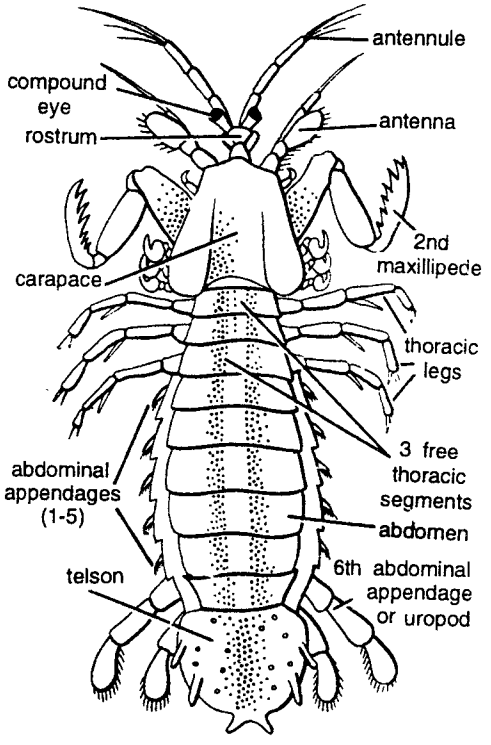


Fig. 148. *Squilla.*

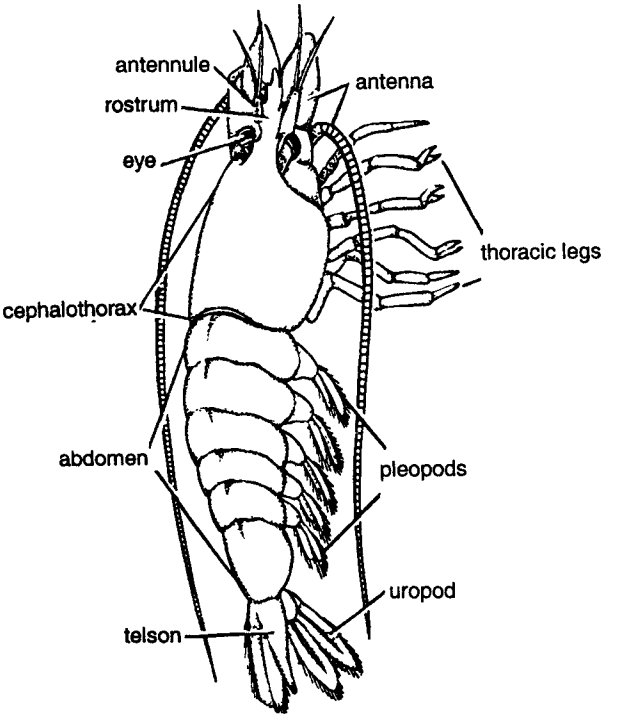


Fig. 149. *Penaeus.*

149. *Penaeus*

Classification :

Phylum.....Arthropoda	→	Jointed appendages.
Class.....Crustacea	→	Exoskeleton thick.
Sub-class.....Malacostraca	→	Body distinctly segmented.
Order.....Decapoda	→	Carapace present.
Sub-order.....Macrura	→	Abdomen well developed and hard.
Genus.....*Penaeus*		

Habit and habitat : ***Penaeus*** is a marine and deep sea form, chiefly inhabiting tropics.

Distribution : It is found in American water.

Comments :

(1) It is commonly called as **prawn**.

(2) The preserved specimen is orange-pink in colour having thin integument.

(3) Body is divided into an anterior rigid **cephalothorax**, posterior flexible **abdomen** and a post segmental terminal **telson**. All these divisions contain appendages.

(4) Cephalothorax is formed of 6 **cephalic and** 8 **thoracic segments**. **Head contains** 2 **prominent eyes, very long antennae** and **short antennules**.

(5) Endopodite of the first **maxillula** is elongated and segmented.
(6) **Walking legs** are attached to thorax and the first three pairs of legs are chelate. Each leg bears **exopodite** and **endopodite**.
(7) **Abdomen** consists of 6 segments and contains swimmerets of biramous swimming pleopods. They lack finger-like processes called appendix internae on their exopodites. Abdomen is laterally compressed but not bent sharply. **Pleopods** are biramous and devoid of appendix internae.
(8) Pleura of the second abdominal segment do not overlap those of the first.
(9) Development includes nauplius, protozoaea and zoaea stages.

Economic value : ***Penaeus*** has edible value.

Identification : Since the specimen contains cephalothorax, and leaf like uropods, flexed abdomen and all above features, hence it is ***Penaeus***.

150. *Palaemon malcolmsonii*

Classification : Same as that of ***Penaeus***.

Genus.....***Palaemon***

Species.....***malcolmsonii***

Habit and habitat : ***Palaemon*** is found in fresh-water streams, rivers, ponds and lakes. The animal is **nocturnal**, hiding at the bottom during the day and coming to the surface at night in search of food.

Distribution : Commonly found in India.

Comments :

(1) **Commonly** called as **prawn**.
(2) Body is elongated, spindle-shaped, bilaterally symmetrical and deep orange coloured when preserved and measuring about 25 cm in length.
(3) Divisions of the body are **cephalothorax**, **abdomen** and **telson**.
(4) **Cephalothorax** is made up of 5 **head** and 8 **thoracic segments**. **Carapace** is anteriorly produced into **sawtoothed rostrum**. There are two **prominent eyes** on the head.

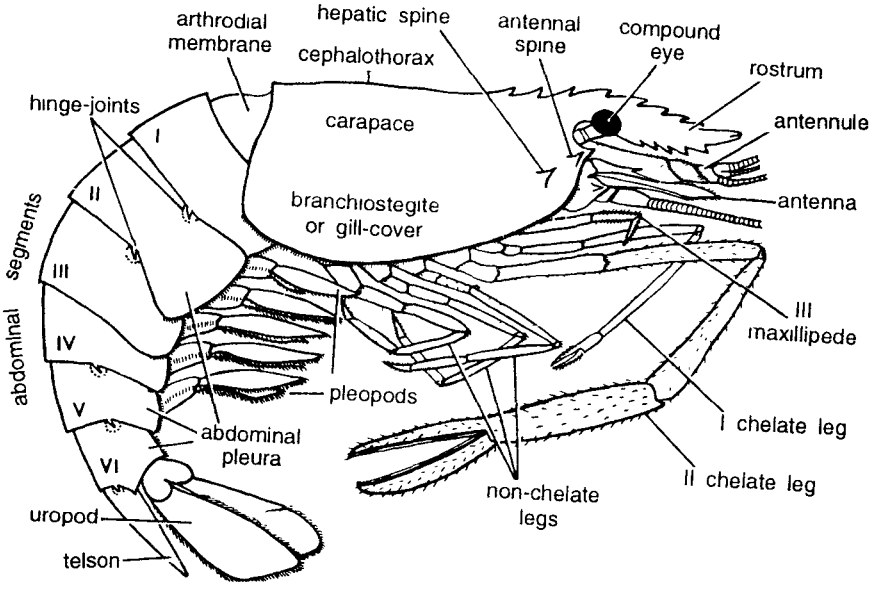


Fig. 150. *Palaemon malcolmsonii* : Prawn.

(5) Abdomen is made up of 6 segments. It is dorsally rounded, laterally compressed and normally bent under the cephalothorax so that the animal looks like comma.
(6) There are 19 pairs of appendages, one pair in each segment. The **cephalic** appendages comprise of **antennules**, **antennae**, **mandibles**, **maxillulae** and **maxillae**. A large platelike antennal used as a rudder in swimming.
(7) Thoracic appendages are **I maxillipedes**, **II maxillipedes**, **III maxillipedes** and 5 **pairs of jointed walking legs**.
(8) First abdomen somite is not reduced. Rest five abdominal segments contain paired **biramous swimming pleopods**. **VIth abdominal segment contains paired uropods and a telson**. Development includes nauplius larva.

Special features : Prawns have edible importance and they have great educational importance. They are most familiar animals for dissection to understand invertebrate anatomy.

Identification : Since the specimen is larger than ***Penaeus***, contains spatulate uropods and all above characters, hence it is ***Palaemon malcolmsonii***.

151. *Astacus fluviatilis*

Classification : Same as that of ***Penaeus***.
Genus.....***Astacus***
Species.....***fluviatilis***

Habit and habitat : ***Astacus*** is common in streams, rivers and lakes. It is **omnivorous** feeding on any alive or dead matter. Its acts as **scavenger**.

Distribution : It is found on the Pacific slope, Europe, Asia, England, U.S.A., Australia and New Zealand.

Comments :
(1) **Commonly** called as **cray-fish**.
(2) **Body** is essentially sub-cylindrical in shape, small, about 9 cm in length and divided into anterior **cephalothorax**, middle flexible **abdomen** and posterior **telson**.
(3) Cephalothorax comprises of **head** and **thorax** and is covered by **carapace**, which is produced into **short** and unserrated **rostrum** and on sides covers the gills. Cervical groove demarcates head and thorax.
(4) **Eyes are stalked**, **antennules short** and **antennae** elongated.
(5) Appendages are 19 pairs—5 **cephalic**, 8 **thoracic** and 6 **abdominal**.
(6) Abdomen contains 6 pairs of **swimming appendages** or pleopods and a **telson**.
(7) Abdominal segments are movable upon one another in a vertical plane. The abdomen is long and extended and ending in tail fans.
(8) Walking legs are **chelate**. One pair of legs are called as **chelipeds**. These are much enlarged appendages, terminating in huge claws or chelate.
(9) **Telson** forms a **tail-fan** together with **uropods**.

Special features : Female carries hundreds of small, rounded eggs on the ventral side of her abdomen. Eggs hatch into young cray-fishes, which are exact replicas of the mother and cling to her for some time.

Economic value : It is relished as food.

Identification : Since the specimen contains, cephalothorax, cheliped, fan-like uropod and all above features hence it is ***Astacus***.

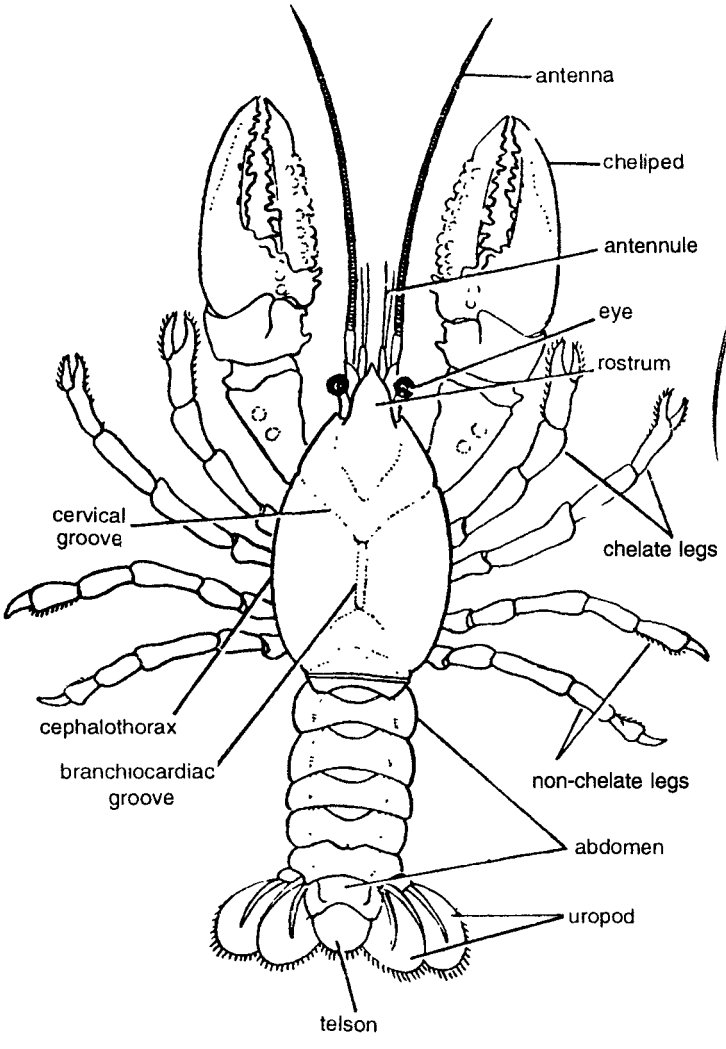


Fig. 151. *Astacus fluviatilis.*

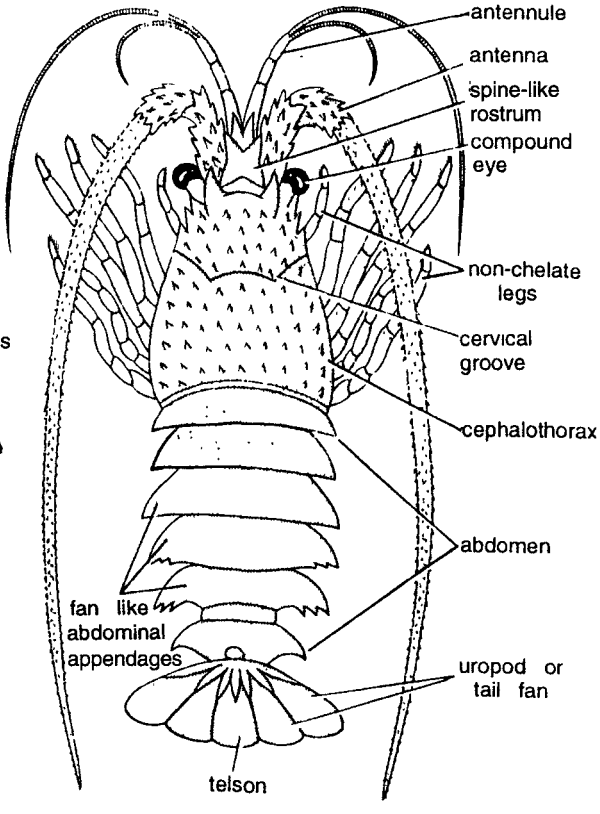


Fig. 152. *Palinurus.*

152. *Palinurus*

Classification : Same as that of ***Penaeus***.

Genus.....*Palinurus*

Habit and habitat : ***Palinurus*** is a marine crustacean.

Distribution : It is found in Europe and Asia.

Comments :

(1) **Commonly** called as **marine rock lobster** or **spiny lobster**.

(2) Body is either not compressed or is dorsoventrally compressed and differentiated into cephalothorax and abdomen.

(3) It differs from other crayfishes and lobsters in having a small **spine-like rostrum** over cephalothorax.

(4) Cephalic appendages are **antennae**, **antennules** and eyes. **Antenna sac** is absent and **antennae are much elongated**.

(5) Thoracic appendages bear **non-chelate but clawed walking legs** of the same size.
(6) **Abdominal appendages** are **fan-like**, but the first abdominal segment is without appendages. The abdomen is long and extended and ending in a tail fan. The pleura of second abdominal segment do not usually overlap those in front.
(7) Meat of the lobster is very delicious and very much sought after.
(8) Larva is called as **Phyllosoma**, which is a broad and thin schizopod larva.

Special features : The rock lobster produces a peculiar sound like creaming of leather by rubbing antennal pad against a sternal keel.

Identification : Since the specimen contains much elongated antennae, fan-shaped abdomen, uropod and all above features, hence it is ***Palinurus***.

153. *Eupagurus* : Hermit-crab

Classification :

Phylum.....Arthropoda	→	Jointed appendages.
Class.....Crustacea	→	Exoskeleton thick, antennae 2 pairs, jaws 3 pairs.
Sub-class.....Malacostraca	→	Free-living Crustacea with compound eyes, biramous antennules, mandibles, 8 thoracic and 6 abdominal segments having appendages.
Order.....Decapoda	→	Carapace present; first three thoracic limbs from maxillipedes.
Sub-order.....Anomura	→	Abdomen flexed.

Genus..... ***Eupagurus*** **(The Hermit-crab)**

Habit and habitat : ***Eupagurus*** leads a **commensal life**. It occupies a gastropod shell and it adjusts in the coils of shell with appendages protruding.

Distribution : Cosmopolitan. It is found from Alaska to lower California and Main to Florida. At Mumbai and Goa beaches. Eupagurus is a very favourite sea-shore animal.

Comments :

(1) **Commonly** known as **Hermit-crab**.
(2) **Eupagurus** (Hermit-crab) is a peculiar crustacean having extreme modifications in order to adjust in the coils of molluscan shells. Modifications are as under :
  (i) Body is reduced in varying degree and asymmetrical but shows usual divisions into **head, thorax** and **abdomen**.

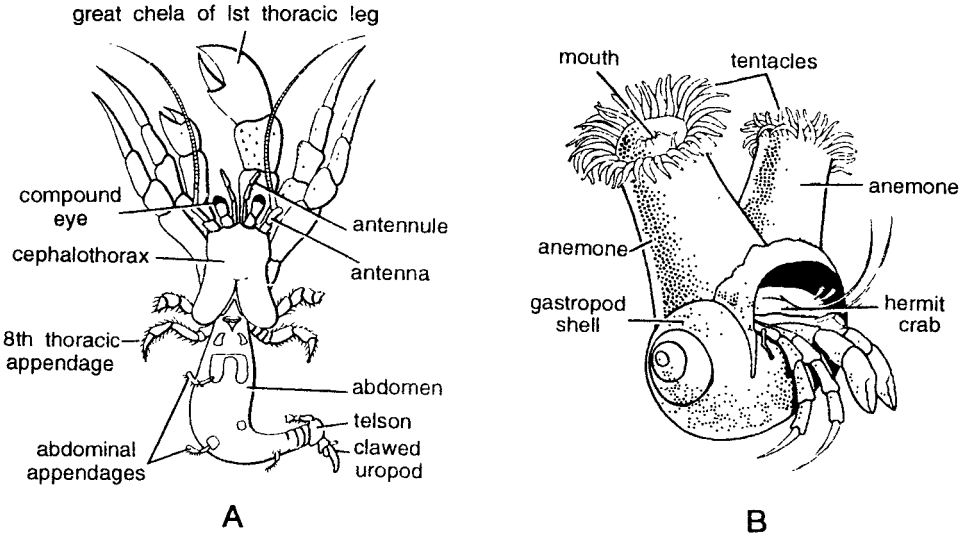


Fig. 153. A. Hermit-crab, **B. Commensalism** between hermit-crab and sea-anemone.

(ii) **Carapace** reduced and not fused at the sides with **epistome**. It covers head. Rostrum absent.

(iii) Head contains **antennules**, **antennae** and **stalked eyes**. **Thoracic appendages protrude through the opening of the shell**. **First thoracic** leg is **chelate** and **rest reduced**. Right chelate leg is very large as compared to left and it acts as lid or **operculum**. Abdomen is asymmetrical, soft fleshy, elongated and twisted or bent under the thorax. Abdominal appendages of the right side absent while those of left side **reduced**. Sixth left abdominal appendages (**uropod**) adapted for holding the body in hollow objects.

(iv) Seventh and eighth thoracic appendages are reduced and remain inside the mollusc shell.

(v) **Uropods** are hooked and notched in the shell.

Special features : Hermit-crab inside the gastropod shell and sea-anemone over the shell associate themselves to lead a **commensal life**. The hermit-crab by its appendages takes sea-anemone to varied places for food and in turn sea-anemone protects itself as well as the crab by its stinging cells. When the growth of the body demands, the ***Eupagurus*** selects a new large shell and deserts the old one. There is no metabolic dependency in above association.

Identification : Since the specimen has protruding thoracic appendages, from mollusc shell and all above characters hence it is **Hermit-crab** (***Eupagurus***).

154. *Hippa*

Classification : Same as that of ***Eupagurus***.

Genus.....*Hippa*

Habit and habitat : ***Hippa*** is commonly found in the sand bottoms and beaches near the coastal region. It burrows with fast speed.

Distribution : It is found on Pacific coast, U.S.A. and Oregon to Mexico.

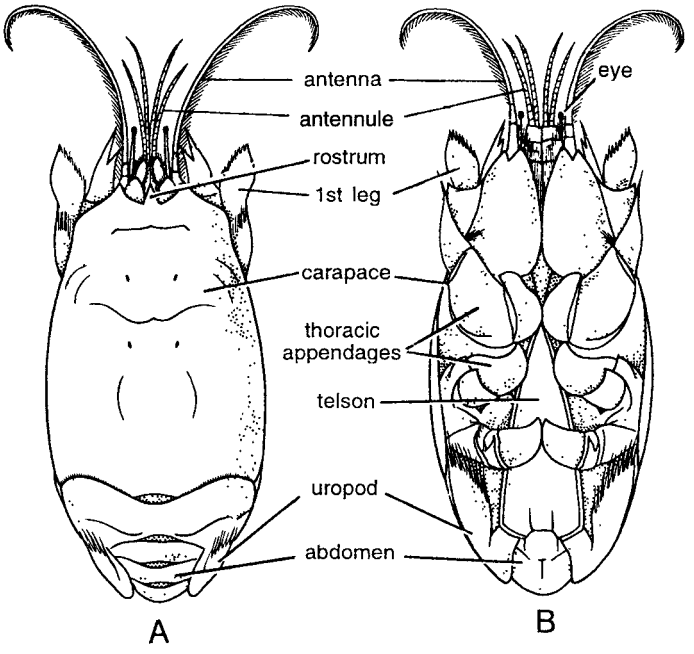


Fig. 154. *Hippa.* **A.** Dorsal view, **B.** Ventral view.

Comments :

(1) **Commonly** called as **mole crab.**

(2) Body is somewhat reduced and the sub-cylindrical **carapace** is provided with wings which cover the legs. Rostrum is reduced.

(3) **Head** appendages are a pair of stalked **compound eyes**, a pair of **short antennules** a pair of long **hairy antennae**. The **third maxillipedes** are broad.

(4) 7 pairs of **thoracic appendages** are present. First 2 pairs are partially chelate, next two pairs are pointed anteriorly and last three pairs are backwardly pointed. A **gill** is attached with each thoracic legs.

(5) Last one or two pairs of thoracic appendages are usually smaller and often concealed by the carapace.

(6) **Abdomen** is more or less reduced often soft and bent upon itself. The abdominal pleura small.

(7) **Abdomen** 6-segmented. First 3 abdominal segments bear **swimming appendages** and produce water current to bathe the gills. The last three are posteriorly directed and are called as **uropods**, which are used for darting.

Identifications : Since the specimen contains sub-cylindrical carapace concealing appendages and all above features, hence it is ***Hippa***.

Instructions : *Make a comparative account of* ***Squilla***, ***Penaeus***, ***Palaemon***, ***Astacus***, ***Palinurus*** and ***Hippa***. *Observe various modifications especially in* ***Hippa***.

155. *Carcinus*

Classification :

Phylum..... Arthropoda	→	Jointed appendages.
Class..... Crustacea	→	Exoskeleton thick, antennae 2 pairs, jaws 3 pairs.
Sub-class..... Malacostraca	→	Free-living Crustacea with compound eyes, biramous antennules, mandibles, 8 thoracic and 6 abdominal segments having appendages.
Order..... Decapoda	→	Carapace present; first three thoracic limbs from maxillipedes.
Sub-order..... Brachyura	→	Abdomen reduced.

Genus..... ***Carcinus*** **(The common crab)**

Habit and habitat : ***Carcinus*** is found buried among rocks or mud in shallow water. The crabs are highly specialized crustacean. Breeding season is spring.

Distribution : It has cosmopolitan distribution and specially found in Europe, U.S.A. and India.

Comments :

(1) **Commonly** called as **Rock crab** or **True crab.**

(2) Body generally dorsoventrally compressed and consist of a large and broad cephalothorax and a **stumpy abdomen. Cephalothorax** is broader than long. The **carapace** is fused with epistome at the sides and nearly always in the middle. Rostrum absent.

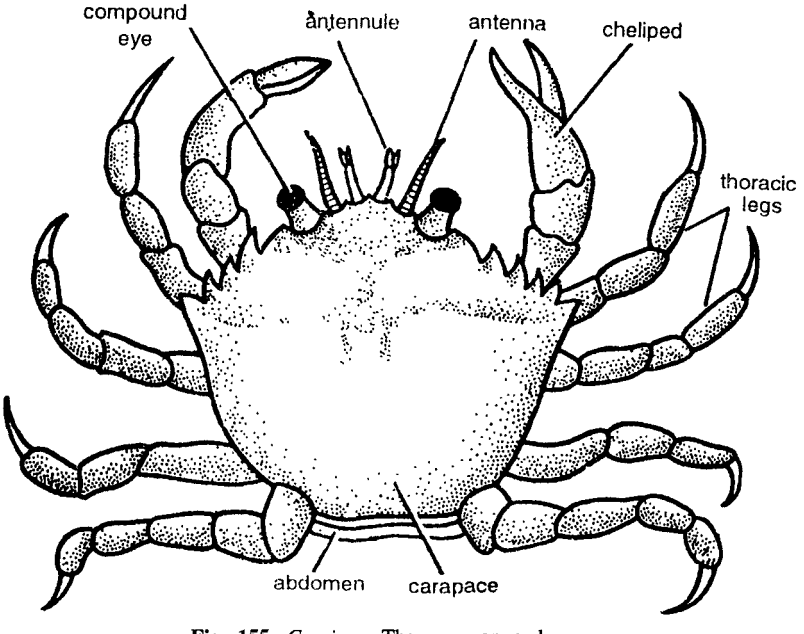


Fig. 155. *Carcinus.* The common crab.

(3) Small **antennules**, **antennae** and **eye spots** are contained in the sockets of the carapace.
(4) **Third maxillipedes** are broad flat, valve like covering the other mouth parts on ventral surfaces.
(5) Five pairs of thoracic legs are well developed.
(6) **Abdomen** is reduced and fixed under cephalothorax. It is permanently bent under the cephalothorax fitting into a groove in the thoracic sterna, thus remaining invisible in the dorsal view of the animal.
(7) Abdomen is narrower in male but somewhat broader in female. The abdominal pleura greatly reduced or absent and the abdomen without tailfans.
(8) **Pleopods** are greatly reduced. The male has only 2 pairs of pleopods to act as copulatory organ while the female has 4 pairs for the attachment of the eggs. **Uropods** are absent.
(9) Young hatches in the zoaea stage and passes through a megalopa stage before reaching maturity.

Identification : Since the specimen contains stumpy abdomen and all above characters, hence it is ***Carcinus***.

156. *Scolopendra* : Centipede

Classification :

Phylum.....Arthropoda → Jointed appendages.
Class.....Chilopoda → Carnivorous; body dorsoventrally flattened. One pair of walking legs in each segment (Centipedes).
Order.....Scolopendromorpha
Genus.....*Scolopendra* (Centipede)

Habit and habitat : ***Scolopendra*** is tropical animal, found in swampy places under bark, stones, decaying wood, etc. It requires absolute moisture. In less than 100% humidity, it loses water through spiracles and dies. It is **carnivorous**, usually hides by day below stones, plant leaves etc. and runs swiftly by night to prey on insects and earthworms.

Distribution : It is found in India, America (Austin and Texas).

Comments :

(1) **Commonly** called as **centipede**.
(2) Body is elongated, dark greenish-brown in colour, dorsoventrally flattened and is divided into a distinct **head** and a long, segmented **trunk** or **body**.
(3) **Head** segments are closely fused. Head appendages are long **antennae**, **ocelli** and reduced maxillae and mandible visible on ventral side.
(4) Mouth is guarded by labrum, mandibles and first maxillae.
(5) Body segments have 21 pairs of walking legs. The first pair of legs are curved, clawed and forwardly directed to **form maxillipedes** or **poison claws**, while the rest of walking legs have 7 **joints**. All walking legs are similar.
(6) Each leg is composed of coxa, trochanter, femur, tibia and 3 tarsi ending in a single claw.
(7) Paired, oval spiracles or stigmata lie on the **pleural areas**, above the leg bases on segments 4,6,9,11,13,15,17,19 and 21.
(8) Last segment bears ventral **anus**, **genital atrium** and a pair of **anal style**.
(9) There is a single pair of tracheal tufts opening to the exterior on the head.
(10) ***Scolopendra*** is harmful to mankind.

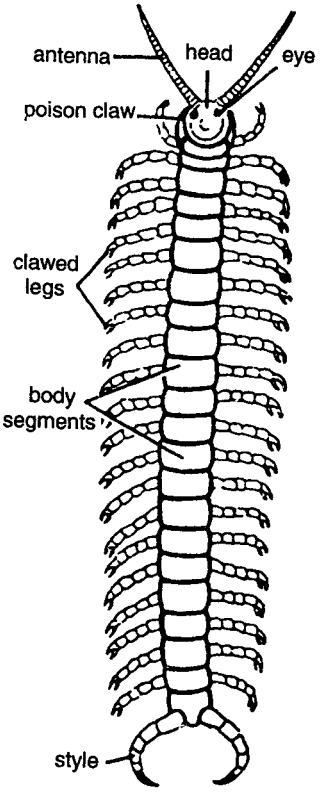


Fig. 156. *Scolopendra* : Centipede.

Identification : Since the specimen has a pair of short clawed legs in each segment and all above features, hence it is ***Scolopendra.***

157. *Julus* : Millipede

Classification :

Phylum..... Arthropoda → Jointed appendages.
Class..... Diplopoda → Two pairs of legs in each body segment. Herbivorous (Millipedes).
Genus..... *Julus* (The wire worm)

Habit and habitat : ***Julus*** is also tropical, found in dark and damp places in meadows and gardens under stones and bark of dead trees. The animal is rolled up under stones. It is herbivorous. It also burrows into the soil to feed on the roots of the living plants to which it causes great damage.

Distribution : It has cosmopolitan distribution found in India, U.S.A. and Europe.

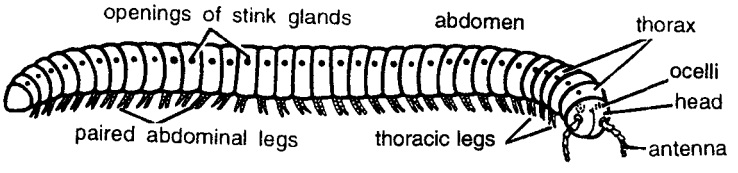


Fig. 157. *Julus* : Millipede.

Comments :

(1) **Commonly** called as **wire worm.**
(2) Body of the animal is differentiated into **head, thorax** and **abdomen.**
(3) **Head** is covered by cephalic shields bent downwards. Head appendages are 7 jointed delicate **antennae,** groups of **ocelli, mandibles,** obscured by gnathochilarium. Antennae on the sides of the head.
(4) **Thorax** has four segments and each of the last three segments is provided with one **pair of walking legs.**
(5) **Abdominal** segments are double, each having one tergum, two small sterna, two pairs of walking legs and two pairs of obscure spiracles.
(6) Sides of most terga have dark openings of **odoriferous** glands, secreting **noxious** substance.
(7) Animal moves very slow in spite of its so many legs. The colour may be yellowish brown or reddish-chestnut.
(8) There is no tracheal system.

Identification : Since the specimen contains two pairs of short legs and all above features hence it is ***Julus. Myroglutus*** is another millipede.

Instructions : *Differentiate between* ***Julus*** *and* ***Scolopendra.***

158. *Peripatus*

Classification :

Phylum..... Arthropoda → Jointed appendages.
Class..... Onychophora → Primitive arthropods with unjointed legs and annelidan set up.
Genus..... *Peripatus*

Habit and habitat : ***Peripatus*** is a nocturnal carnivorous animal, living in rock crevices, under bark of trees, stones and moist places.

Distribution : It has a discontinuous distribution. Found in damp forests of Africa, Malaysia, Australia, South America and New Zealand.

Comments :

(1) It is referred as **living fossil.**

(2) Body of the animal is cylindrical and elongated caterpillar like and measuring 4 to 6 cm in length.

(3) Outer covering of the body is thin velvety, chitinous showing transverse **wrinkles**, numerous small **papillae** or **tubercles**.

(4) Anterior end is marked by **preantennae** and ventral **mouth** and posterior end by **anus**.

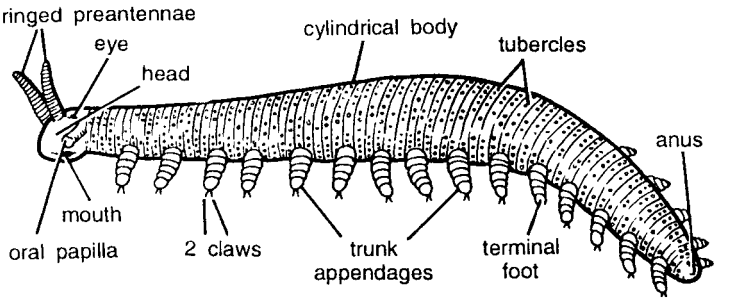


Fig. 158. *Peripatus.*

(5) There is a head of three segments which is not clearly separate form the body.

(6) Post-oral segments of the head bear pair of hooked jaws, a pair of **oral papillae**, a pair of **simple eyes** and a pair of **segmented antennae**. It feeds on insects which they catch by means of slime ejected from their oral papillae.

(7) There are about, **fifteen pairs of walking legs**. Each leg is unjointed but is ringed by ridges having tubercles and terminates in a **foot**, which bears two curved claws and three distinct tubercles.

(8) There is a tracheal system (for respiration) with **spiracles** scattered irregularly over the body surface. Excretion nephridial. Sexes separate.

(9) **Crural** glands are absent and genital pore is posterior. Mostly viviparous, but some may show oviparity.

(10) ***Peripatus*** is supposed to be the connecting link between **Annelida** and **Arthropoda**.

Special features : ***Peripatus*** was first described in 1825 and was classified with the molluscs due to its slug-like appearance. Grube (1874) kept it under **Annelida** and coined the name ***Onychophora***. Burmeister (1856) placed the group between annelids and arthropods and Moseley (1874) finally demonstrated its relationship with arthropods by showing the presence of trachea. Peripatus is zoologically very interesting, because it exhibits both **arthropod** and **annelid** characters as under :

(i) **Annelidian characters :** *The vermiform body, dermo-muscular body wall, simple eyes, unjointed, hollow stumpy appendages on annelidan pattern.*

(ii) **Arthropodal characters :** *Antennae, chitin in cuticle, haemocoel, tracheae, general structure, development and peculiar salivary glands like arthropods.*

Identification : Since the specimen contains pre-antennae, 2 clawed appendages and above features, hence it is ***Peripatus***.

159. *Palamnaeus* : Scorpion

Classification :

Phylum.....Arthropoda	→	Jointed appendages.
Class.....Arachnida	→	Terrestrial or aquatic arthropods with book-lungs or trachea and without antennae, mandibles and jaws.
Order.....Scorpionida	→	Embolobranchiates in which the prosoma bears 3-jointed chelicerae and chelate pedipals.

Genus.....*Palamnaeus* (Scorpion)

Habit and habitat : ***Palamnaeus*** is a nocturnal arthropod, found in sand, crevices and under stones and in bark of dead trees. It feeds on insects and spiders which they often kill with the sting.

Distribution : It has cosmopolitan distribution and specially found in India, Europe and U.S.A.

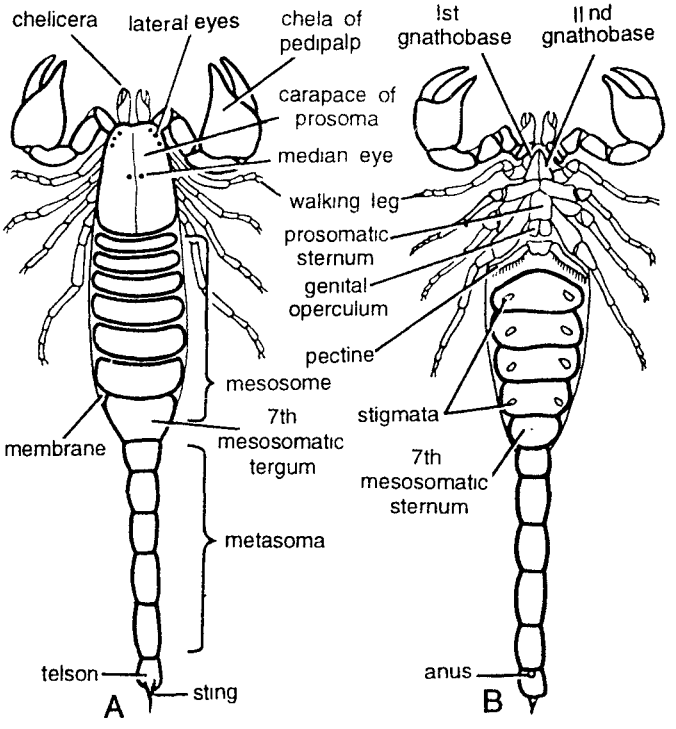


Fig. 159. *Palamnaeus* : Scorpion. **A.** Dorsal view, **B.** Ventral view.

Comments :

(1) **Commonly** called **as scorpion.**

(2) Body is elongated, segmented and differentiated into anterior **prosoma** and posterior **opisthosoma.**

(3) **Opisthosoma** is sub-divided into a broad anterior **mesosoma** and a narrow posterior **metasoma.**

(4) Prosoma is covered dorsally by a **carapace** and its appendages are a pair of small **chelate chelicerae,** a pair of large **chelate pedipalps,** 4 pairs of **walking legs** and **several ocelli.**

(5) Body is encased in chitinous covering. The dorsal side covering is called as **tergum,** side one **pleuron** and ventral one **sternum.**

(6) **Mesosoma** is composed of 7 broad segments and **metasoma** of 5 narrow segments.

(7) Last **metasomatic** segment is **telson** containing a sting. Ventrally the sternum of first **mesosomatic segment** contains a pair of **genital openings.** The second mesosomatic sternum bears a pair of **sensory pectines,** while third, fourth, fifth and sixth **mesosomatic** segments contain 4 pairs of **bilateral stigmata,** which are the openings of the respiratory **booklungs. Metasoma** is limbless.

(8) Just beneath chelicerae there are I and II gnathobases.

(9) Sexes are separate but without sexual dimorphism. **Viviparous.**

Special features : Scorpions are harmful to mankind; its sting causes extreme pain, fever and in some cases collapse. The sting has a poison duct from the sting gland present in telson. Other common forms are ***Buthus*** and ***Centrurus.***

Identification : Since specimen has prosoma, mesosoma, metasoma and all above features, hence it is **Scorpion.**

160. *Aranea* : Spider

Classification :

Phylum.....Arthropoda → Jointed appendages.

Class.....Arachnida → Terrestrial or aquatic arthropods with book-lungs or trachea and without antennae mandibles and jaws.

Order..... Araneida → Embolo branchiates in which prosoma possesses 2 jointed non-chelate chelicerae and non-chelate pedipalps.

Genus.....*Aranea*

Habit and habitat : ***Aranea*** is commonly found in houses and gardens having cosmopolitan distribution. It is carnivorous, feeding on small insects by hunting or in ensnaring.

Distribution : It is found in India, Africa, New Zealand, Myanmar, Bangladesh and U.S.A.

Comments :

(1) **Commonly** called as **spider.**

(2) Integument is never entirely smooth and glabrous but is more or less densely covered with hairs of many varieties, there being simple, plumose, or in the shape of bristles, scales, clubs or spines.

(3) **Body** is differentiated into an anterior **prosoma** and a posterior **opisthosoma** which is superficially limbless. They are often brightly coloured.

(4) **Prosoma** and **opisthosoma** are joined by a delicate narrow **pedicel**. Prosoma is covered by **carapace** having 8 **ocelli** and **appendages.**

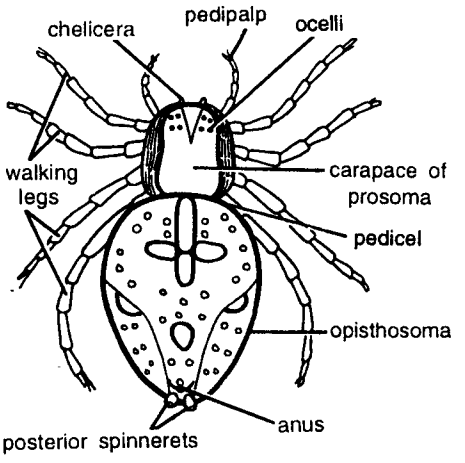


Fig. 160. *Aranea* : Spider.

(5) Head appendages are sub-chelate small **chelicerae** containing **poison glands** and six jointed **pedipalps.**

(6) Segments 4 to 7 bear **walking legs.**

(7) **Opisthosoma** is segmented, soft, rounded and without telson.

(8) Last part of opisthosoma contains **anus** and 4 pairs of **spinnerets spinning organs**, which produce silken threads for the construction of spider web.

(9) Respiratory organs are book-lungs.

(10) Excretory organs are **malpighian tubules** and coxal glands. Sexes are separate with distinct sexual dimorphism.

Special features : The spiders construct **webs** of various types, reticular webs, sheet webs, funnel webs and geometric orb webs. Some spiders are vagabonds and make silk tents only for their protection while moulting or for wintering. Trap door spiders protect the mouth of their burrows with a hinged door.

Identification : Since the specimen has spinnerets spinning organs and all above features, hence it is **spider.**

161. *Limulus* : The King Crab

Classification :

Phylum.....Arthropoda → Jointed appendages.
Class.....Arachnida → Terrestrial or aquatic arthropods with book-lungs or trachea and without antennae, mandibles and jaws.
Order.....Xiphosura → Delobranchiate in which carapace is covered by horseshoe shaped carapace.
Genus.....*Limulus* (The King crab)

Habit and habitat : ***Limulus*** is marine found in muddy bottom, 2 to 6 fathoms deep, partly buried and crawling in sand for food. The king crab lives in shallow water along the shore, where it burrows in the sand and mud and eats worms and small animals. It comes to sandy beaches in the early summer to breed

Distribution : It inhabits eastern coast of Asia and its island and eastern cost of North American from Nova Scotia to Florida. It has restricted and discontinuous distribution.

Comments :

(1) **Commonly** called as **King crab**.
(2) Body is differentiated into a broad **horseshoe-shaped prosoma** and a small nearly triangular **opisthosoma**. Body regions are **cephalothorax, abdomen** and a long spike like **telson** or tail.
(3) **Prosoma** is convex above with sloping sides. It contains one median and two lateral longitudinal ridges.
(4) Prosoma is covered by a large semicircular carapace and joined to opisthosoma by a broad hinge. The prosomatic appendages are first pair of **chelate chelicerae**, while 2 to 7 **segments** bear a pair of **chelate walking legs** each.
(5) **Carapace** also bears one pair of median and two large composite sub-dorsal or **lateral eyes**.

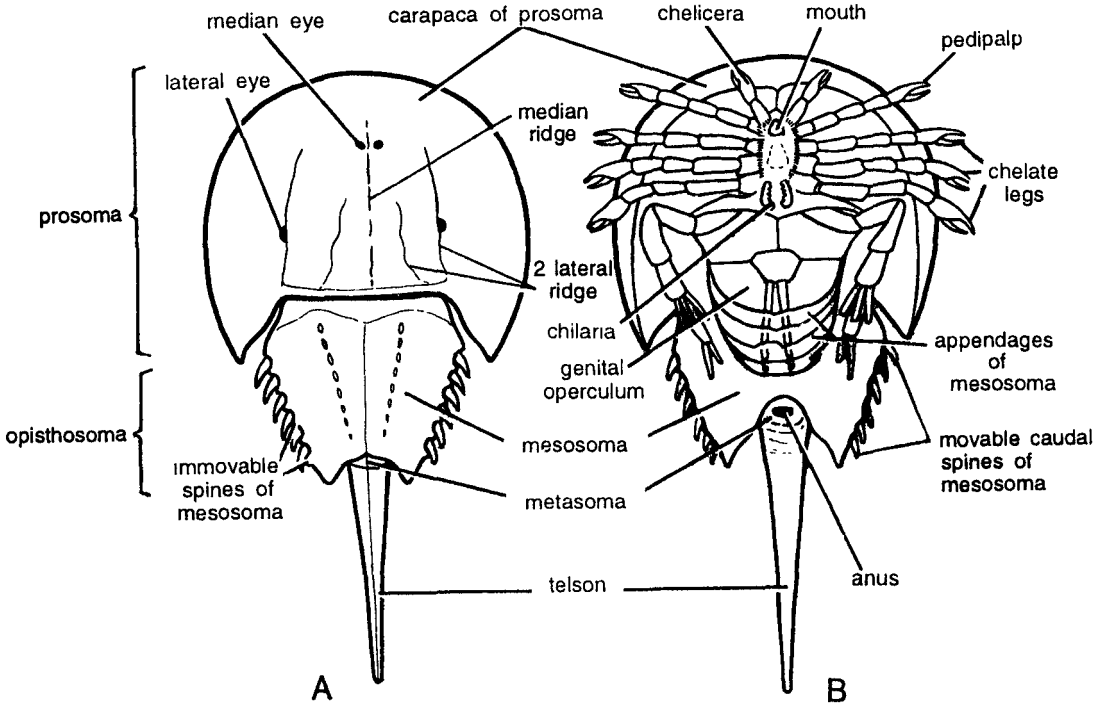


Fig. 161. *Limulus* : King crab. **A.** Dorsal view, **B.** Ventral view.

(6) **Opisthosoma** comprises of six segments, the **mesosoma, a vestigial metasoma** and a long spine like **telson**. Mesosoma contains 6 pairs of **immovable spines**.
(7) **Chelicerae** are 3-jointed small and chelate.
(8) **Legs are biramous** and the last pair are not paddle-shaped.
(9) First pair of mesosomatic appendages form the **genital operculum**. Opisthosoma has book gills. The post anal **caudal spine** is hinged and freely movable.
(10) Young are **planktonic larvae** (Trilobite stage).

Special features : ***Limulus*** has majestic look and hence it is called as king crab. ***Limulus*** has been reported from Paleozoic period when it was abundant and only five species of it, known since Triassic period, are living today, so it has long fossil history. The king crabs although of large size, have little economic importance. Sometimes they are fed to chicken and pigs.

Identification : Since the specimen contains semicircular carapace and all above features, hence it is **King crab**.

162. *Galeodes*

Classification :

Phylum.....Arthropoda **Class.....Arachnida**	→	Characters same as those of ***Limulus***.
Order.....Solpugida	→	Carapace of prosoma divided.
Genus.....*Galeodes*		

Habit and habitat : ***Galeodes*** inhabits dry warm region.

Distribution : Found in India and Asia.

Comments :

(1) Animal looks like insect.
(2) **Carapace of prosoma** is divided with two **chelicerae** having two joints.
(3) The **prosoma** divided into **head** and **thorax**.
(4) **Pedipalps** are elongated, 6 jointed, leg like and sensory.
(5) **Opisthosoma** contains 10 segments.
(6) The **thoracic appendages** 3 pairs.
(7) The body of the animal has large number of **setae**.

Identification : Since the specimen has 6 joined pedipalp and all above characters, hence it is ***Galeodes***.

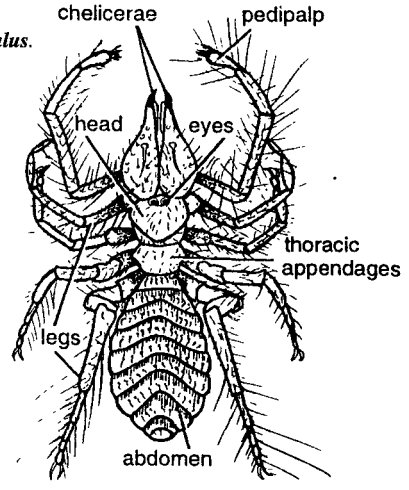


Fig. 162. *Galeodes.*

163. *Lepisma*

Classification :

Phylum.....Arthropoda	→	Jointed appendages.
Class.....Insecta	→	3 pairs of legs.
Sub-class.....Pterygota	→	Wingless insects.
Order.....Thysanura	→	Body covered with small scales.
Genus.....*Lepisma* (Silver fish)		

Habit and habitat : ***Lepisma*** is a common household pest, hiding in damp cool places like basements, in books, under pictures, clothes and wall-paper, etc., and feeding on starch, starched cloth, paste or glue of book bindings. It is a fast runner insect.

Distribution : It is found all over Asia, Europe and U.S.A.

Comments :

(1) **Commonly** known as **silver fish.**
(2) It is a delicate, glistening silver white and fish-shaped insect, which avoids light.
(3) Adults are primitively **wingless.**
(4) Animal measures 1.25 cm in length and is divided into **head, thorax** and **abdomen.**
(5) Body surface is covered with loosely attached scales.
(6) **Head** contains a pair of long many jointed **antennae** and a pair of **compound eyes.**
(7) Antennae joints are incapable of independent movement and it moves as a whole upon its base.
(8) **Mouth parts** adapted for **biting. Thorax** has 3 pairs of small **walking legs** present.
(9) Abdomen has 11 segments with a pair of small appendages, a pair of many jointed and **Cerci** and a median many jointed **telson.**
(10) Development **epimorphic**, i.e., the number of post-cephalic segments increases by proliferation in the hind part of the body following the first embryonic stages, but becomes fixed during the embryonic period. Thus the animal hatches from the egg with the adult number of segments.

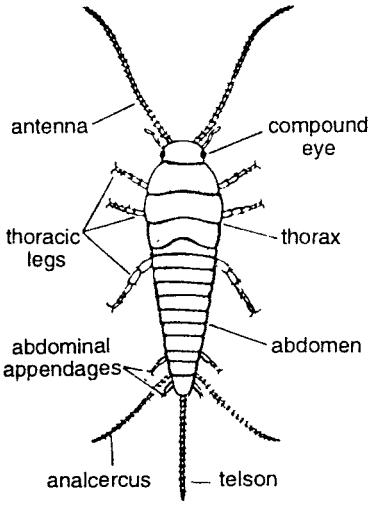


Fig. 163. *Lepisma.*

Economic value : Silver fishes cause considerable damage to the books and clothing by chewing off the starch, sizing or any other articles containing glue.

Identification : Since the specimen has silvery white body and all above characters, hence it is ***Lepisma.***

164. *Periplaneta* : Cockroach

Classification :

Phylum..... Arthropoda	→	Jointed appendages.
Class..... Insecta	→	3 pairs of legs.
Sub-class..... Pterygota	→	Winged insects.
Division..... Exopterygota	→	Wings develop externally.
Order..... Orthoptera	→	Straight wings.
Genus..... *Periplaneta*		
Species.....*americana* (The common cockroach)		

Habit and habitat : ***Periplaneta*** is a nocturnal creature, avoiding the daylight and found in warm and damp places like kitchens, bakeries, hotels, restaurants, godowns, stores, channels and ships, etc.

Distribution : It is found in India, Asia and U.S.A. It has original home in Mexico but has travelled with man to all parts of the world. They flourish chiefly in tropical damp forests but occur throughout the world.

Comments :

(1) **Commonly** called as **cockroach.**
(2) Body reddish brown in colour measuring 2.5 cm in length.
(3) Body elongated bilaterally symmetrical dorsoventrally flattened.
(4) Body strongly differentiated into dorsal and ventral surface and divided into **head, thorax** and **abdomen.**
(5) **Dorsal surface** has following structures :
  (i) **Head** is slightly movable containing of a pair of long sensory **antennae** and pair of **compound.**
  (ii) **Thorax** divisible into **prothorax mesothorax** and **metathorax. Thorax** contains 3 pairs of **walking legs**, a pair of anterior **forewing**, a pair of posterior **hind wings.** At rest wings remain folded and completely cover thorax and abdomen.
  (iii) Abdomen contains 10 segments.

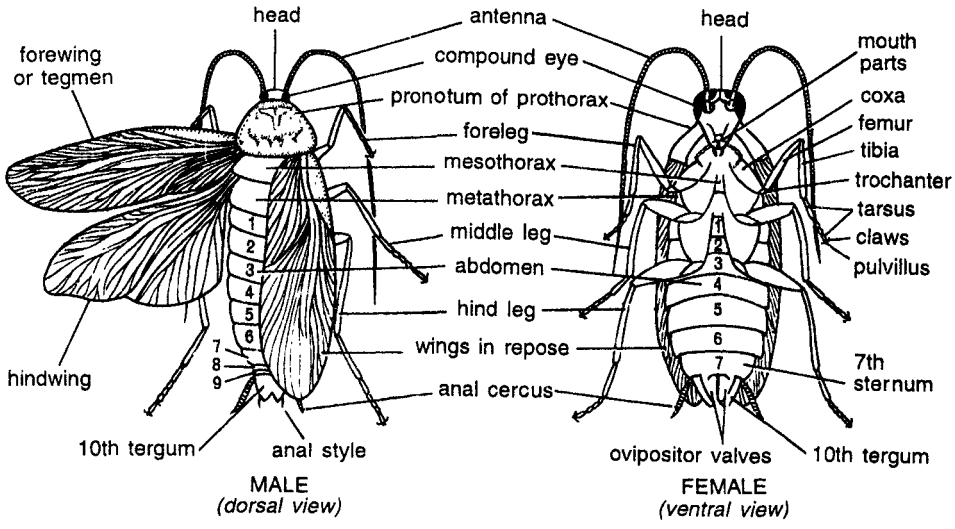


Fig. 164. *Periplaneta* : Cockroach.

(6) **Ventral surface** shows following structures :
  (i) Tentacles and eyes prominent in head.
  (ii) **Head** contains **chewing** type of clearly visible **mouth parts**.
  (iii) Three pairs of **legs** in thorax, **foreleg, middle leg** and **hind leg**. Each contains coxa, trochantex, femur, tibia, tarsus, claws and pulvillus.

(7) Male and female cockroaches are distinguished by the appendages in 10th abdominal segment.

(8) **Male** cockroach has a pair of **segmented anal cerci** on sides and a pairs of unsegmented **anal styles** in 10th abdominal segment.

(9) Female cockroach has **anal cerci** and **ovipositor valves**.

Economic status : These are the most important insect pests of human habitations destroying food and other things leaving behind a disagreable odour. They are regarded on general nuisance and sign of unclean conditions. Cockroaches are not devoid of goodness because they are extensively used for dissections to study invertebrate anatomy. They are also extensively used for physiological, biochemical, and toxicological researches in insects.

Identification : The cockroaches are so characteristic that there is no difficulty in indentifying them.

165. *Gryllus*

Classification : Same as that of ***Periplaneta***.

Genus.....*Gryllus*

Habit and habitat : ***Gryllus*** is commonly found during rainy seasons under walls and crevices in kitchens. It is omnivorous (Fig. 165).

Distribution : It is found in India, Srilanka, Myanmar, Asia, Europe, U.K., U.S.A. and Canada.

Comments :

(1) **Commonly** called as **cricket**.

(2) It is a solitary insect differing from locust and grasshopper in having longer **antennae**.

(3) It betrays its presence by the familiar, monotonous and intensely shrill **chirping**. The male cricket chirps by rubbing its front wings together during courtship.

(4) Body is divisible into **head, thorax** and **abdomen**.

(5) Head has eyes and **antennae**.
(6) Thorax contains wings and 3 pairs of walking legs.
(7) **Last abdominal segment** contains a pair of anal **cerci**.
(8) Wings are **exopterygotes**.
(9) Female has a long ovipositor, which serves for depositing the eggs in soil.

Economic status : Harmful insect. It **destroys clothing, fruits, vegetables,** etc.

Identification : Since the specimen contains long antennae and all above characters hence it is ***Gryllus***.

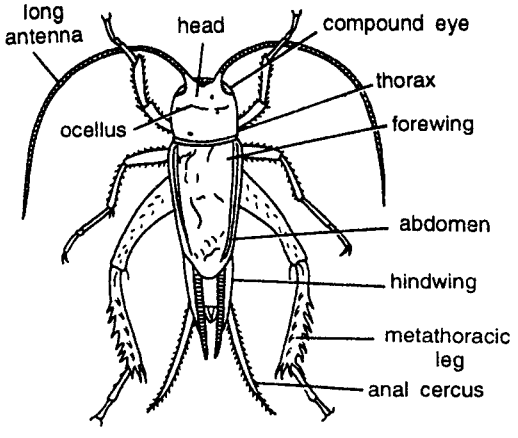


Fig. 165. *Gryllus.*

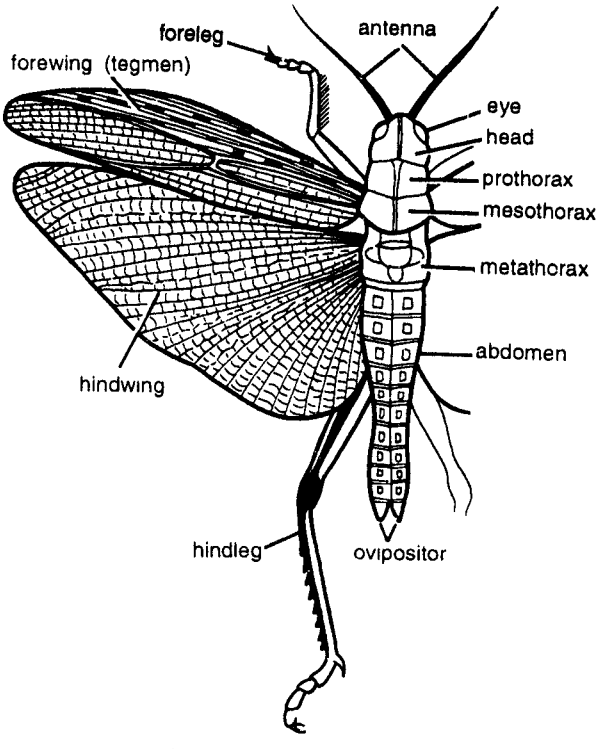


Fig. 166. *Schistocerca gregaria* : Locust.

166. *Schistocerca gregaria* : Locust

Classification : Same as that of ***Periplaneta***.

Genus.....***Schistocerca***
Species.....***gregaria***

Habit and habitat : ***Schistocerca*** is solitary, herbivorous insect found abundantly in the green vegetation. It feeds on the grass or leafy vegetation.

Distribution : It is commonly found in Africa, Arabia, India, Mexico, Japan, Philippines. Afghanistan and U.S.A.

Comments :

(1) **Commonly** called as the **desert locust** (Fig. 166).
(2) Their colour and form blending with the grass or vegetation among which they live.
(3) Body is differentiated into **head, thorax** and **abdomen**.
(4) Head lies into **prothorax** with mouth bent downwards. It contains **chewing** and **biting mouth parts** with large compound eyes and short antennae.

(5) **Walking legs** are three pairs, adapted for **crawling**. Posterior legs are modified for crawling. Tarsi 3 or 4 jointed cerci show little segmentation.
(6) **Wings** are two pairs; forewings are leathery, while hind wings are membranous and have well developed anal field.
(7) **Abdomen** has 11 cylindrical segments and each segment contains a pair of spiracle in ventrolateral position.
(8) Sexes are separate. Male has anal styles and female is provided with indistinct ovipositor.
(9) They have **stridulating** organs and organs of hearing.
(10) Desert locusts have two phases—(i) **solitary** or **non-migratory phase** with yellow colour, and (ii) **migratory phase** with pinkish body. During migratory phase they migrate towards plain green fields.

Economic status : Harmful insect in 3 ways :
(1) **As crop pest :** Grasshoppers always move into new feeding grounds damaging crop and green plantation. Both adults and nymphs destroy succulent vegetation.
(2) **As intermediate host :** Locust acts as intermediate hosts for helminth parasites.
(3) **Useful insect :** Locust provides food as eggs, nymphs and adults are eaten as food by predatory insects, birds, reptiles, mammals and even man.

Identification : Since the specimen has membranous wings and all above characters, hence it is **Locust**.

167. *Melanopus* or *Poecillocerus* : Grasshopper

Classification : Same as that of ***Periplaneta***.
Genus.....*Melanopus*
Habit and habitat : ***Melanopus*** is commonly found in green fields and trees and hence green coloured.
Comments :
(1) **Commonly** known as **grasshopper** (Fig. 167).
(2) Body is differentiated into **head**, **thorax** and **abdomen**.
(3) Head contains **chewing mouth parts** with large **compound eyes** and elongated backwardly directed **antennules**. **Pronotum** although large is not noticeably elongated.
(4) **Thorax** is divided into **prothorax**, **mesothorax** and **metathorax** having **foreleg**, **middle leg** and **hind leg** respectively.

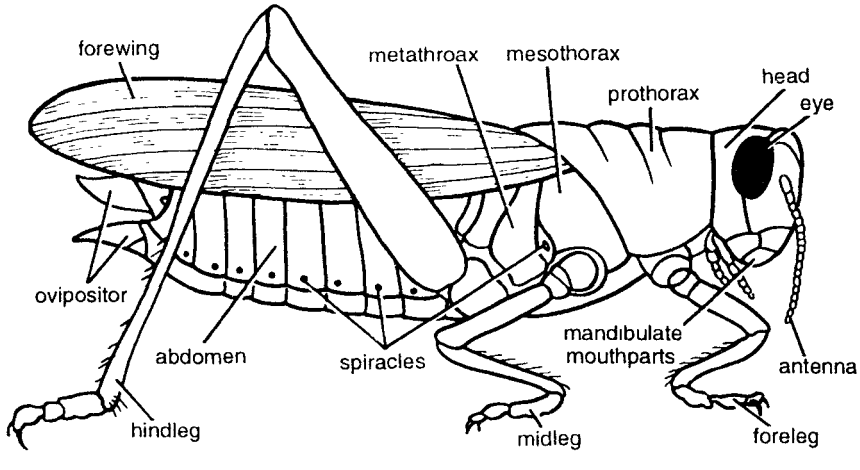


Fig. 167. *Melanopus* or *Poecillocerus* : Grasshopper.

(5) Hind legs are modified for **jumping** and **leaping** and are called as **Saltatoral legs**.
(6) Thorax contains 2 pairs of wings. Forewings are opaque called as **tegmen** while hind wings are membraneous.
(7) Female has a long ovipositor. Eggs are laid in groups.
(8) Auditory organs are **tympanum** having stridulating organs.
(9) Abdomen contains 11 **segments**, each having a pair of **spiracular** opening in ventrolateral position.
(10) Nymphs are wingless.

Economic status : Harmful insect destroying agricultural crops.

Identification : Since the insect contains jumping legs and all above features hence it is ***Melanopus***.

168. *Gryllotalpa*

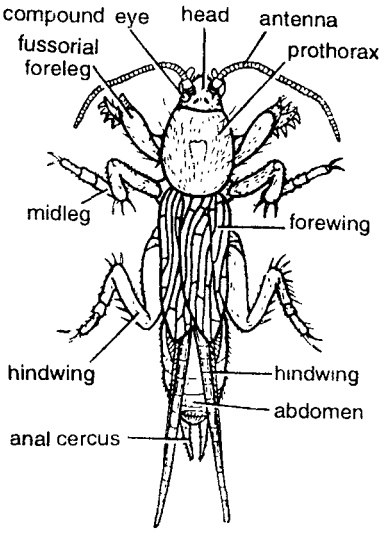


Fig. 168. *Gryllotalpa.*

Classification : Same as that of ***Periplaneta***.

Genus.....*Gryllotalpa*

Habit and habitat : ***Gryllotalpa*** is commonly found in fields near ponds burrowing in soil. It is subterranean. It is **carnivorous** feeding on small insects.

Distribution : ***Gryllotalpa africana*** is widespread over Indian plains, lower hills, warmer parts of Asia and Europe. ***G. vulgaris*** is found in Himalayas, Europe, Egypt and U.S.A.

Comments :

(1) **Commonly** called as the **mole cricket**.
(2) Body is covered with short fine hairs and is differentiated into **head**, **thorax** and **abdomen**.
(3) Head contains a pair of **compound eyes** and a pair of **antennae**.
(4) **Mouth parts** are of **biting** and **chewing type**.
(5) **Forelegs** are modified for **digging** and are called as **fossorial legs**. These legs are broad and are provided with stout **spines** adapted for **digging**. By digging and pressing the hard head and prothorax through the soil and then the soft abdomen and weaker posterior legs follow.
(6) **Middle legs** and **hind legs** are elongated.
(7) There are two pairs of wings. Forewings are short while hind pair large and membranous and have well developed anal field.
(8) Hind wings extend backwards and appears as slender processes beyond the **tegmina** when at rest.
(9) A pair of unsegmented anal cerci at the end of abdomen of male and ovipositor in female well developed.
(10) **Stridulating** (sound producing) organs and auditory (hearing) organs.

Economic status : Mole crickets are also agricultural pests causing damage to the cultivated crops. In search of food about 20 feet deep, mole cricket burrows through the soil and it destroys the roots of the plants.

Identification : Since the insect contains fussorid legs and all above characters hence it is ***Gryllotalpa***.

169. *Carausius* : Stick Insect

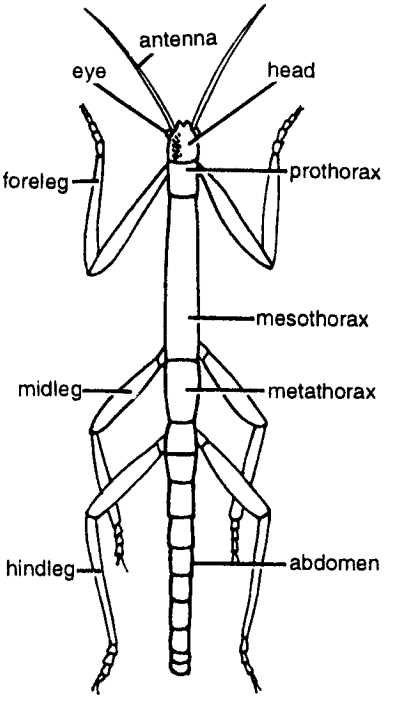


Fig. 169. *Carausius* : Stick insect.

Classification : Same as that of ***Periplaneta***.
Genus.....*Carausius*

Habit and habitat : ***Carausius*** found in tropical forests and thick vegetation. All the species are vegetable feeders.

Distribution : It is found in India, Myanmar, Srilanka, other Asian countries and Europe.

Comments :

(1) **Commonly** called as **stick insect.**
(2) It is called as **walking stick,** because its slender body resembles a **twig** or **stick** and is a greatly modified orthopteran attaining 22.5 to 32.5 cm in length.
(3) This insect has great power of **mimicry** and shows changes in colour like its environment and jumps swiftly.
(4) Body is differentiated into **head, thorax** and **abdomen.**
(5) Head is small containing small **antennae** and a pair of **compound eyes.**
(6) **Thorax** has **prothorax, mesothorax** and **metathorax.** Thorax is small, containing 3 pairs of flattened leaf coloured legs. Anterior part of thorax is fused with head forming **prothorax.**
(7) **Prothorax** is short, while mesothorax and metathorax are elongated.
(8) **Abdomen** is also elongated and consists of 9 **segments.** Tegmina small or absent.
(9) Walking legs are three pairs, simple and adapted for walking. The tarsi are usually 5 jointed.
(10) Sexes are separate. The male is small, active and winged and the female is large, sluggish and apterous. **Ovipositor** rudimentary.

Special features : They are the leaf feeders of the trees. They sometimes are sufficiently abundant to defoliate large areas of woodland. Insects are never conspicuous. Their stick like appearance and green or brown colouring gives them almost perfect protection from observation without close scrutiny. They move very slowly and act as dead if disturbed.

Identification : Since the body is like stick with cylindrically elongated head, thorax, abdomen and all above features, hence it is **stick insect.**

170. *Phyllium scythe* : Leaf Insect

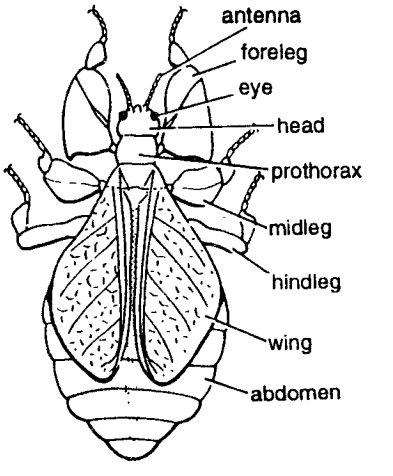


Fig. 170. *Phyllium scythe* : Leaf insect.

Classification : Same as that of ***Periplaneta***.
Genus.....*Phyllium*
Species.....*scythe*

Habit and habitat : ***Phyllium*** is found in the forests.

Distribution : It is almost entirely confined to the moist parts of the Oriental Region, islands of the Indian Ocean and forests of Assam.

Comments :

(1) **Commonly** called as **leaf insect.**
(2) It shows extreme degree of **mimicry** or camouflage, because its body, wings and even legs are flattened and green coloured like plants.

(3) They resemble and match so much with the foliage on which they feed that they become invisible. Even the **wings** become veined like leaf veins.
(4) Body is divided into **head, thorax** and **abdomen.**
(5) Head contains **compound eyes** and **filiform antennae.**
(6) **Thorax** is also small, containing 3 pairs of **flattened leaf-coloured legs. Abdomen** has 10 segments.
(7) **Prothorax** short, **mesothorax** and **metathorax** elongated and tergum of prothorax called as pronotum is also short.
(8) **Males** have small, tegmina, well-developed wings and relatively narrow bodies.
(9) In **females** the tegmina are extensive leaf-like expansions, the wings are vestigial and the body is very much expanded.

Special features : Leaf insect shows mimicry which is a protective device from enemies.
Identification : Since the specimen has expanded wings and all above features, hence it is **leaf insect.**

171. *Mantis religiosa* : Praying Mantis

Classification : Same as that of ***Periplaneta.***
Genus.....*Mantis*
Species.....*religiosa*
Habit and habitat : ***Mantis*** is commonly found in green vegetation and other garden places. It is **canibolic, pugnacious** and **predacious.**
Distribution : It is found in U.S.A. North America, Africa, South Europe and Western Asia. Most of the Indian mantis are spread over India and Malaysia region.
Comments :
(1) **Commonly** called as **praying mantis.**
(2) Body of the animal is differentiated into **head, thorax** and **abdomen** and it is not dorsoventrally flattened.
(3) **Eyes** are large and set on extremely mobile triangular head. There are three **ocelli** mouth parts of **biting type.**
(4) Head contains **compound eyes,** a pair of **antennae** and biting **mouth parts.**
(5) **Prothorax** is elongated and fused with the head.
(6) ***Mantis*** is called as praying mantis because its forelegs remain clasped like folded hands during rest like in praying and thus waiting for some unwary insect to approach within striking distance.
(7) **Middle** and **hind legs** are elongated.
(8) Its pincer-like or **raptorial tibia** of sub-chelate forelegs are modified for **grasping prey. Wings** are folded flat and overlapping the sides of the body.
(9) **Abdomen** has 10 segment. Last abdominal segment contains a pair of **anal cerci.**
(10) They are **pugnacious,** that is, larger forms attack smaller forms and females eat males after nuptials and lay their eggs. Ovipositor is not erected.
(11) **Eggs** are laid in ootheca formed by viscid secretion, which becomes hard and eggs are arranged in chambers.

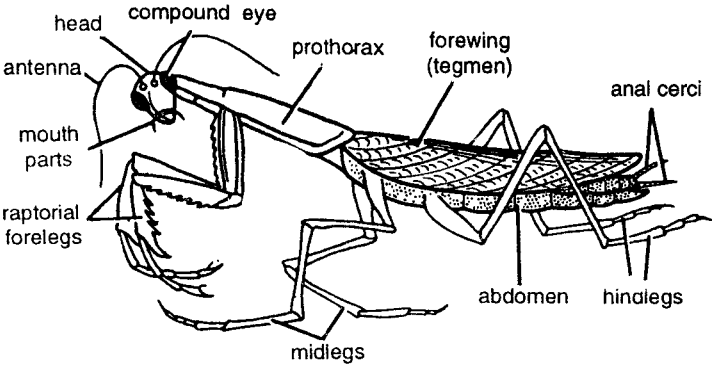


Fig. 171. *Mantis religiosa* : Praying mantis.

Special features : Many legends and superstitions are associated with the species ***M. religiosa***. The ancient Greeks endowed it with **supernatural powers;** some of the Muslim people maintain that it prays with its face turned towards **Mecca** and in other countries it is called as saint. The colouration and form of the body is usually adapted to resemble parts of plants.

Identification : Since the specimen contains clasped forelegs and all above features, hence it is **praying mantis.**

172. *Forficula* : Earwig

Classification :

Phylum..... Arthropoda	→	Jointed appendages.
Class..... Insecta	→	3 pairs of legs.
Sub-class..... Pterygota	→	Wings present.
Division..... Exopterygota	→	Wings develop externally.
Order..... Dermaptera	→	Skin wing.
Genus..... *Forficula* (Earwig)		

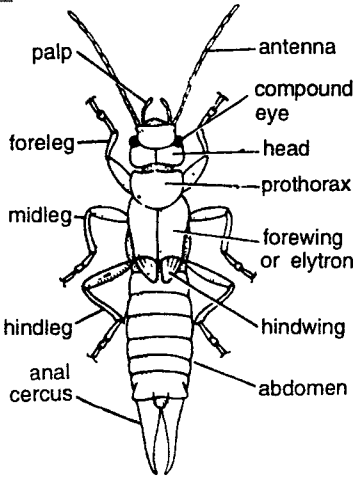


Fig. 172. *Forficula* : Earwig.

Habit and habitat : Earwigs are **nocturnal, omnivorous, predaceous,** active at night feeding actively on decaying vegetation or occasionally on plant tissues. During day they hide under bark and board, in the soil, in cracks and crevices of every sort.

Distribution : It is abundantly found throughout Europe and in Palaearctic region and also in North America. The group is chiefly tropical but is also found in Mexico, Asia, Africa and on the coasts of South Pacific and Indian ocean.

Comments :

(1) **Commonly** called as **Earwig.**

(2) Earwigs are medium-sized insects rarely exceeding half an inch in length.

(3) The term earwig possibly took its origin from the fact that these insects have been known to use human ear for purposes of concealment.

(4) It can be easily recognized by the forceps-like appendages or **anal cercii** on the end of the abdomen.

(5) Body is divided into **head, thorax** and **abdomen.** Head contains eyes and a pair of long and filiform **antennae. Pronotum** is large and Tarsi 3 jointed. **Anal cercii** are unjointed and almost modified to form **horny forceps. Maxillary palps** are small in size.

(6) Mouth parts are of **biting** and **chewing** type.

(7) **Prothorax** is fused with head. Thorax contains 3 pairs of **walking legs** and peculiar **hind wings.**

(8) First pair of wings form hard veinless truncated wing covers or **elytra** below which the second pair is fan-shaped with peculiar venation. When not in flight, it is folded into compact **complicated mass,** covered entirely by wing covers or **elytra.**

(9) When disturbed or alarmed or molested, the extremity of the abdomen is often upraised and the forceps widely opened in a threatening manner.

(10) **Ovipositer** absent. Metamorphosis gradual.

Economic status : Harmful insect. Earwig is frequently destructive to ornamental plants and mainly a feeder around garden and home. It destroys roses, dahlias and other flowers eating off the petals at the base and causing them to drop. Earwig shows **parental care** for its eggs and young ones.

Identification : Since the insect contains forceps like anal cercii and all above features, hence it is **Earwig.**

173. Queen Termite

Classification :

Phylum.....Arthropoda	→	Jointed appendages.
Class.....Insecta	→	3 pairs of legs.
Sub-class.....Pterygota	→	Wings present.
Division.....Expoterygota	→	Wings develop externally.
Order.....Isoptera	→	Wings are equal.
Genus.....Queen termite		

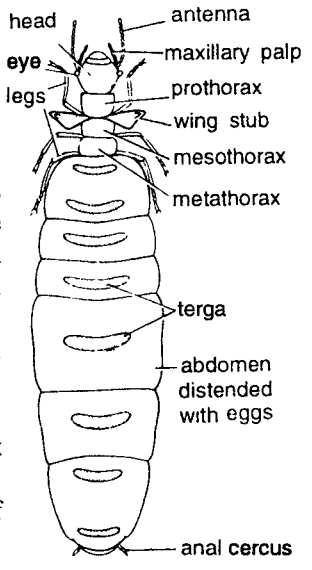


Fig. 173. Queen termite.

Habit and habitat : The **termites** may be wood dwelling or subterranean. They form nests which consist of numberless chambers and galleries having moderately hard walls. The wood dwelling species, excavate galleries in the logs, planks, fences, poles, door frames, furniture and piles of books. The ground dwelling species form nest or **termitarium**. They feed on cellulose.

Distribution : They are found throughout temperate and tropical countries. They have cosmopolitan distribution.

Comments :

(1) **Commonly** called as **Queen termite**. Body divided into **head, thorax** and **abdomen.**

(2) Head contains paired compound eyes, paired antennae and a pair of small maxillary palp.

(3) Thorax divisible into **prothorax, mesothorax** and **metathorax**. Tergum of prothorax **(pronotum)** does not cover head.

(4) **Thorax** contains a pair of short reduced **wing stubs** and 3 pairs of **legs.**

(5) **Head** and **thorax** comparatively shorter while abdomen is much elongated and swollen for accommodating large number of eggs. Last abdominal segment contains a pair of **anal cerci.**

(6) **Mouth parts** are of **biting type.**

Special features : Termites have caste system, comprising three fertile reproductive castes and two sterile **caste**. Reproductive system includes 3 forms : (i) **Winged forms having true kings** and **Queens. Queen termite** is a sexually mature female of the colony with elongated abdomen. Queen termite produces large number of eggs. (ii) Short winged forms having **neotenic kings** and **queens.** (iii) Wingless forms comprising worker like substitute **kings** and **queens.**

Identification : Since the specimen contains elongated and expanded abdomen and all above characters, hence it is **Queen termite.**

174. *Ephimera* : May Fly

Classification :

Phylum.....Arthropoda	→	Jointed appendages.
Class.....Insecta	→	3 pairs of legs.
Sub-class.....Pterygota	→	Wings present.
Division.....Exopterygota	→	Wings develop externally.
Order.....Ephemeroptera	→	Live for a day or two (adults).
Genus.....*Ephimera* (May fly)		

Habit and habitat : ***Ephimera*** is a soft-bodied and most familiar insect found on the margins of lakes, streams and rivers.

Distribution : It is found in U.S.A. (Florida, Illinois), India, Srilanka and Myanmar.

Comments :

(1) **Commonly** called as **May fly**.

(2) May flies are small to large, soft bodied, slender insects with gradual metamorphosis.

(3) Thorax is divisible into small **prothorax**, long **mesothorax** and short **metathorax**.

(4) **Head** is small and contains short setaceous **antennae**, **vestigeal** but biting **mouthparts**, a pair of **compound eyes** and 3 **ocelli** between compound eyes.

(5) Thorax has 3 pairs of inconstant **walking legs**.

(6) **Forewings** are, in repose, held together above the body in an upright position and with long anal process. **Hind wings** small. The venation is very little reduced with numerous intercalary and cross veins. There is no pterostigma in the wings.

(7) **Abdomen** is 10 **segmented** with a reduced **tergum**. The last segment contains a pair of long **many-jointed anal cerci**. The tergum is produced into a long **caudal filament**.

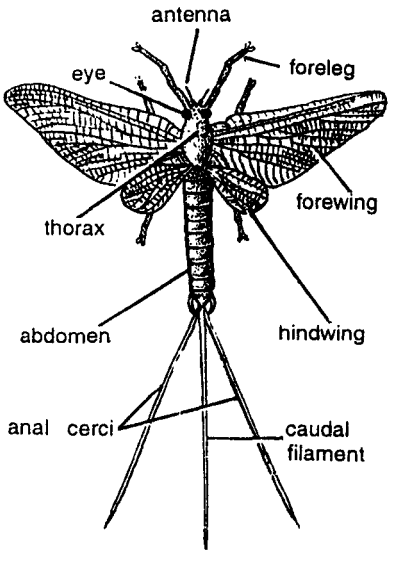


Fig. 174. *Ephimera* : May fly.

(8) **Male** has 3 jointed, clasping organ and the **female** has no ovipositor.

(9) Nymph lasts for 3 years in water as naiad, feeding on aquatic plants and animals. Certain naiads act as intermediate hosts for nematode parasites of vertebrates. The imago moults prior to mating and is extremely short lived.

Economic status : Useful insect. May fly plays an extremely important role in the fish-food economy. They are the most abundant insects found in several types of fishing waters. In these areas fish-stomach content indicate presence of several may flies.

Identification : Since the specimen contains short abdomen and all above features, hence it is **May fly**.

175. Dragon Fly

Classification :

Phylum.....Arthropoda	→	Jointed appendages.
Class.....Insecta	→	3 pairs of legs.
Sub-class.....Pterygota	→	Wings present.
Division.....Exopterygota	→	Wings develop externally.
Order.....Odonata	→	Incomplete metamorphosis.
Genus.....Dragon fly		

Habit and habitat : Dragon flies are abundantly found during rainy season resting on twigs, leaves or grass stalks (Fig. 175).

Distribution : It has cosmopolitan distribution especially found in India, Myanmar, Srilanka, Malaysia, Asia, Europe and U.S.A.

Comments :

(1) Dragon fly is an elegant insect, famous for its beauty and brilliancy of its pigmentary and structural colours.

(2) Body is divided into **head**, **thorax** and **abdomen**.

(3) Head is exceptionally mobile and is attached to an exceedingly slender neck.

(4) Head possesses large **compound eyes**, **filiform antennae** and **biting** and **masticatory mouth parts**.

(5) **Thorax** indistinctly divided into reduced **prothorax** and fused **mesothorax** and **metathorax**. Thoracic legs 3 pairs, namely **foreleg, mid leg** and **hind leg**.

(6) Wings are large, **membranous** and almost of equal size, frequently narrowing at the base and with venation only slightly reduced. A pterostigma is present and also enlargement of the veins known as '**arculus**' and the '**nodus**'. When at rest the wings may be held either vertically (damsel flies) or horizontally (dragon flies) wings have **intercalated veins**.

(7) **Abdomen** contains 10 **elongated segments** with vestiges of 11th and 12th segments. 12th segment contains a pair of **caudal furca** or **copulatory organs**.

(8) Oviposition **endophytic** or **exophytic**.

(9) **Metamorphosis** is **incomplete**.

(10) Nymphs are aquatic and respire by means of rectal or caudal gills. Labium in the nymphs is modified to form a **prehensile grasping organ**, the mask.

Special features : The adult members especially the larger ones are great favourites, with the out-of-door enthusiasts. Each dragon fly has a regular beat up and down in search of flying insect. When insect is sighted the dragon fly wheels from its course to capture the prey. When the insect is captured the dragon fly wheels back to its regular beat.

Identification : Since the specimen contains whitish membranous wings and all above features, hence it is **Dragon fly**.

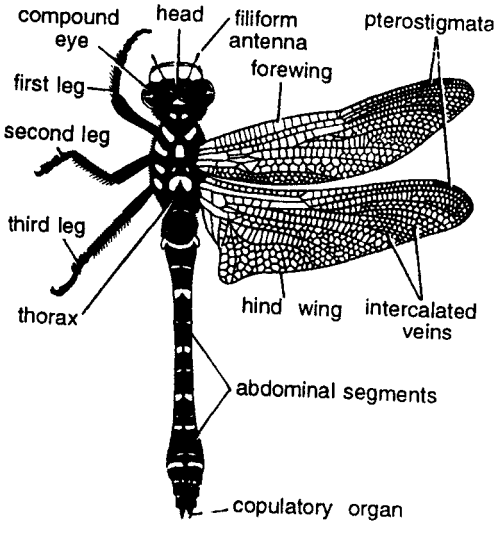


Fig. 175. Dragon fly.

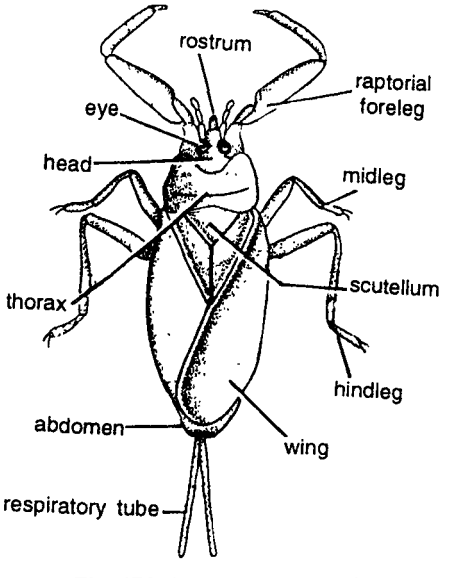


Fig. 176. *Nepa* : Water scorpion.

176. *Nepa* : Water Scorpion

Classification :

Phylum..... Arthropoda	→	Jointed appendages.
Class..... Insecta	→	3 pairs of legs.
Sub-class..... Pterygota	→	Wings present.
Division..... Exopterygota	→	Wings develop externally.
Order..... Hemiptera	→	Metamorphosis gradual.
Genus..... *Nepa* (Water scorpion)		

Habit and habitat : *Nepa* is commonly found in shallow waters.

Distribution : It has cosmopolitan distribution.

Comments :

(1) **Commonly** called as **water scorpion**.
(2) Body is short dorsoventrally compressed, and divisible into **head**, **thorax** and **abdomen**.
(3) Head contains 3-jointed **antennae** and **eyes**. Mouth parts form a long **rostrum** adapted for **piercing** and **sucking**. The **pronotum** is large.
(4) Respiratory tube is most striking and consists of two spine line processes.
(5) Three pairs of false **spiracles** are situated respectively on 3rd, 4th and 5th ventral abdominal segments.
(6) False spiracles consist of sieve-like structures with the perforations occluded by a delicate membrane.
(7) **Forewings** are not uniform. The proximal portion is hardened and distal portion membranous. At rest the wings overlap and lie flat above the abdomen.
(8) Just below thorax is **scutellum**.
(9) Female is provided with a pointed, toothed ovipositor. Sexes separate. Thorax contains **walking legs**. The **tarsi** usually 3-jointed.
(10) Eggs are deposited in chains, the ova adhering to one another by means of seven long filaments, radiating from one extremity.

Identification : Since it has 3-jointed antennae and above features, hence it is ***Nepa***.

177. *Belostoma*

Classification : Same as that of ***Nepa***.

Genus.....*Belostoma*

Habit and habitat : ***Belostoma*** is the largest insect found in the rivers, ponds and lakes. They are rapacious feeding on insects, tadpoles, snails and small flies.

Distribution : ***Belostoma*** is found in U.K., North America, South Africa and India.

Comments :

(1) **Common** called as **giant water-bug**.
(2) This is large insect, measuring 10 cm in length and is adapted for swimming and crawling.
(3) Body is dorsoventrally compressed and has usually three parts, namely **head**, **thorax** and **abdomen**. **Pronotum** large.
(4) Head has large **compound eyes**. **Antennae** 4-**jointed**. Mouth parts adapted for **piercing** and **sucking**.
(5) **Mouth** parts adapted for **piercing** and **sucking**.
(6) Thorax contains **walking legs**. Posterior legs adapted for swimming **Tarsi** 3-**jointed**. Tibia flattened and fringed with hairs.

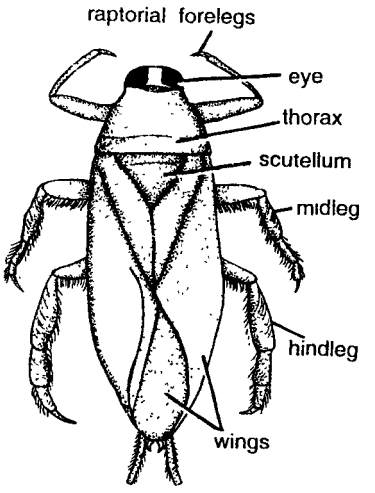


Fig. 177. *Belostoma.*

(7) Just below thorax is **scutellum**.
(8) **Wings membranous**. **Forewings** are not uniform. Distal portion membranous while distal part hardened. At rest the wings lie flat over the abdomen in overlapping manner.
(9) **Abdomen** is provided with two **retractile** apical appendages.
(10) In certain species female deposits its eggs on the back of the male where they are carried till hatching. **Ovipositor** well developed.

Special features : Legs inflict injuries on prey. It also inflicts heavy wound on man which is very painful.

Identification : Since the specimen contains 4-jointed antennae and all above features hence it is ***Belostoma***.

178. Aphid

Classification : Same as that of *Nepa*.
Genus.....*Octopus*

Habit and habitat : Aphid is a small insect infecting every kind of plant, sucking the juice. It presents peculiar feature, i.e. adaptation to parasitic mode of life.

Distribution : They occur specially on mustard, wheat and cotton plants.

Comments :

(1) **Commonly** called as **plant lice**.
(2) These insects are easily distinguished by the rounded body form and a pair of siphons. They are dull yellow, green or black coloured insects.
(3) Body is short divided into **head**, **thorax** and **abdomen**.
(4) **Head** is distinct with long straight **antennae**, small **compound eyes** and long thread like mouth parts extruded from a short proboscis.

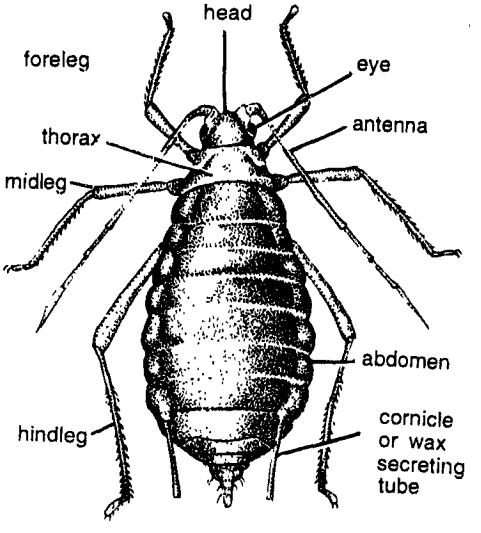


Fig. 178. Aphid.

(5) **Mouth parts** are of **sucking** and **piercing** type.
(6) **Thorax** and elongated abdominal robut.
(7) **Abdomen** contains a pair of **elongated wax secreting tube** or **cormidia**.
(8) Labial proboscis extend to anterior coxi.
(9) **Spiracles** in pairs.
(10) Their life cycle is very complex involving **asexual** and **sexual phases** and both winged and wingless forms.

Economic importance : Harmful insects. Aphids are economically important. Aphids destroy mustard and wheat crops and also cotton plants. Certain they use aphids as '**ant cows**'. They nurse ants and strike them gently, while they are feeding and thus '**milk**' them of a sweet juice called **honey dew**. Certain aphids show **hyperparasitism**. They live inside the body of other aphids.

Special features : The females are as a general rule parthenogenetic producing eggs and young ones without intervention of males. The question arises as to how they are able to carry genetic constitution and genetic continuity.

Identification : Since the aphid has elongated antennae and all above features, hence it is **Aphid**.

179. *Cicada*

Classification : Same as that of *Nepa*.
Genus.....*Cicada*

Habit and habitat : ***Cicadas*** are dependent upon trees for food and occur most abundantly in forests and well wooded moist localities (Fig. 179).

Distribution : It is found in tropical, sub-tropical and temperate forests. It is specially found in India, Europe and America.

Comments :

(1) ***Cicada*** is a large insect with entirely membranous wings and 3 sub-contiguous ocelli and measuring one to several inches.

(2) Body is divided into **head, thorax** and **abdomen** all well developed.
(3) **Head** is broad, having 2 lateral well **developed compound eyes** and 2 **short antennae**.
(4) **Thorax** is composed of **prothorax, mesothorax** and **metathorax**.
(5) **Wings are large**, often coloured and lie at an angle over the abdomen.
(6) **Abdomen** is elongated and 10 **segmented** and is broadly jointed to thorax.
(7) Sound production and breeding habits are peculiar.

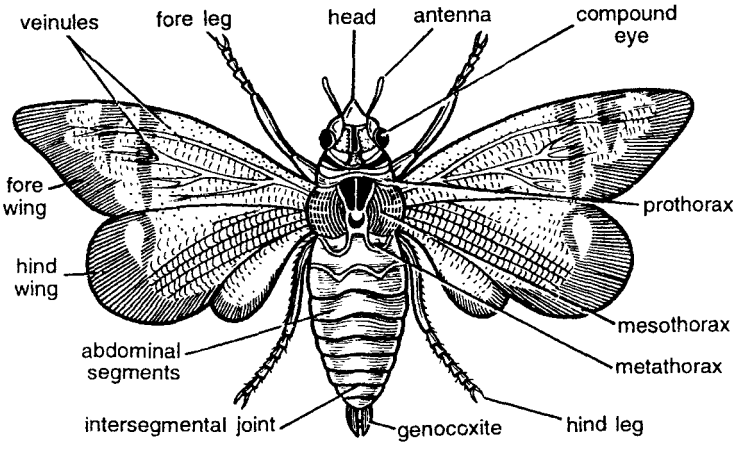


Fig. 179. *Cicada.*

(8) Sound is produced by the male only, which has a drum-like apparatus, called as aedeagus. ***Cicada*** is capable of producing **loud, shrill, vibrating sound**, supposed to be sexual call. The sound can be compared to knife-grinder or even a railway whistle.
(9) **Life cycle** is completed in 2 to 17 years.
(10) **Nymph** burrows in soil, feeds on plants and emerges adult after 2 to 17 years and hence it is often called as '**seventeen-year locust**'.

Economic status : The ovipositing females may cause serious damage to the twigs and branches of fruit and hardwood trees.

Identification : Since the insect has membranous wings and all above features, hence it is ***Cicada.***

180. *Papillio* : Butterfly

Classification :

Phylum..... Arthropoda	→	Jointed appendages.
Class..... Insecta	→	3 pairs of legs.
Sub-class..... Pterygota	→	Winged insects.
Division..... Endopterygota	→	Wings develop internally.
Order..... Lepidoptera	→	Scale wing.
Genus..... *Papillio* (Butterfly)		

Habit and habitat : Butterflies are eminently found in the densely forested hills where vegetation is abundant and varied. They are day fliers.

Distribution : Few species are found in the dry cultivated plains. The ideal place for butterflies is the lower slopes of the hills well clothed with forest with a sub-tropical climate. The grass feeding species and species feeding on flowering plants and cultivated plants are widely distributed. It has cosmopolitan distribution.

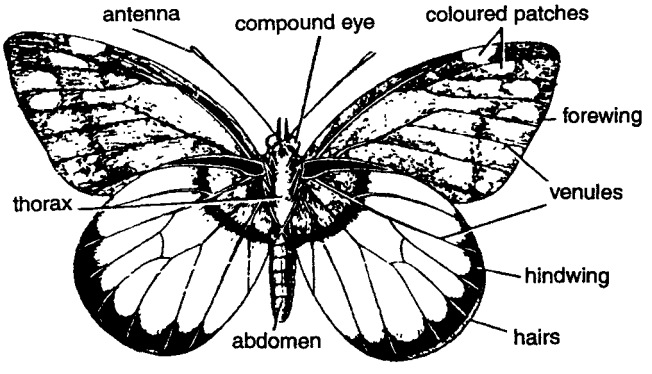


Fig. 180. *Papillio* : Butterfly.

Comments :

(1) **Butterfly** is a large and the most beautiful lepidopteran insect.
(2) Body is divided usually into three parts, namely **head**, **thorax** and **abdomen** and is slender.
(3) Head if freely movable and possesses a pair of large **compound eyes** and **clubbate antennae** (with swollen tips).
(4) Mouth parts are of **sucking type** provided with a **spirally coiled suctorial proboscis**.
(5) **Maxillae** are modified into spirally-coiled proboscis.
(6) Thorax has 3 **pairs of legs** and 2 **pairs of wings**. Wings are typically covered with broad pigmented scales. When at rest the wings may be held vertically above the body or roof-life or more or less horizontal and lengthwise over the body. The venation is predominantly longitudinal with cross veins. The wings are coupled and beat together. Wings have **coloured patches**. Margin of hind wings contain hairs.
(7) **Abdomen** has 10 **segments** covered with scales.
(8) There are no **cerci**. Ovipositor rarely present.
(9) Larva is a caterpillar.
(10) Common butterflies are **dead-leaf butterfly**, **monarch butterfly**, **cabbage butterfly** and **swallow tail butterfly**. The allied forms are moths, which have stouter bodies, and feather-like antennae and during rest, their wings are horizontally held. They are night, fliers.

Economic status : Butterflies are very useful to men because they amuse us by their brilliant colouration and help in pollinating the crop plants and other flowering plants. They are the most familiar insect to mankind due to their large size brilliant colouration and sunshine loving habits. The children are more fascinated by them.

Identification : Since the specimen contains clubbate antennae and all above features hence it is **Butterfly**.

181. Moth

Classification : Same as that of **butterfly**.

Genus.....Moth

Habit and habitat : Found in dry cultivated plains, lower hills (slopes), forest, grasses and cultivated crops. They are night fliers or nocturnal. At night they are found near light (bulb or tube).

Distribution : Cosmopolitans.

Comments :

(1) Body is divided into **head**, **thorax** and **abdomen**.
(2) Head contains **compound eyes**, **feathry antennae** and **mouth parts**.
(3) During resting period wings are horizontally held.
(4) Mouth parts are of **sucking** and **siphoning type** with long coiled **proboscis**.
(5) Hind wings are smaller than forewings. Wings are membranous, also **coupled** and **beat together**.
(6) **Thorax** has 3 **pairs of legs**.
(7) **Abdomen** has 10 segments.
(8) There are several varieties of moths as **cercopia moths**, **cloth moths** and **sphinx moths**.
(9) Common cloth **moth is *Tinea pellionella***.

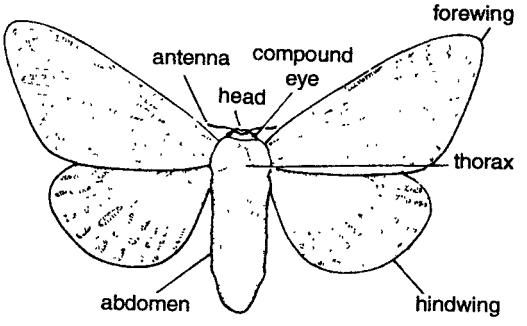


Fig. 181. Moth.

Identification : Since the insect contains short, feathry tentacle and all above features hence it is **moth**.

182. *Melolontha* : Beetle

Classification :

Phylum..... Arthropoda	→	Jointed appendages.
Class..... Insecta	→	3 pairs of legs.
Sub-class..... Pterygota	→	Winged insects.
Division..... Endopterygota	→	Wings develop internally.
Genus..... *Melolontha* (Cockchafer beetle)		

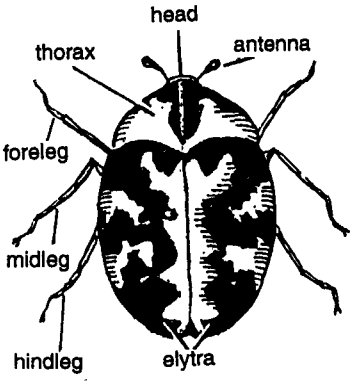


Fig. 182. *Melolontha* : Beetle.

Habit and habitat : ***Melolontha*** is a terrestrial and burrowings insect.

Distribution : It has wide distribution but specially occurs in India, Malaysia, Myanmar, Srilanka.

Comments :

(1) **Commonly** called as **beetle.**

(2) Body is black coloured having leathery and horny integument.

(3) Body division consists of **head, thorax** and **abdomen.**

(4) **Head** is bent or flexed ventrally, containing large **compound eyes** and a pairs of long **antennae having** a series of overlapping plates at distal ends.

(5) **Mouth parts** are of **chewing type.**

(6) **Thorax** has strong chitinised **pronotum** and **pleural sclerites.**

(7) **Prothorax** is large, firmly attached to the head, but articulated with the **mesothorax.**

(8) **Abdomen has** 10 **segments** but only 7 sternal and 8 tergal plates are visible. The posterior abdominal segment is reduced and it contains chitinous **aedeagus** (penis).

(9) **Wings are two pairs. Forewings** are modified into **horny** or **leathery elytra** and when at rest almost always meet to form a straight, mid-dorsal structure. The venation of the wings is reduced. **Hind wings** are membranous and are usually folded beneath the elytra.

(10) No cerci and no true ovipositor.

Economic status : Some beetle, like **buffalo carpet beetle,** is a common household pest, which feeds on wool, fur, rugs and other clothes. Various species of the beetles act as intermediate host for nematode parasites of domesticated animals.

Identification : Since the insect has peculiar elytra and all above features, hence it is ***Melolontha.***

Instructions : *Make insect boxes. Collect various types of insects with insect net in different season.*

183. *Apis indica* : Honey Bee

Classification :

Phylum..... Arthropoda	→	Jointed appendages.
Class..... Insecta	→	3 pairs of legs.
Sub-class..... Pterygota	→	Winged insects.
Division..... Exopterygota	→	Wings develop externally.
Order..... Hymenoptera	→	2 pairs of wings.
Genus..... *Apis*		
Species..... *indica*		

Habit and habitat : Honey bee is a social and colonial insect living **nests** or **bee hives.** It is a polymorphic insect existing in **worker, queen** and **drove.** One hive contains 50,000 to 80,000 individuals. It shows caste system mentioned above.

Distribution : Cosmopolitan.

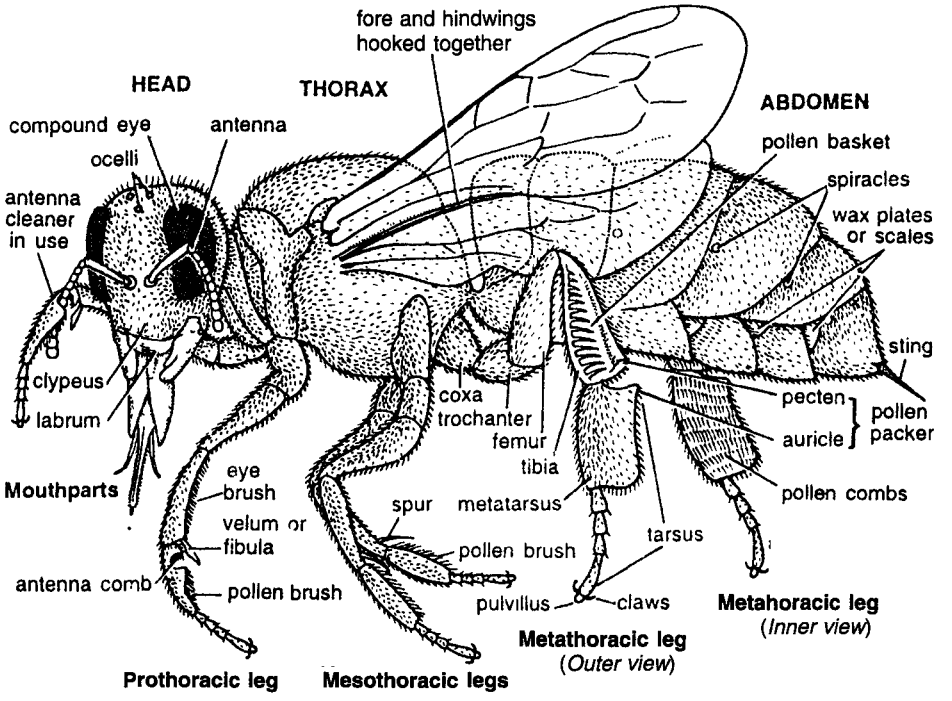


Fig. 183. *Apis* : Honey bee.

Comments :

(1) Commonly called as **Honey bee**.

(2) Body divisible into **head**, **thorax** and **abdomen** in all castes.

(3) **Queen** is largest and fertile. **Worker** is smallest — Head triangular, containing **compound eyes** in dorsolateral position and many jointed **antennae besides ocelli**.

(4) **Clypeus**, **labrum** and other **mouth parts** visible in lateral position. Mouth parts are **rasping** and **lapping** type.

(5) **Thorax** is divided into **prothorax**, **mesothorax** and **metathorax** each containing a pair of legs. **Prothoracic** leg contains **eye brush**, **velum** or **fibula**, **antennae comb** and pollen brush. **Mesothoracic** leg contains **spur**, **pollen brush** and **pulvillus**. **Metathoracic** leg contains **pollen basket**, **pollen** comb. **Thorax** contains a pairs of **wings**.

(6) Abdomen has 6 segments. Last segment contain sting. Ventral surface of last four segments contains **wax plates** and **wax glands**. Spiracles are found over abdomen.

(7) Workers act as repairers, store keepers, cleaners, nector (honey) collectors and defenders.

(8) Drones are male members. They fertilize the eggs laid by queen. They do not do any work.

Economic value : ***Apis*** produces honey and wax for various useful purposes. Honey has medical importance.

Identification : Insect is **polymorphic**, worker has pollen basket and all above features, hence it is ***Apis***.

184. Honey bee : Stages of Life Cycle

Comments : There are six stages of life cycle of Honey bee : (1) **Egg**, (2) **Larva**, (3) **Pupa**, (4) **Adult worker**, (5) **Drone** and (6) **Queen**.

(1) **Egg :** Queen after mid air mating with a drone returns to hive and lays bean shaped eggs.

(2) **Larva :** After 3 days eggs hatch into small larvae. Each larva has head and body segments containing spiracles. Larva develop either into queen or worker depending upon the food they take. A larva feeding on royal jelly develops into a queen. Honey-fed larva develops into a worker.

(3) **Pupa :** Larva develops into pupa in the sealed chamber of hive. Body divisible into **head, thorax** and **abdomen**. Head contains antennae compound eyes and antennae. Throrax contains rudiments of wings and 3 pairs of walking legs. After metamorphosis pupa develops into **adult worker, queen** and **drone** after 18, 13 and 21 days respectively.

(4) **Worker :** Body blackish brownish in colour divisible into **head, thorax** and **abdomen**. Head contains **antenna, compound eye** and **mouth** parts. Worker collects nector and secretes was by wax-glands of abdomen. Thorax contains 3 pairs of legs, a pair of forewing and a pair of hind wings. Tibia of metathoraxic leg has **Pollen basket.**

(5) **Drone :** Measures 15 to 17 mm in length. Body divisible into **head, thorax** and **abdomen**. Head contains **compound eyes antennae** and mouth parts. Thorax has 3 pairs of walking legs. Entire body covered by **Chaetae**. No pollen collecting apparatus and no wax secreting mechanism.

(6) **Queen :** Fertile female measuring 15 to 20 mm in length. Body divisible into **head, thorax** and **abdomen**. Head contains large **compound eyes, antennae** and **mouth parts**. Thorax contains 3 pairs of walking legs and 2 pairs of wings. Abdomen is elongated and swellen to accomodate large number of eggs. Queen termite does not collects nector, neither secretes wax and lays eggs only.

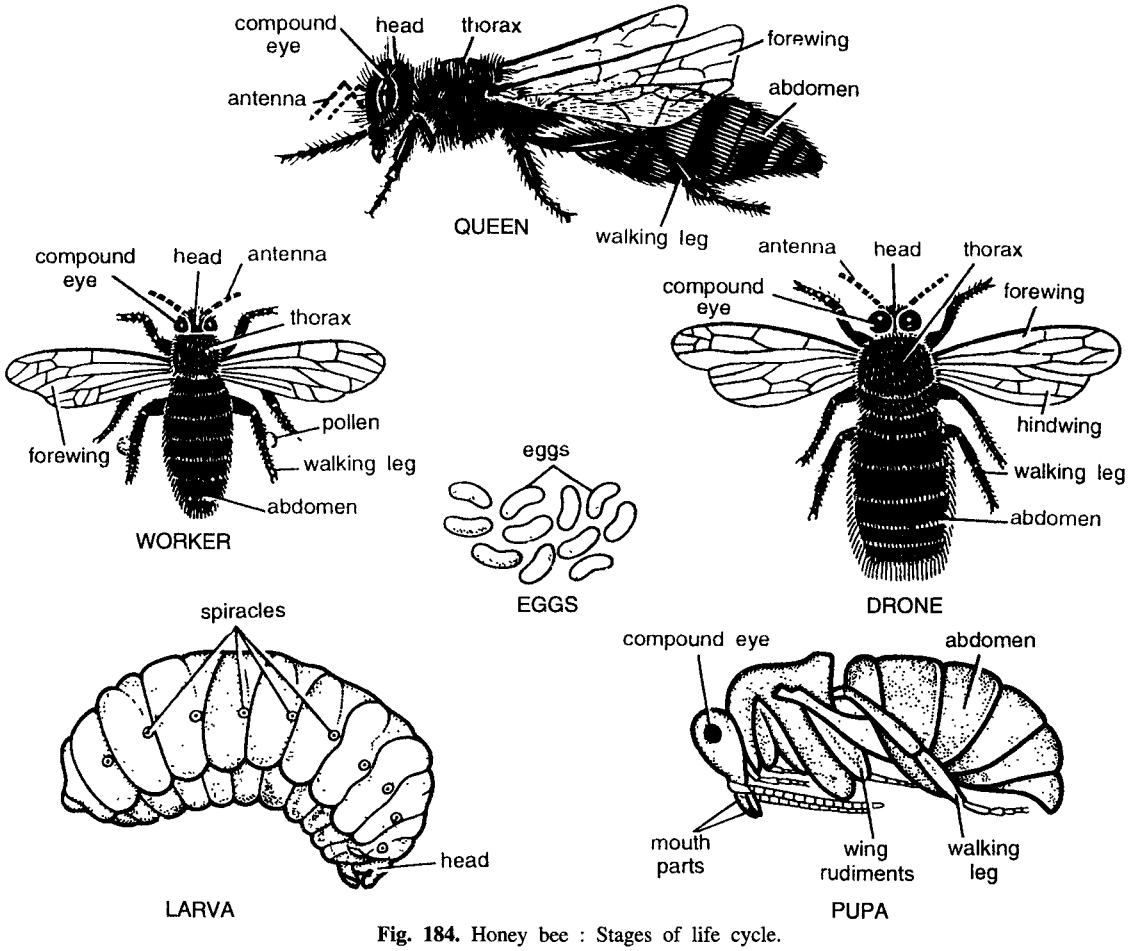


Fig. 184. Honey bee : Stages of life cycle.

185. Termite : Stages of Life Cycle

Comments :

(1) Termites are social insects living in colonies with fertile male and female castes.
(2) Different life-history stages are **eggs, workers, soldiers, nasutes, king** and **queen.**
(3) **Eggs** : Large number of eggs are layed by queen termite.
(4) Eggs develop into **Nymphs.** Nymphs developed into two directions (i) **Worker, reproductive female** or **queen.** Reproductive male or king and (ii) **Soldier** and **Nasute.**
(5) **Workers :** Under-developed wingless forms. Body divisible into **head, thorax** and **abdomen. Head** contains **antennae, maxillary palp** and **compound eyes.** Thorax has 3 pairs of legs (**foreleg, middle leg** and **hind leg**).
(6) **Soldiers :** Bigger than workers with large head. Body divisible into **head, thorax** and **abdomen.** Head contains long **mandibles, antennae, maxillary palp** and **compound eyes.** Thorax contains 3 pairs of legs.

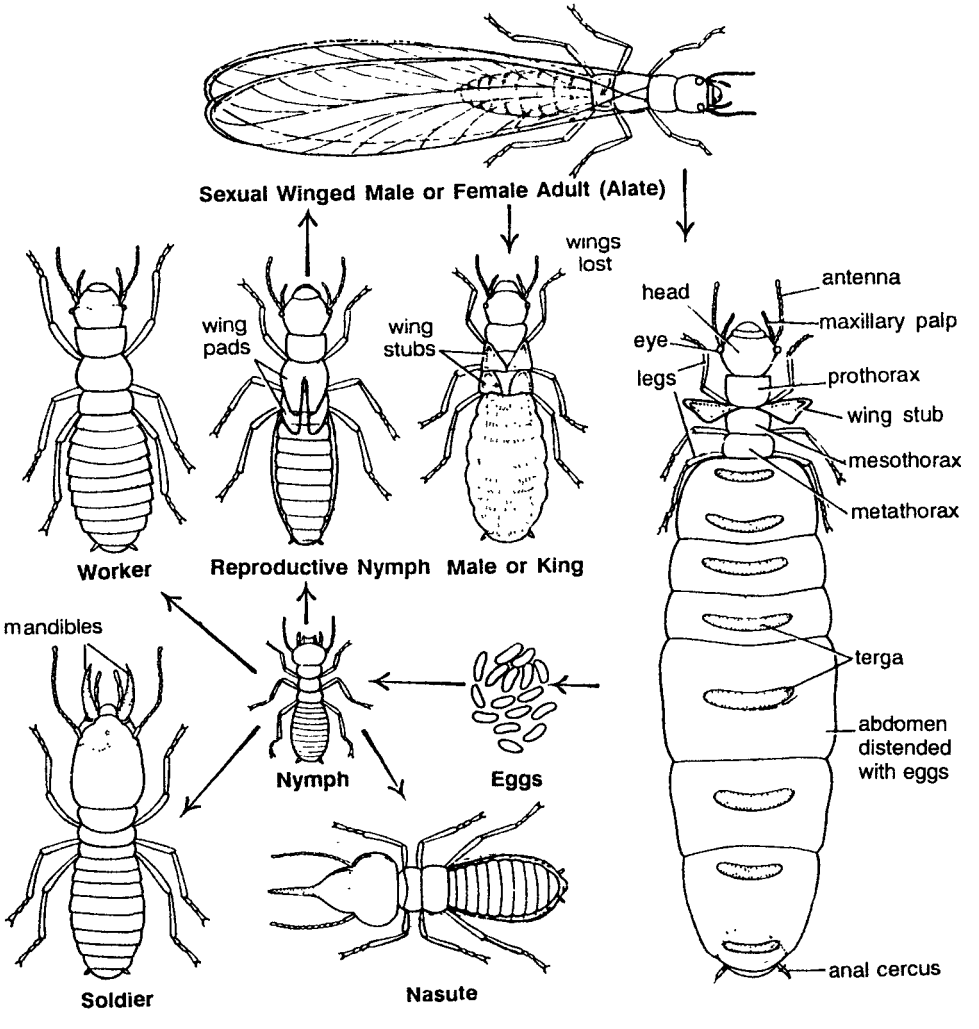


Fig. 185. Termite. Stages of life cycle.

(7) **Nasutes :** In some termites soldiers are replaced by wingless Nasutes which secrete sticky secretion for the destruction of enemies. Body divisible into **head**, **thorax** and **abdomen**. Head contains **rostrum**, **antennae** and **compound eyes**. Thorax contains 3 pairs of legs.

(8) **Queen** in reproductive caste layes large number of eggs. Body, especially abdomen, is much elongated. Body is divisible into **head**, **thorax** and **abdomen**. Head contains **antennae**, **maxillary palp** and **compound** eyes. Thoraxic segments are reduced. Thorax has **prothorax**, **mesothorax** and **metathorax**. Thorax has 3 pairs of legs and a pair of **wing stubs**.

(9) **Termites** build large **termatorium** made of sand particles and soil.

(10) Termites are harmful insects destroying house hold goods, furniture, clothes and books etc.

186. *Bombyx mori* : Silkworm : Stages of Life Cycle

Comments :

(1) Various stages of life cycle are **egg**, **larva**, **pupa**, **adult male** and **female**.

(2) **Eggs :** Female lays 300-500 eggs in clusters upon leaves of mulberry plant. After laying eggs female dies. Egg hatches into larva.

(3) **Larva :** Larva is called as **caterpillar**.

(4) **Body of larva** divisible into **head**, **thorax** and **abdomen**. Thorax contains 3 pairs of legs and posteriorly a dorsal horn wings 2 pairs.

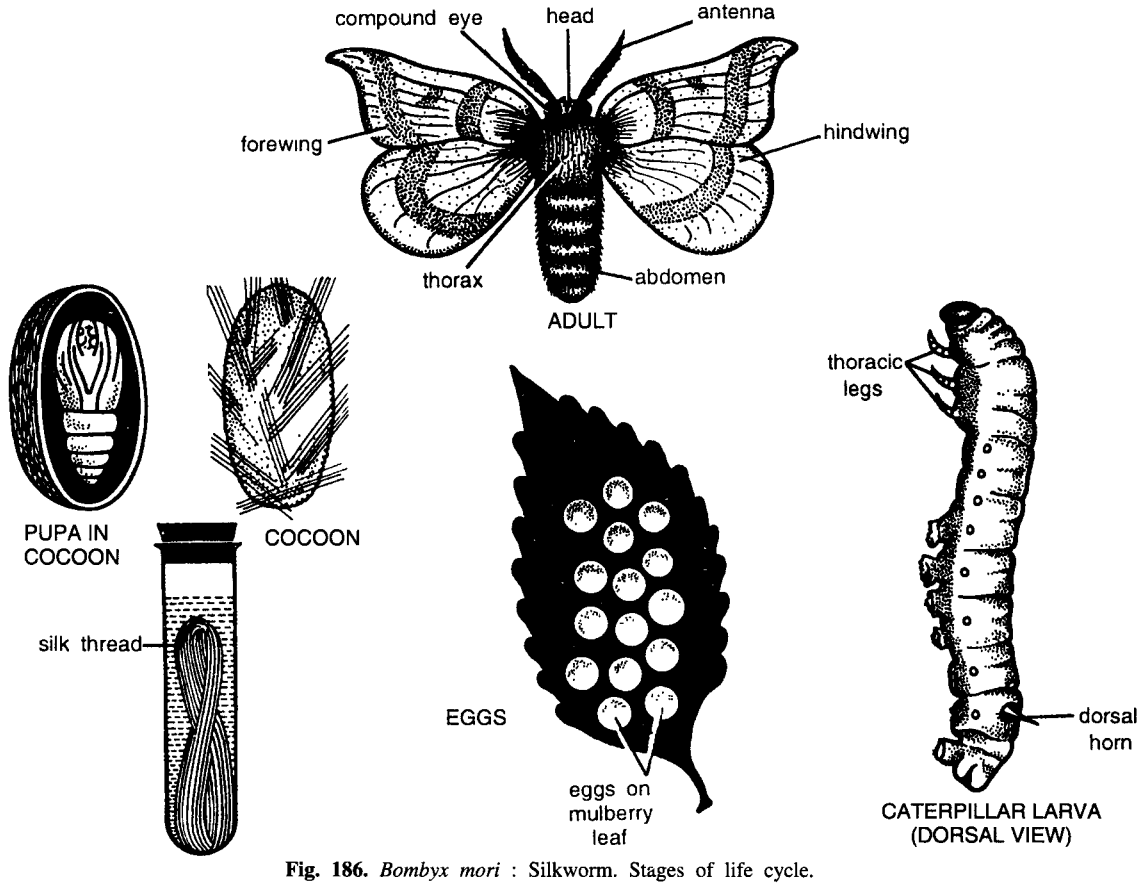


Fig. 186. *Bombyx mori* : Silkworm. Stages of life cycle.

(5) Larva feeds on mulberry leaves by its mandibles and mouth parts and undergoes moulting as it grows.

(6) Fully mature larva stops feeding and **secretes liquid** silk by its salivary glands. Liquid silk comes out through spinnerts and hardens into 5 **silk filaments**. Another gland secretes **ciricin** which sticks to silk filaments forming silk threads. Larva changes into **pupa**.

(7) Body of female divisible into **head, thorax** and **abdomen**. Head contains antennae, paired compound eyes. Thorax has 3 pairs of legs, a pair of fore leg, a pair of mid leg and a pair of hind leg.

Economic importance : Silk worms feeding on different plants and vegetation produce different variety of silk. ***Bombyx mori*** (Mulberry silkworm), ***Antheraea assamensis*** (Muga silkworm), ***A. mylitta*** (Tussora silkworm), Attacus atlas (Eri silkworm) producing Mulberry silk, Muga silk, Tussor silk and Eri silk respectively. Silk is used for elegant garments saries, jackets, shirts, parachute, wireless receivers.

187. *Pollistis*

Classification :

Phylum.....Arthropoda	→	Jointed appendages.
Class.....Insecta	→	3 pairs of legs.
Sub-class.....Pterygota	→	Winged insects.
Division.....Exopterygota	→	Wings develop externally.
Order.....Hymenoptera	→	Wings 2 pairs.
Genus.....*Pollistis*		

Habit and habitat : Found on walls, root of houses, trees and hives made of clay. Diurnal flying insects.

Distribution : Cosmopolitan.

Comments :

(1) **Commonly** called as **yellow wasp** (***Pollistis herbraeus***). ***Vaspa orientalis*** is **red** and **yellow coloured wasp**.

(2) Body divisible into **head thorax** and **abdomen**.

(3) **Head** contains paired **antennae** and **compound eyes. Mouth parts biting** and **chewing**.

(4) **Thorax** and **abdomen** more or less **oval abdomen larger**.

(5) Thorax contain **prothoracic, mesothoracic** and **metathoracic legs**.

(6) Wings two pairs **hind wings** and **forewings**.

(7) Last abdominal segment contains **sting**.

(8) Insects sting man which cause **pain** and **inflammation**.

(9) Yellow coloured wasp are often found howevering over glass walls.

(10) Red coloured wasp are larger than yellow coloured and are often found around open sweat items. They also sting man and it is very painful.

Identification : Since body is yellow coloured and insect has all above features, hence it is ***Pollistis***.

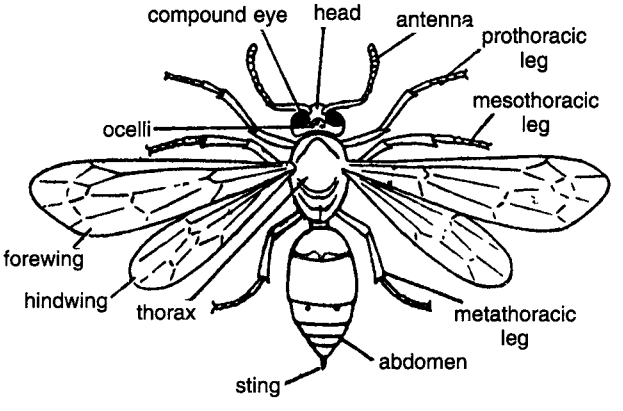


Fig. 187. *Pollistis*. Dorsal view.

PHYLUM ECHINODERMATA

Natural history

Echinodermata are defined as spiny skined animals (Greek word *echinos* = hedgehog; *derma* = skin). Beginning their life race from lower cambrian, they are successfully continuing their biological activities.

Echinoderms are at the top of invertebrate and very close to the chordates. They are unique combination of advanced and primitive characters. The advanced characters are (i) They aie deuterostomes, (ii) Presence of mesodermal calcium carbonate endoskeleton (note other invertebrates have no endoskeleton), (iii) Coelom enterocoelus, (iv) Exclusively free-living marine.

Diagnostic characters

(1) **Spiny-skinned** animals.
(2) **Triploblastic deuterostomes.**
(3) Distinct head and segmentation absent.
(4) Body divided into oral and **aboral surfaces.**
(5) Peculiar **water vascular system** for locomotion.
(6) Exclusively marine.
(7) **Non-microscopic.**

Classification

SUB-PHYLUM I PELMATOZOA
1. Sedentary echinoderms.
2. Oral surface oriented upwards and aboral surface with jointed cirri.

CLASS I CRINOIDEA
1. Commonly called as sea lilies.
2. Body consists of a cup like calyx and cylindrical arms.
3. Tube feet, madreporite and pedicellaria absent.
   Ex. *Antedon.*

SUB-PHYLUM II ELEUTHEROZOA
1. Free-living echinoderms.
2. Oral surface directed downwards.

CLASS II ASTEROIDEA
1. Commonly called as star fishes.
2. Body star shaped central disc and arms not sharply demarcated.

Order 1 Phanaerozonia
1. Marginal plates distinct in 2 rows.
2. Pedicellaria sessile.
   Ex. *Pentaceros, Astropecten, Luidia, Anthena.*

Order 2 Spinulosa
1. Marginal plates indistinct.
2. Pedicellariae pedunculate.
   Ex. *Solaster, Asterina.*

Order 3 Forcipulata
1. Pedicellariaes traught or crossed.
2. Tube feet in 4 rows.
   Ex. *Pisaster, Asterias.*

CLASS III OPHIUROIDEA
1. Commonly called as brittle stars.
2. Central disk and arms sharply demarcated.

Order 1 Streptophiurae
1. Arms slender.
   Ex. *Ophiomyxa.*

Order 2 Zygophiurae
1. Arms simple with horizontal movement.
2. Disk and arms covered by plates.
   Ex. *Ophioderma, Ophiocoma, Ophiolepis, Ophiura, Ophiopholis.*

Order 3. Cladophiurae
1. Arms much elongated and rolled as basket.
2. Called as basket star.
   Ex. *Gorgonocephalus.*

CLASS IV ECHINOIDEA
1. Commonly called as sea urchins and sand dollars.
2. Skeletal plates saturated forming a complete test.
3. Body disk shaped, egg-shaped or heart shaped.

Sub-class A. Bothriocidarida (Extinct).

Sub-class B. Regularia
1. Body globular, usually circular.
2. 5 petaloids radially symmetrical.
3. Locomotion by podia.

Order 1 Lepidocentroida
1. Test flexible, imbricate or separate.
2. Ambulacral plates continue on peristome.
   Ex. *Phoromosa.*

Order 2 Melonechinada (Extinct).

Order 3 Cidaroidea
1. Anus aboral, central.
2. Peristomial gills absent.
3. Rigid globular test with two rows of long narrow ambulacral plates and 2 rows of interambulacral plates.
   Ex. *Histocidaris, Apocidaris.*

Order 4 Diadematoida
1. Anus aboral central.
2. Peristomial gills and Aristotles lantern present.
3. Symmetrical globular test.
   Ex. *Diadema, Echinus, Strongylocentrotus.*

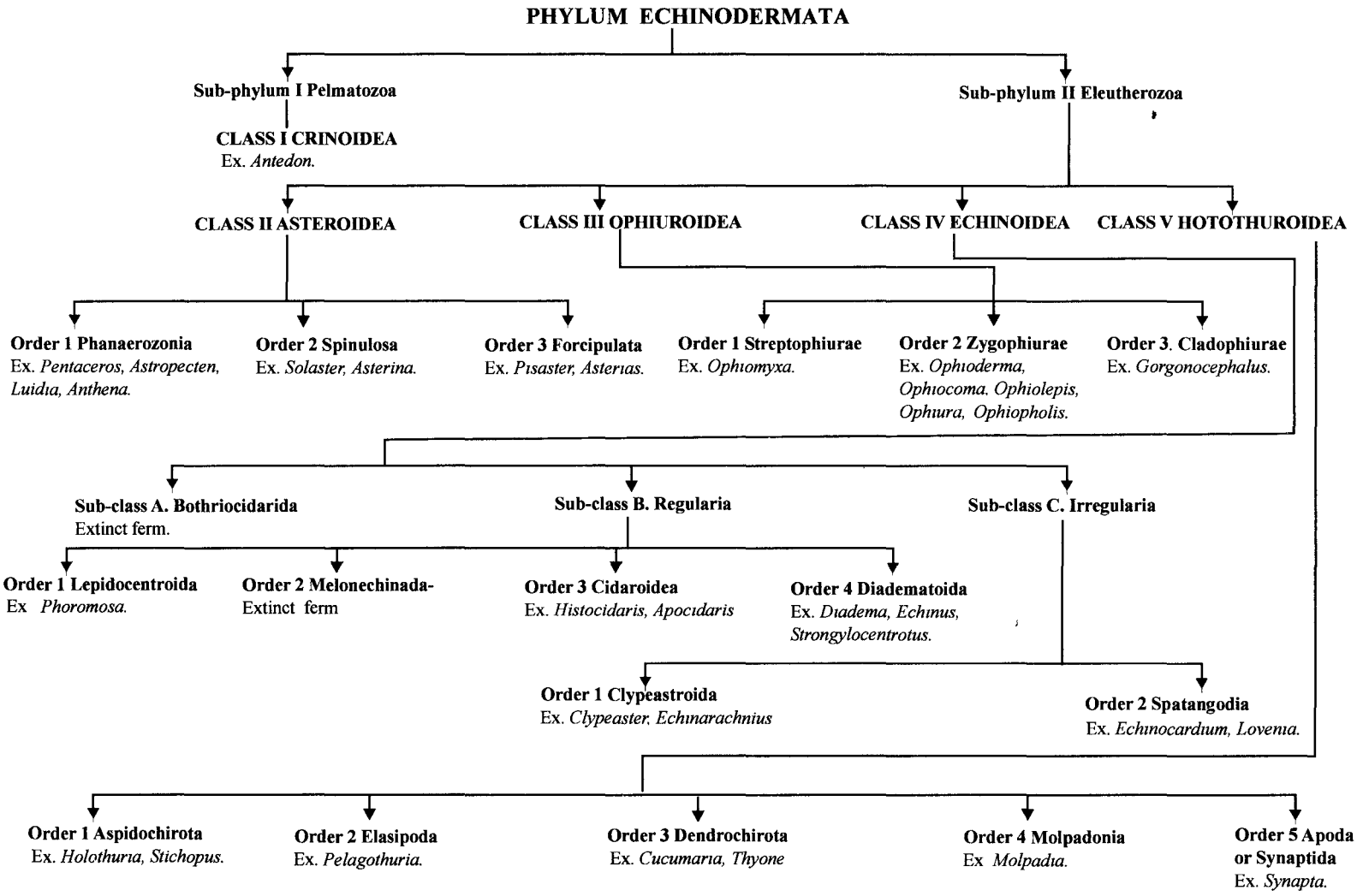
Sub-class C. Irregularia
1. Body flattened on oral aboral axis in oval manner but not exactly symmetrical.
2. Podia non-locomotor.

Order 1 Clypeastroida
1. Commonly called as sand dollars.
2. Test flattened or oval, lantern present and gills absent. Burry in sand.
   Ex. *Clypeaster, Echinarachnius.*

Order 2 Spatangodia
1. Commonly called as heart urchins.
2. Ambulacral plates petaloid.
   Ex. *Echinocardium, Lovenia.*

CLASS V HOTOTHUROIDEA
1. Commonly called as sea cucumbers.
2. Body elongated on oral-aboral axis with anterior mouth.
3. Skeleton of microscopic plates embedded in body wall.
4. Digestive system s=shaped Respiration by respiratory tree.

(Classification cont. on Page 172)


PHYLUM ECHINODERMATA
Sub-phylum I Pelmatozoa
CLASS I CRINOIDEA
Ex. Antedon.
Sub-phylum II Eleutherozoa
CLASS II ASTEROIDEA
CLASS III OPHIUROIDEA
CLASS IV ECHINOIDEA
CLASS V HOTOTHURIOIDEA
Order 1 Phanaerozonia
Ex. Pentaceros, Astropecten, Luidia, Anthena.
Order 2 Spinulosa
Ex. Solaster, Asterina.
Order 3 Forcipulata
Ex. Pisaster, Asterias.
Order 1 Streptophiurae
Ex. Ophiomyxa.
Order 2 Zygophiurae
Ex. Ophioderma, Ophiocoma, Ophiolepis, Ophiura, Ophiopholis.
Order 3. Cladophiurae
Ex. Gorgonocephalus.
Sub-class A. Bothriocidarida
Extinct ferm.
Sub-class B. Regularia
Sub-class C. Irregularia
Order 1 Lepidocentroida
Ex Phoromosa.
Order 2 Melonechinada-
Extinct ferm
Order 3 Cidaroidea
Ex. Histocidaris, Apocidaris
Order 4 Diadematoida
Ex. Diadema, Echinus, Strongylocentrotus.
Order 1 Clypeastroida
Ex. Clypeaster, Echinarachnius
Order 2 Spatangodia
Ex. Echinocardium, Lovenia.
Order 1 Aspidochirota
Ex. Holothuria, Stichopus.
Order 2 Elasipoda
Ex. Pelagothuria.
Order 3 Dendrochirota
Ex. Cucumaria, Thyone
Order 4 Molpadonia
Ex Molpadia.
Order 5 Apoda or Synaptida
Ex. Synapta.

Order 1 Aspidochirota
1. Tentacles branched anteriorly.
2. Podia several.
3. Respiratory tree present.
   Ex. *Holothuria, Stichopus.*

Order 2 Elasipoda
1. Tentacles branched distally.
2. Respiratory tree absent. Tube feet.
3. Modified as fins.
   Ex. *Pelagothuria.*

Order 3 Dendrochirota
1. Tentacles irregularly branched.
2. Tube feet numerous.
3. Respiratory tree present.
   Ex. *Cucumaria, Thyone.*

Order 4 Molpadonia
1. Tentacles small hand shaped.
2. Tube feet absent.
   Ex. *Molpadia.*

Order 5 Apoda or Synaptida
1. Tentacles present. Body transparent.
2. Tube feet. Respiratory tree absent.
   Ex. *Synapta.*

188. *Antedon*

Classification :

Phylum.....Echinodermata	→	Coelomate, pentaradiate and spiny skinned animals with vascular system.
Sub-phylum.....Pelmatozoa	→	Sedentary throughout life.
Class.....Crinoidea	→	Attachment by aboral stalk, Pedicellariae spines and madreporite absent.
Order.....Articulata	→	Central disc covered by a movable tegmen having various ossicles. Food grooves open.

Genus.....*Antedon* (The feather star)

Habit and habitat : ***Antedon*** is marine and occurs about 2 fathoms deep and remains attached to rocks by cirri from central disc. They are gregarious forms and feed on microscopic living organisms.

Distribution : It has world-wide distribution found in all seas and at all depths down to 5,800 meters. It is especially found along Atlantic coast in 25 to 500 fathoms from Chesa peake Bay to the banks of Newfoundland. The members are known form lower Cambrian to Recent.

Comments :

(1) **Commonly** called on **sea-lily or feather-star.**

(2) On the aboral side **calyx** bears a knob-like structure called as centrodorsal plate or stalk.

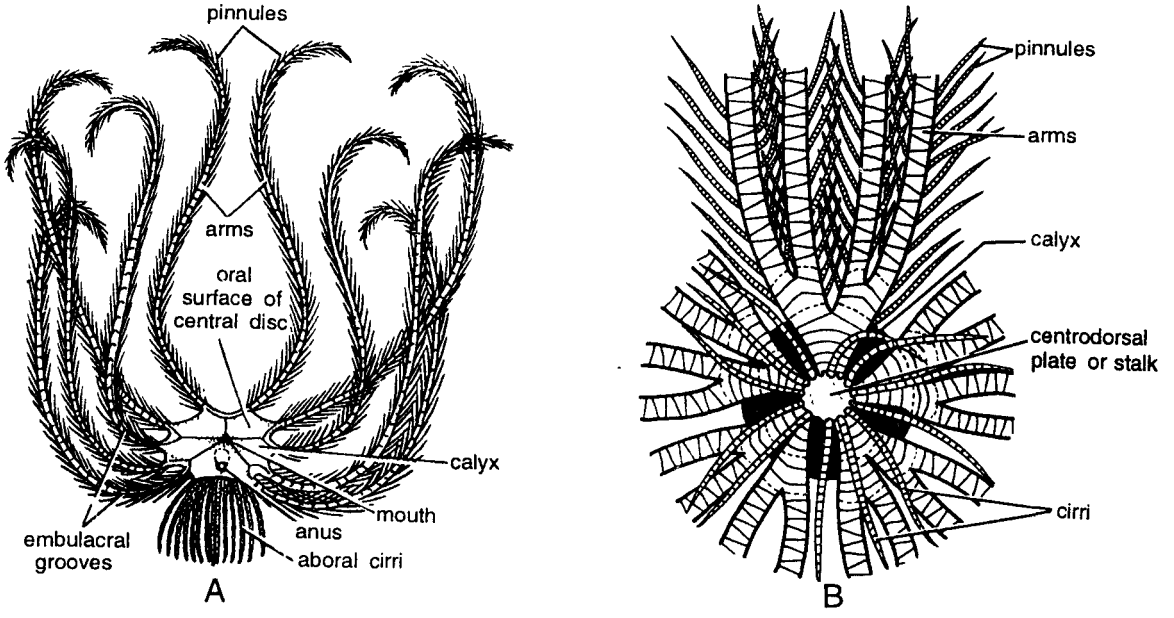


Fig. 188. *Antedon* : Feather star. **A.** Entire, **B.** Central disc in aboral view.

(3) The calyx is differentiated into an upper convex **oral surface**, having **mouth** and **anus** and the lower flat **aboral surface**, into which arms and **cirri** are inserted.
(4) On the aboral side **calyx** bears a knob-like structure, called as stung of the **stalk**.
(5) The **oral surface** is covered by a leathery skin in which numerous **calcareous plates** are embedded. It is directed upwards.
(6) **Mouth** is central and directed upwards which leads into 5 food open grooves or **ambulacral grooves**, which divide into 10 as they reach near the edge and lead into the arms. The mouth is surrounded by sensory tube feet or podia which are without suckers. The **ambulacral grooves** give branches into each **pinnule** and throughout their course contain finger-like, non-prehensile tube feet or **podia**. **Water vascular system** is well developed. There is no madreporite.
(7) There are 10 **arms** having extensions of viscera and each bears numerous **pinnules** containing gonads.
(8) The **cirri** are emerging from aboral surface and are composed of skeletal ossicles.
(9) Sea-lily attaches to substratum by **cirri**. **Anus** on aboral surface.
(10) It is one of the living representatives of the class Crinoidea. Sexes are separate. Development includes **cystidian** and **pentacrinoid** larva.

Identification : Since the specimen contains aboral **cirri** and all above feature, hence it is ***Antedon***.

189. *Asterias* : Sea Star or Starfish

Classification :

Phylum.....Echinodermata	→	Coelomate, pentaradiate and spiny-skinned animals with water vascular system.
Sub-phylum.....Eleutherozoa	→	Non-pedicellate and free-living.
Class.....Asteroidea	→	Central disc and arms fused.
Order.....Forcipulata	→	Forcipulate and pedicellate pedicellariae.
Genus.....*Asterias*		

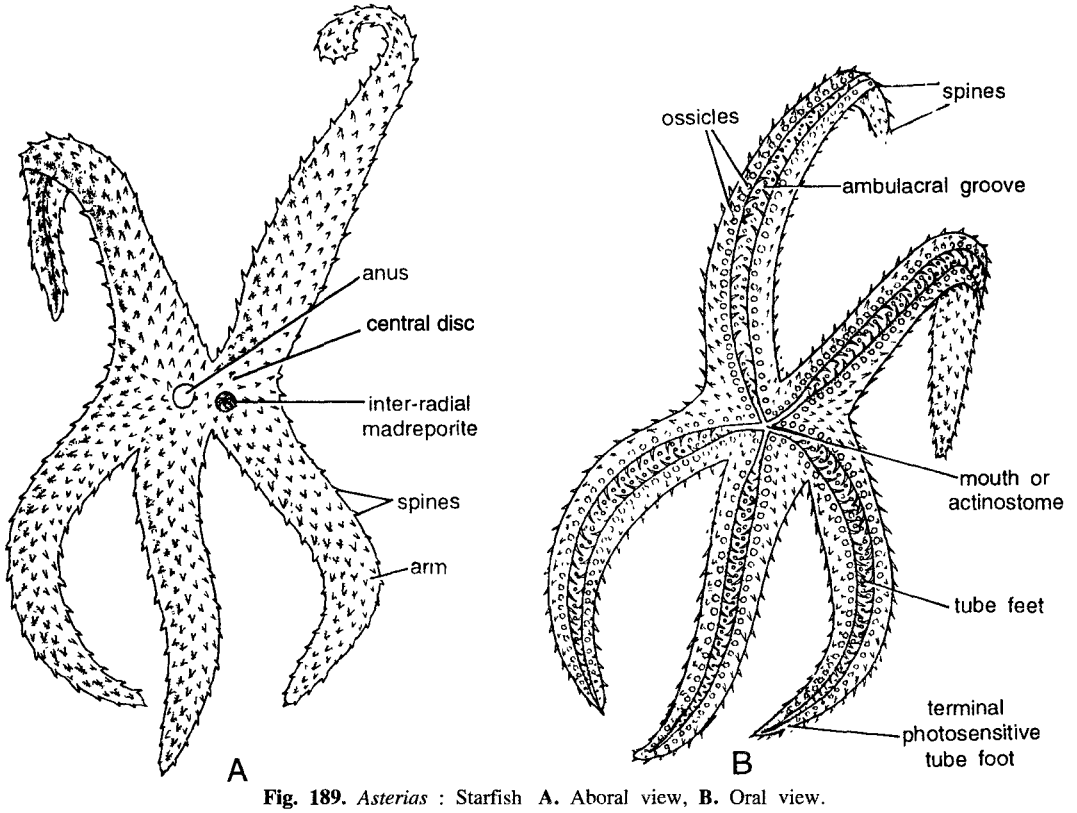


Fig. 189. *Asterias* : Starfish **A.** Aboral view, **B.** Oral view.

Habit and habitat : ***Asterias*** is a marine form, found below 200 fathoms on most of the eastern seashore.

Distribution : It is distributed in shallow water in North temperate seas and especially abundant and reaching large size on the North Atlantic coast. It is specially found in India and U. S. A.

Comments :

(1) **Commonly** called as **starfish** or **sea star**. Members are radially symmetrical, free living and star shaped and hence called as starfishes or sea stars (Fig. 189).
(2) Body is radially symmetrical, star-shaped and pentagonal.
(3) Body or **central disc** of the animal is distinguished into downwardly directed **oral** (mouth) and upwardly directed **aboral** surfaces.
(4) Central disc is continued into 5 arms.
(5) **Aboral surface** is pink and contains conical spines all over and asymmetrical sub-pentagonal **madreporite plate** in inter-radial position. The finger-like semi-transparent branchiae and **pedicellariae** are also present on aboral surface.
(6) Terminal tube feet are **photosensitive**.
(7) Oral surface contains central **actinostome** or mouth, from which five **ambulacral grooves** extend, one in each arm. The open ambulacral groove accommodates a large number of podia or tube feet. **Water vascular system** is well developed. Tube feet usually terminate in **suckers**.
(8) Skeleton consists partly of a mesh work of ossicles and partly of a series of closely set, discrete plates.
(9) **Pedicellariae** are usually present and may be of more than one kind.
(10) Sexes are separate. **Fertilization is external**. The larva is typically a **bipinnaria** developing into a **brachiolaria** before metamorphosis into adult.

Identification : Since the specimen contains conical spines and all above features, hence it is ***Astrias***.

190. *Pentaceros* : Sea Pentagon or Starfish

Classification :

Phylum.....**Echinodermata**
Sub-phylum.....**Eleutherozoa** } → Characters same as those of ***Asterias***.
Class.....**Asteroidea**
Order.....**Phanerozonia** → Marginal plates distinct.
Genus.....***Pentaceros*** **(Starfish)**

Habit and habitat : ***Pentaceros*** is the most common eleutherozoan echinoderm found in sea from shallow water to 1,000 fathoms.

Distribution : It is found in U. K., U.S.A., India, Panama and South America.

Comments :

(1) **Commonly** called as **sea pentagon** or **starfish**.
(2) Body is enclosed in a tough, hard and leathery integument containing several ossicles.
(3) **Central disc** and the **arms** are fused together. Arms contain extension of gonad, coelom and the gut.
(4) Arms are 5 in number and symmetrically arranged in the form of star around the central disc. Body is differentiated into **oral** and **aboral** surfaces.
(5) Aboral surface is brown and convex, containing rows of definitely arranged spines. **The marginal plates** are large and distinct.
(6) There is a rounded sieve plate or **madreporite plate** in one of the inter-radii. It forms the first part of the **water vascular system** which is well developed.
(7) **Oral surface** is concave, dark brown, having a centrally-placed mouth or **actinostome**. **Mouth is 5-angled** and each angle is continued into the **ambulacral groove up** to the tip of an arm.
(8) **Ambulacral groove** contain double rows of locomotory organs of **tube foot**.

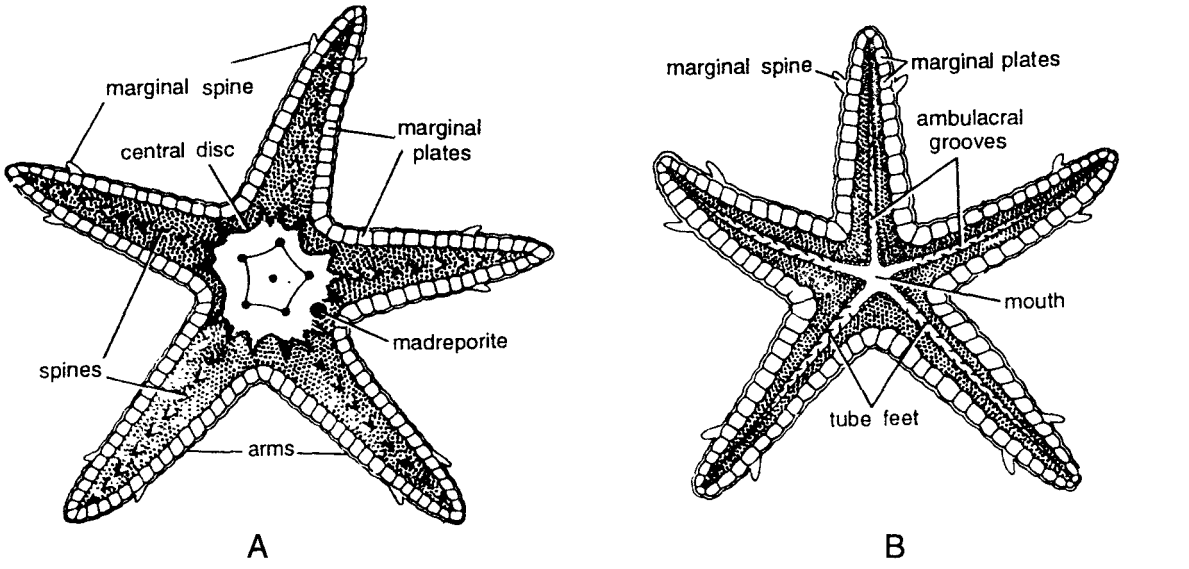


Fig. 190. *Pentaceros.* **A.** Aboral view, **B.** Oral view.

(9) **Sexes** are **separate**. Development indirect which includes **bipinnaria larva**.
(10) ***Pentaceros*** is the most familiar seashore animals.
Identification : Since the specimen contains leathery surface and all above features, hence, it is ***Pentaceros***.

191. *Anthena*

Classification : Same as that of ***Pentaceros***.

Genus.....*Anthena*

Habit and habitat : ***Anthena*** is commonly found in all seas from shallow to deep waters.
Distribution : It is found in the Australian sea.

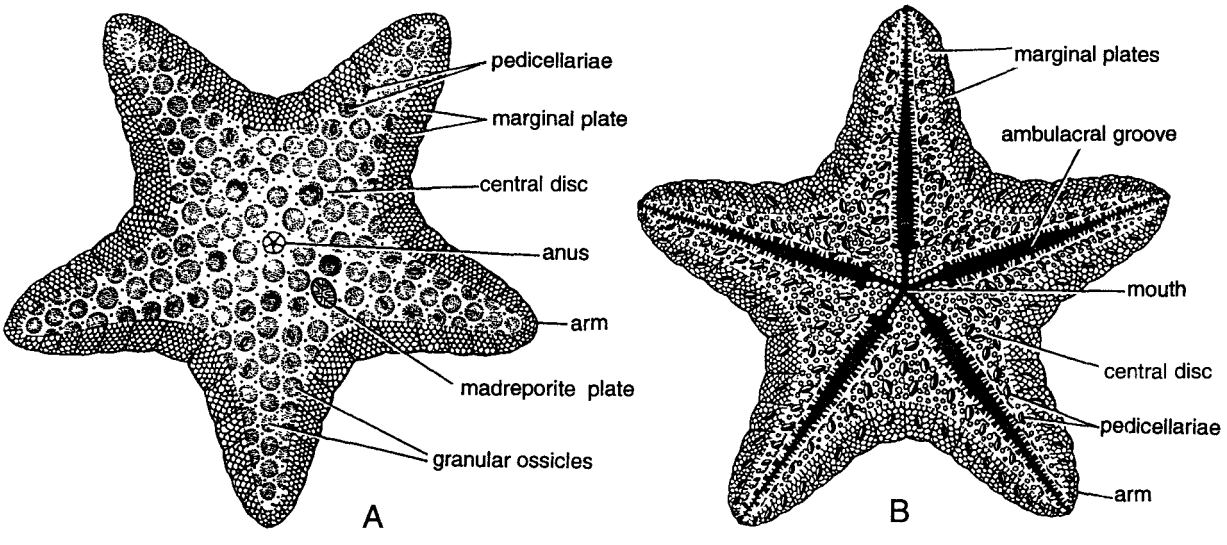


Fig. 191. *Anthena.* **A.** Aboral view, **B.** Oral view.

Comments :

(1) **Commonly** called as **starfish**.

(2) Animal consists of a relatively large central disc and five relatively **short arms**, which taper rapidly towards their extremities.

(3) Body is differentiated into **oral** and **aboral** surface.

(4) **Aboral surface** is strongly convex and is having inter-radial depression. It is dotted over with several small, rounded tubercles arranged in irregular radiation lines.

(5) **Aboral surface** is dotted over with several small rounded granular ossicles arranged in regular radiating lines.

(6) Flat surface between ambulacral grooves contains plate-like ossicles beset with a number of minute, rounded tubercles or granules, which sometimes assume spiny shape.

(7) **Pedicellariae** are also present, which are small, narrow and oblong. Calcareous bodies consist of two parallel narrow valves of jaws.

(8) ***Anthena*** has vertical calcareous and inter-radial partitions.

Identification : Since the specimen has large central disc, short arms and all above features, hence it is ***Anthena.***

192. *Luidia*

Classification : Same as that of ***Pentaceros***.

Genus.....*Luidia*

Habit and habitat : ***Luidia*** is a tropical and sub-tropical asteroid echinoderm commonly present below low-water mark to 190 fathoms (Fig. 192).

Distribution : It is found in Atlantic; Pacific coast from Alaska to Mexico; Florida; West Indies and West coast of Africa.

Comments :

(1) **Commonly** called as **star-fish**.

(2) Animal consists of a comparatively small, central disc and 5 to 11 elongated, flexible and **cylindrical arms**.

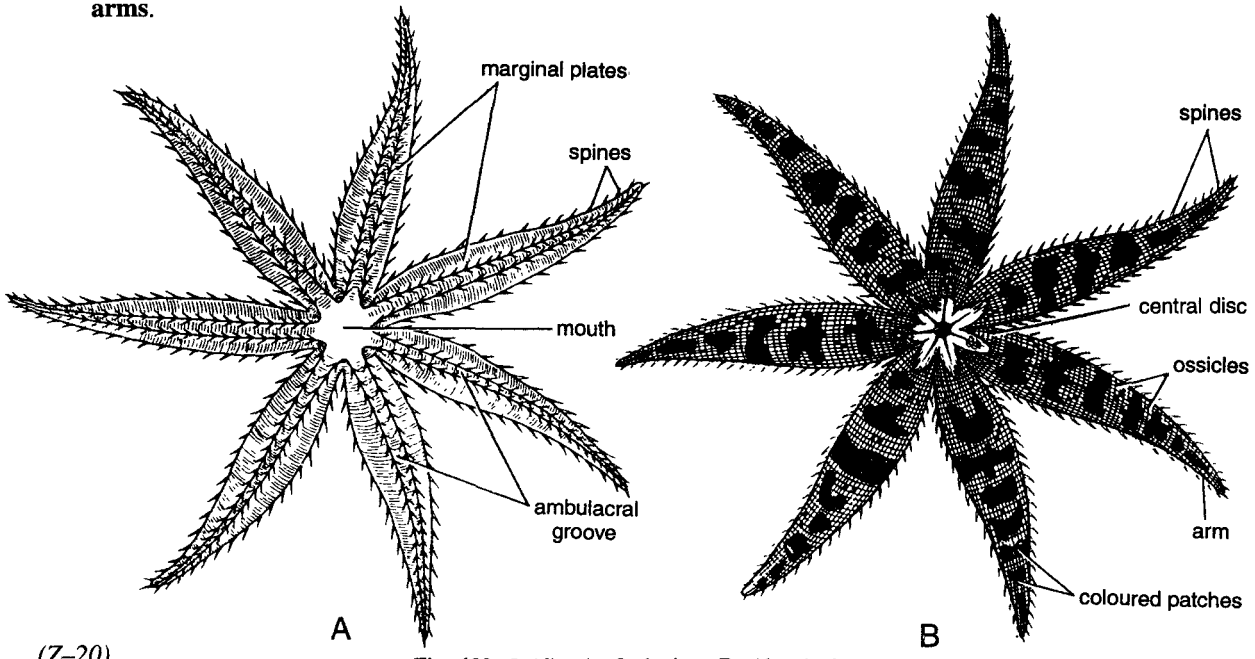


Fig. 192. *Luidia.* **A.** Oral view, **B.** Aboral view.

(3) Body differentiated into **oral** and **aboral** surfaces.
(4) **Arms** are bordered with spiny fringe.
(5) Oral surface contains a central mouth with communicates with **ambulacral grooves** in each **arm**.
(6) **Marginal plates** on margin.
(7) **Infra-marginal plate** is separated from the **ambulacral plate** by a small intermediate plate.
(8) Aboral surface is made up of several small rectangular ossicles. This surface is marked by coloured patches.
(9) **Pedicellariae** are generally found. The gills are branched. Anus and intestinal caeca are absent.

Special features : A **polynoid** polychete (***Achloe astericola***) is found as commensal in the ambulacral groove of ***Luidia***.

Identification : Since the specimen contains comparatively short central disc, long flexible arms and all above features hence it is ***Luidia***.

193. *Astropecten*

Classification : Same as that of ***Pentaceros***.

Genus.....*Astropecten*

Habit and habitat : ***Astropecten*** is a large starfish, commonly found in sea below the tide line to great depths. They inhabit sandy bottom where they can burrow. It creeps very slowly on the sea-bottom, but at rest, it lies partly buried in sand with the central part of its body raised into a cone above the sand. *A. **auranciacus*** swims 30 to 60 cm per minute (Fig. 193).

Distribution : It is found in all parts of the world mostly littoral; New Jersey Southwards; North Carolina Southwards and California.

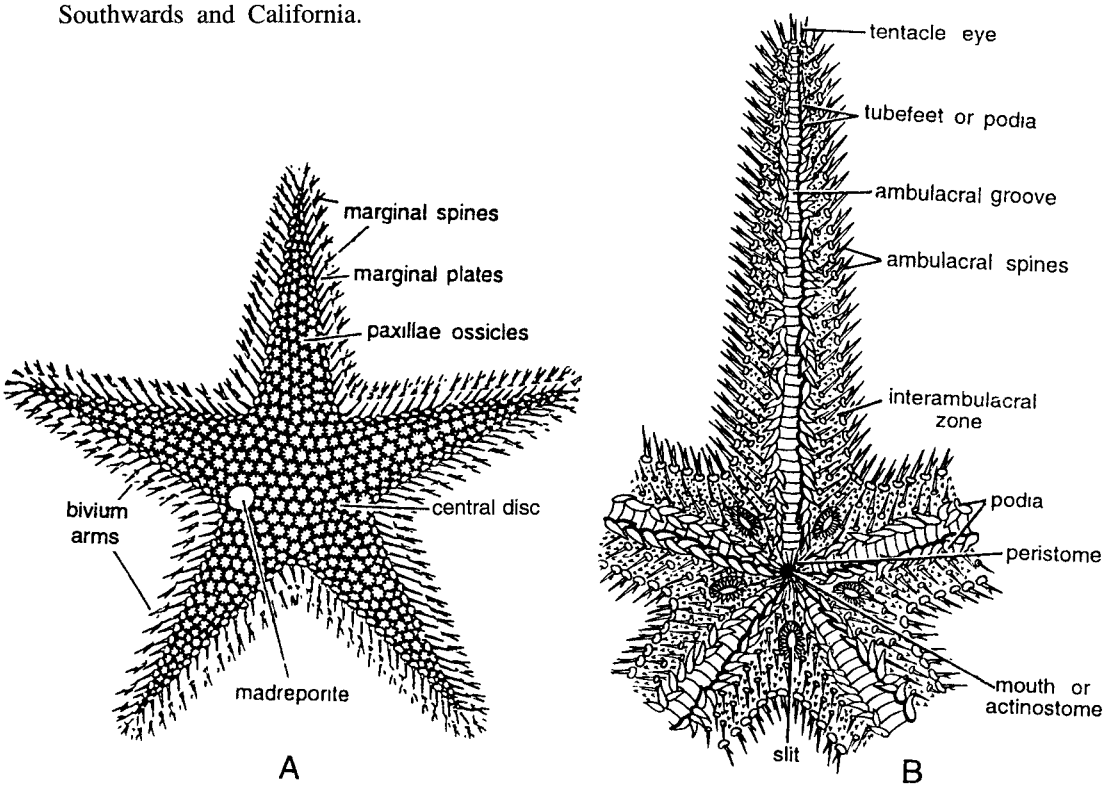


Fig. 193. *Astropecten.* **A.** Aboral view, **B.** Oral view.

Comments :

(1) **Commonly** called as **starfish**. Body is star-shaped, consisting of flattened five-pointed central disc with 5 short flexible, triangular arms with tapering tips. **Oral** and **aboral** surfaces are distinctly marked.
(2) Body is covered by a soft transparent skin through which skeleton could be seen.
(3) **Oral surface** contains centrally-placed **mouth**, which communicates with 5 broadly opened **ambulacral grooves** having **double rows** or **tube feet**.
(4) Mouth is very widely distensible which can swallon bivalves, molluscs, snails and crustaceans very easily.
(5) **Infra-marginal plates** are elongated and meet the **adambulacral** to form the oral surface of the arms. Arms are distinctly marked off from the central disc but do not contain prolongations of either the perivisceral coelom or the gut.
(6) **Mouth** is very widely distensible, which can swallow bivalves, molluscs, snails and crustaceans very easily.
(7) **Aboral surface** has madreporite in one of the interradii. **Skin is soft** and somewhat transparent and **internal skeleton** is seen from outside.
(8) Aboral surface contains blunt spines, finger-like dermal branchiae and pedicellariae. In some forms spines are absent.
(9) Sexes are separate. The development includes **brachiolaria** larva.

Identification : Since the specimen contains soft surface blunt spines and all above features, hence it is ***Astropecten***.

194. *Ophioderma*

Classification :

Phylum..... Echinodermata	→	Coelomate, pentaradiate and spiny-skinned animals with water vascular system.
Sub-phylum.....Eleutherozoa	→	Non-pedicellate and free living.
Class..... Ophiuroidea	→	Central disc and arms distinct.
Order.....Zygophiurae	→	Arms bent only to lateral sides.

Genus.....*Ophioderma* (The brittle star)

Habit and habitat : Exclusively marine (Fig. 194).

Distribution : It is found along the North Atlantic Mediterranean littoral, tropical and West Indian seas.

Comments :

(1) **Commonly** called as **brittle star**.
(2) Body consists of a small pentagonal disc set by closely set granules. Oral **papillae** numerous and arranged in a continuous series.
(3) Body is differentiated into **oral** and **aboral** surfaces with distinct central disc and five surpentine arms.
(4) **Arms** are covered by arm shields or calcareous ossicles and small spines.
(5) The **oral surface** has star-shaped mouth fringed with **oral papillae**.
(6) Skin covers the disc which is composed calcareous plates in the disc and typically of articulating ossicles in the arms.
(7) Internal structures are restricted to central disc only.
(8) **Anus** and **pedicellariae** absent.
(9) **Madreporite** is oral. The ambulacral grooves are usually covered. Tube feet lack suckers.
(10) Most important individual characteristic feature of the genus is the presence of two slits in each **bursa**, one situated orally and the other peripherally. Larva is **Ophiopluteus**.

Identification : Since the specimen contains distinct rounded disk, serpentine arms with spine and all above features hence it is ***Ophioderma***.

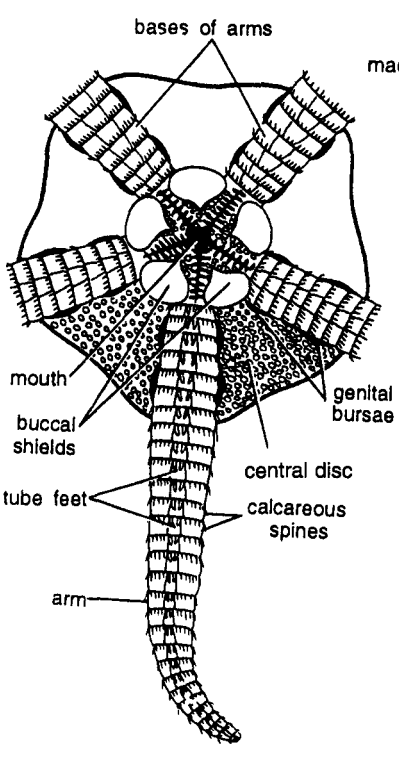


Fig. 194. *Ophioderma.* Disc and one arm.

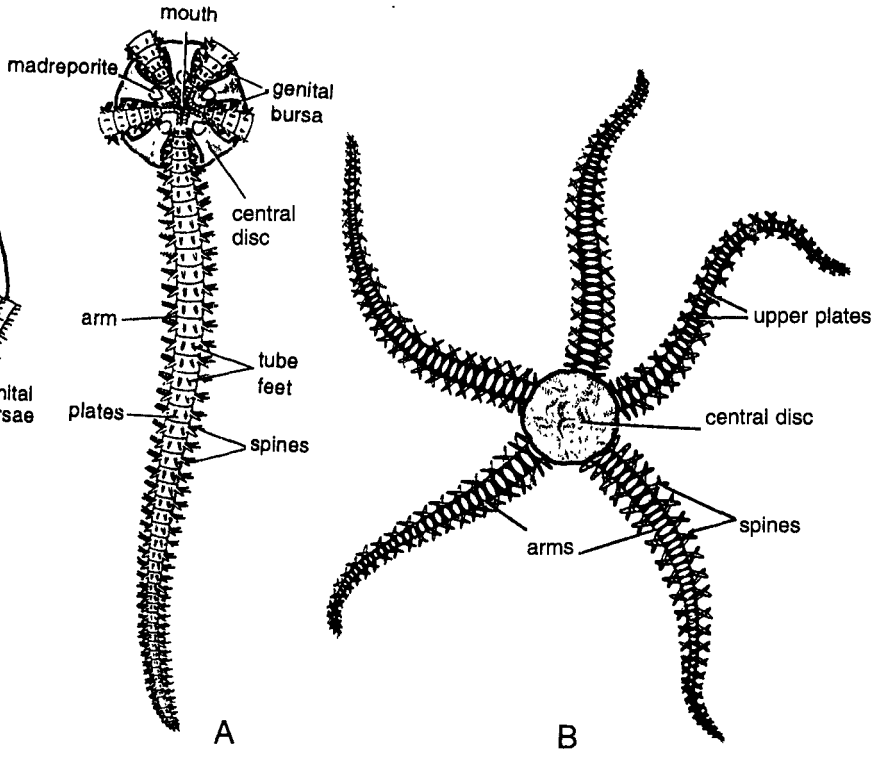


Fig. 195. *Ophiocoma.* **A.** Aboral surface, **B.** Oral surface.

195. *Ophiocoma*

Classification : Same as that ***Ophioderma***.

Genus.....*Ophiocoma*

Habit and habitat : ***Ophiocoma*** is commonly found in shallow waters.

Distribution : It is found along the Red Sea shores. West Indian regions and Florida.

Comments :

(1) **Commonly** called as **brittle star**.

(2) Body consists of a **small**, rounded central disc and 5 long slender, **tapering arms**, which are inserted on the under-surfaces of the disc.

(3) **Central disk** and **arms** quite distinct.

(4) **Arms** are distinctly marked off from the **central disc** and do not have prolongations of perivisceral coelom and alimentation.

(5) **Oral** and **aboral** surfaces are distinctly marked.

(6) Oral surface has leathery skin. Anus and pedicellariae absent.

(7) Oral surface has a central, pentagonal mouth opening and indistinct inter-radial oral **madreporite**. The **ambulacral grooves covered**.

(8) There are 10 elongated slits, two on either side of the base of each arm, called as **genital bursae** in which gonoducts open.

(9) Three rows of pointed spines are borne on lateral plates. Single row of short **tube feet** projects on each side between lower and lateral plates. **Ossicles** of arms are articulating.

Identification : Since the specimen contains three rows of pointed spines and all above features, hence it is ***Ophiocoma***.

Instructions : *Differentiate between various animals of* **Asteroids** *and* **Ophiuroids**.

196. *Ophiolepis*

Classification : Same as in ***Ophioderma***.

Genus.....*Ophiolepis*

Habit and habitat : They are abundant in littoral zone hidden often in the sand and other objects. Some live in sponges.

Distribution : Distributed from tropical to polar regions and they have been collected from depths of 6,000 m.

Comments :

(1) **Commonly** called as **Brittle stars**.
(2) **Oral** and **aboral** surfaces well differentiated.
(3) **Central disc** and arms quite distinct. Arms contain **podia**.
(4) **Mesodermal endoskeleton** consits of clacareous ossicles.
(5) **Central disc** of aboral surface is composed of radial shield, lateral arms shield, aboral shield, central plate and primary concentric plates.
(6) Central disc has primitive **concentric** arrangement of plates.
(7) Branchial, dermal papillae and pedicellarea are absent.

Identification : Since specimen has primitive concentric arrangement of plates in central disc and all above features, hence, it is ***Ophiolepis***.

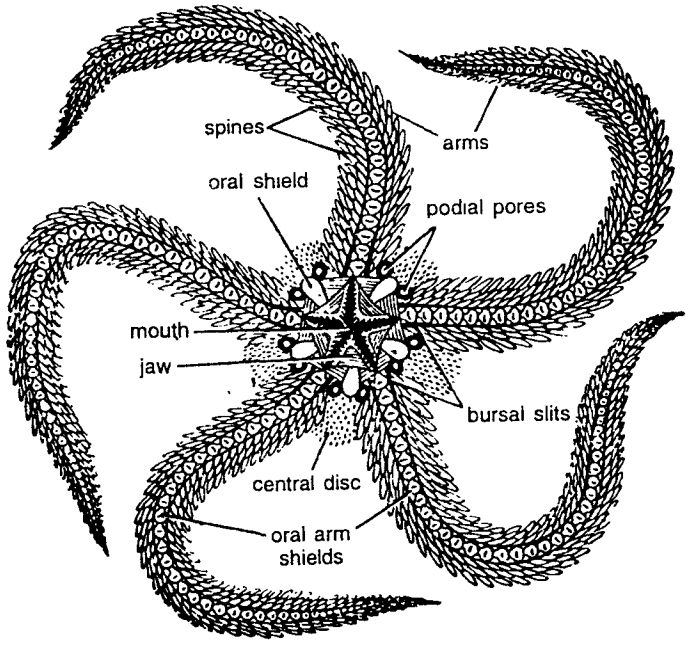


Fig. 196. *Ophiolepis.*

197. *Ophiothrix*

Classification : Same as those of ***Ophioderma.***

Genus.....*Ophiothrix*

Habit and habitat : ***Ophiothrix*** is found in sea shore and in shallow waters. It is microphagus feeding on microbes.

Distribution : Cosmopolitan.

Comments :

(1) **Commonly** called as **Brittle star.**

(2) ***Ophiothrix*** reveals considerable variation in **spine** armature and colour pattern. No two individuals are alike.

(3) Body divisible into **oral** and **aboral** surfaces. Central disc and arms quite distinct.

(4) Spines on the disc continue round its sites, lateral spines are larger in size. Interradially and on edges of oral surfaces.

(5) **Aboral** surface has radial shields in central disc.

(6) **Mouth** in oral surface has complicated system of plates, spines and tube feet. Inter-radially **buccal shields** are present and beneath on lateral position are lateral buccal shield. Around mouth are jaw.

(7) At the base of each arm are slit like Bursal slit.

(8) Oral surface reveals each arm is made up of **vertebral** consisting of **lateral plates** and **ventral plate.** Lateral spines, tube foot, jaw and tentacle scale are seen.

(9) Aboral surface contains dorsal plates.

Identification : Since the specimen contains radial shields in aboral surface and all above features hence it is ***Ophiothrix.***

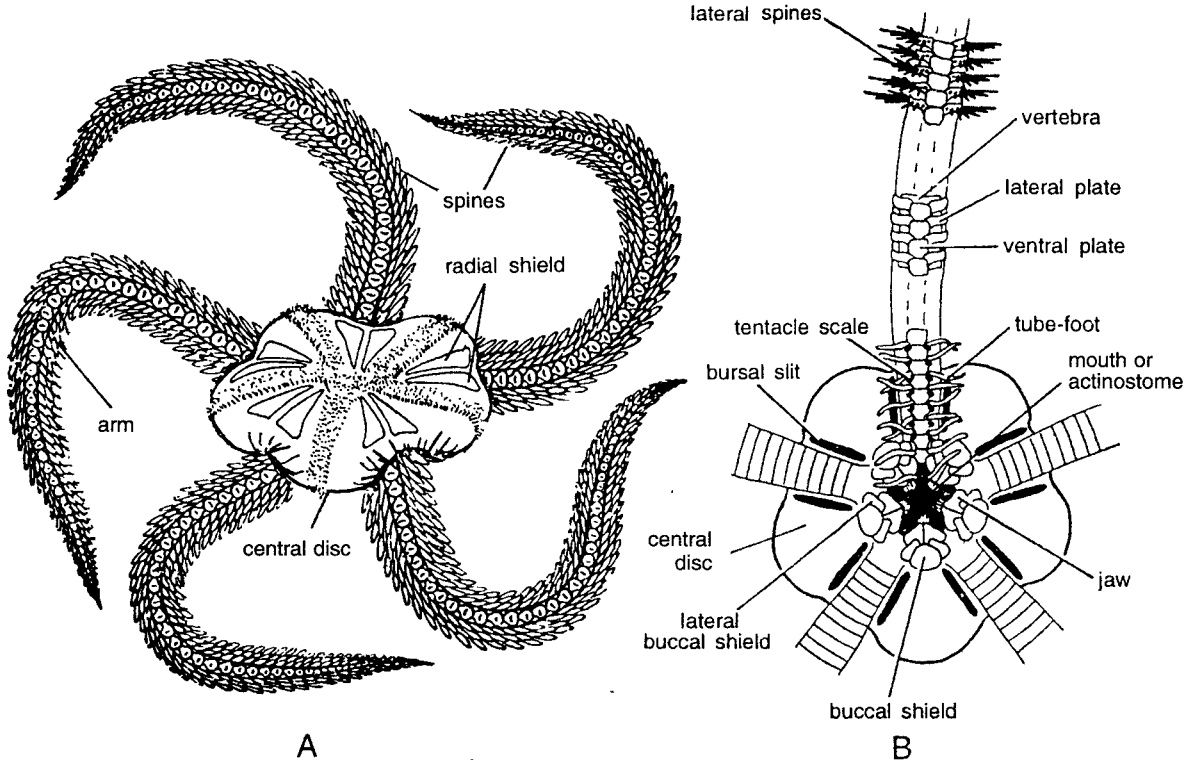


Fig. 197. *Ophiothrix.* **A.** Aboral view, **B.** Oral view.

198. *Echinus*

Classification :

Phylum.....Echinodermata	→	Coelomate, pentaradiate and spiny-skinned animals with water vascular system.
Sub-phylum.....Eleutherozoa	→	Non-pedicellate and free-living.
Class.....Echinoidea	→	Body oval or spherical and composed of test enclosing viscera.
Sub-class.....Regularia or Endocyclia	→	Periproct and peristome, aboral and oral respectively.
Order.....Diadematoidea		
Genus.....*Echinus* (Sea urchin)		

Habit and habitat : ***Echinus*** is a **benthic** animal occurring from inter-tidal zone to a depth of 5000 meters.

Distribution : It is widely distributed in the Atlantic, the Mediterranean and Pacific waters.

Comments :

(1) **Commonly** called as **sea urchin**.

(2) Body is spherical and brownish and is differentiated into flat, **oral** and domed **aboral** surfaces along vertical oral aboral axis.

(3) Body is enclosed in a rigid **globular test** or **corona** which is composed of calcareous plates which regularly interlock to form test.

(4) Entire surface, except peristome and periproct, is covered by movable articulated spines to the test.

(5) **Pedicellariae** and **sphaeridia**, offensive and defensive organs are found between movable articulated spines. The oral surface contains mouth, from where jaw apparatus or **Aristotle's lantern** or masticatory apparatus protrudes internally. The **mouth** is surrounded by a lip or peristome. The inside of peristome contains calcareous ossicles and buccal tube and on outer edge of peristome are ten branching gills.

(6) Test is distinguished into **ambulacral** and **inter-ambulacral zones**. **Water vascular system** is well developed. Ambulacral groove closed.

(7) Test bears numerous spines and rows of tube feet in ambulacral areas.

(8) Dried test contains **ocular plates**, **anus**, **genital plate**, **madreporite plate** and **double row** of podia.

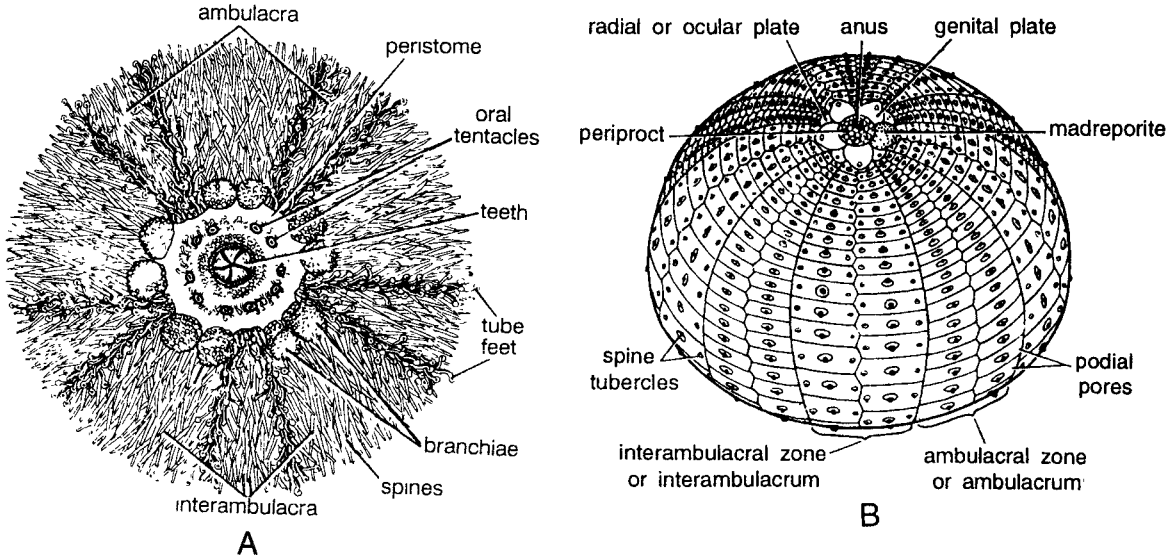


Fig. 198. *Echinus*. **A.** Oral view, **B.** Skeleton in aboral view.

(9) **Madreporite** and **gonophore** are present near anus and aboral in position.
(10) Tube feet end in suckers and form five double meridional rows.

Special features : The mouth on lower surface is surrounded by a lip or **peristome**. In side of **peristome** contains calcareous ossicles and buccal tube and on outer edge of peristome are ten branching gills. The most interesting part is Aristotle's lantern. It is a masticatory apparatus which protrudes internally. Sea urchin's eggs have been extensively used for experimental work in embryology.

Identification : Since the specimen contains rounded test and all above features, hence it is ***Echinus***.

199. *Strongylocentrotus*

Classification : Same as that of ***Echinus***.

Genus.....*Strongylocentrotus*

Habit and habitat : ***Strongylocentrotus*** is a marine and regular echinoid, adapted for swimming life.

Distribution : It is found in Europe, Asia, Pacific coast, Mexico to Alaska and U.S.A.

Comments :

(1) Commonly called as **Sea urchin**.
(2) Body is rounded and contains **large tubercles for thick spines**. Test is differentiated into **oral** and **aboral** surfaces.
(3) Oral surface has a central mouth through which teeth of jaw apparatus **(Aristotle's lantern)** project.
(4) Mouth is surrounded by peristomial membrane.
(5) **Aboral surface** is composed of **calcareous plates**. It is differentiated into ambulacral and inter-ambulacral zones.
(6) Ambulacral grooves are absent. Several tube feet are seen in ambulacral zone. Test contains openings for **tube feet** in ambulacral zone.
(7) Anus is aboral.
(8) Gemmiform pedicellariae are rounded and without teeth.
(9) Gills and **sphaeridia** are present. Development includes **echinopluteus larva**.

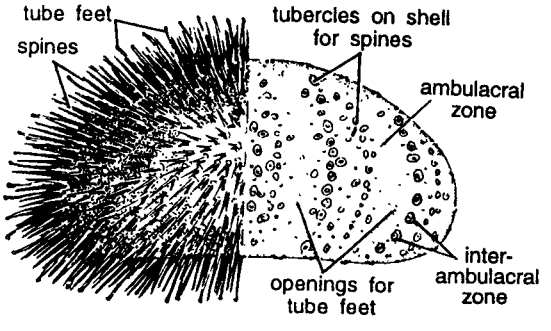


Fig. 199. *Strongylocentrotus.*

Identification : Since the specimen contains brightly coloured spines and all above features, hence it is ***Strongylocentrotus***.

200. *Echinarachinus*

Classification :

Phylum.....Echinodermata	→	Coelomate, pentaradiate and spiny-skinned animals with water vascular system.
Sub-phylum.....Eleutherozoa	→	Non-pedicellate and free-living.
Class.....Echinodea	→	Body oval or spherical and composed of test.
Sub-class.....Irregularia	→	Periproct displaced towards mouth in interradius.
Order.....Clypeastroida	→	Body disk-shaped, ambulacra petaloid and anus displaced laterally.

Genus.....*Echinarachinus* (The sand dollar)

Habit and habitat : ***Echinarachinus*** is commonly found about 800 fathoms deep, lying on sand or partly buried.

Distribution : It is found along West coast on North America, Pacific coast and U.S.A.

Comments :

(1) **Commonly** called as **sand dollar**.
(2) Body is circular, disk-like and dorsoventrally flattened and differentiated into **oral** and **aboral** surface.
(3) Oral surface is composed of **inter-locking ambulacral** and **interambulacral ossicles** beset with tiny **spines**.
(4) Five **petaloid ambulacra** representing opening for tube feet in double row in the form of a petal. One present on aboral surface.
(5) Petaloid also contain paired openings for **flattened respiratory tube feet**.
(6) Entire test has small spines. **Madreporite plate**, **ocular plate** and **genital plate with** genital opening are found on aboral surface.
(7) **Anus** is aboral.
(8) Development includes **echinopluteus larva**.

Identification : Since the specimen contains five petaloid and all above features hence it is ***Echinarachinus***.

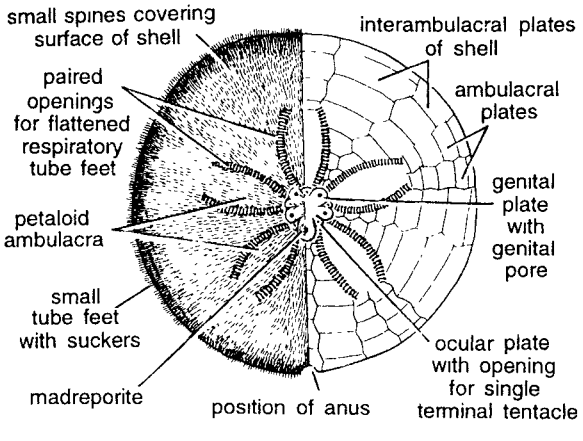


Fig. 200. *Echinarachinus* in aboral view.

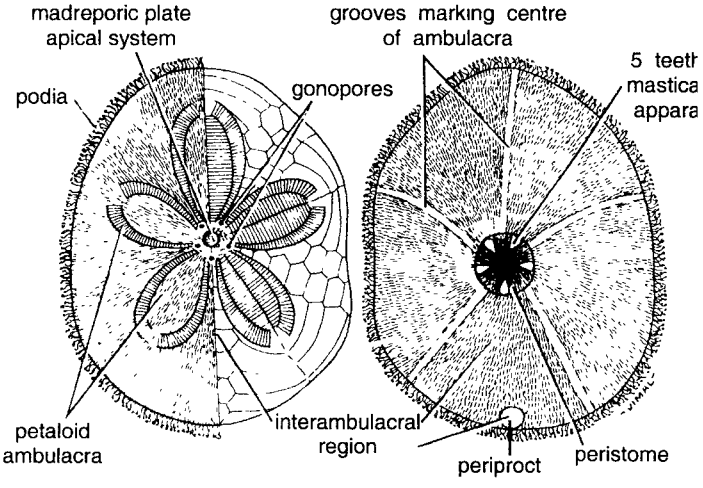


Fig. 201. *Clypeaster*. **A.** Aboral view, **B.** Oral view.

201. *Clypeaster*

Classification : Same as that of ***Echinarachinus***.

Genus.....*Clypeaster*

Habit and habitat : ***Clypeaster*** is found creeping on the bottom or partly buried in sand. It shovels sand by its tube feet (Fig. 201).

Distribution : It is found in tropical, sub-tropical region, Red Sea and North Carolina to Brazil.

Comments :

(1) **Commonly** called as **cake urchin**.
(2) Body is flattened and is exhibiting bilateral symmetry. Test is more or less round in outline and is covered with thick and short **spines**.
(3) Body differentiated into **oral** and **aboral** surfaces.
(4) Shell more or less five sided, each **petaloid** area being wide and well marked and each pair of ambulacral.
(5) **Aboral surface** is slightly convex. Aboral ends of 5 **ambulacral areas** are bordered, each by two rows of flattened, respiratory tube feet, which are arranged in such a way that they appear like petals of flowers and are hence called as **petaloids**.

(6) **Madreporite** is placed at the centre of the aboral side, from which radiate five petaloid ambulacral areas which are clearly seen. Between two petaloid is interambulacral area.
(7) **Oral surface** is flat and covered by a dense velvety coat or short spines and **pedicellariae**. Mouth lies in centre and communicates with 5 simple groove along the centre of the ambulacral areas. Anus or periproct oral. Around mouth is 5 teeth of **masticatory apparatus**. Ambulacral groove is clearly seen.
(8) At the beginning of each ambulacral area near the **peristome** there exist two **sphaeridia** which are immovable and devoid of nerve ring.
(9) Genital plates are fused with the central pentagonal plate. Radial ocular plates are distinct.
(10) Development includes **echinopluteus larva**.

Identification : Since the specimen contains five distinct petaloid and all above features, hence it is ***Clypeaster***.

202. *Echinocardium*

Classification :

Phylum..... Echinodermata	→	Coelomate, pentaradiate and spiny-skinned animals with water vascular system.
Sub-phylum..... Eleutherozoa	→	Non-pedicellate and free-living.
Class..... Echinoidea	→	Body oval or spherical and composed of test.
Sub-class..... Irregularia	→	Periproct displaced towards mouth in innerradius.
Order.....Spatangolda		
Genus..... *Echinocardium* (The heart urchin)		

Habit and habitat : ***Echinocardium*** burrows in sand 10 to 15 cm deep and moves by spines. It lives in a small chamber, which opens to surface by a chimney, through which animal feeds by protruding tube feet.

Distribution : It has world-wide distribution.

Comments :

(1) It shows extreme modification of echinoderm pattern as it becomes heart-shaped and is popularly known as **heart urchin**.
(2) Test is large in size with four well-developed **petaloids** and **aboral** surface and **anterior** and **posterior** sides.
(3) On oral surface long **tubercles** or long **interambulacral spines** are present.
(4) Apical central plate contains gonopores.
(5) **Peristome** or **mouth** becomes **transversely extended**.

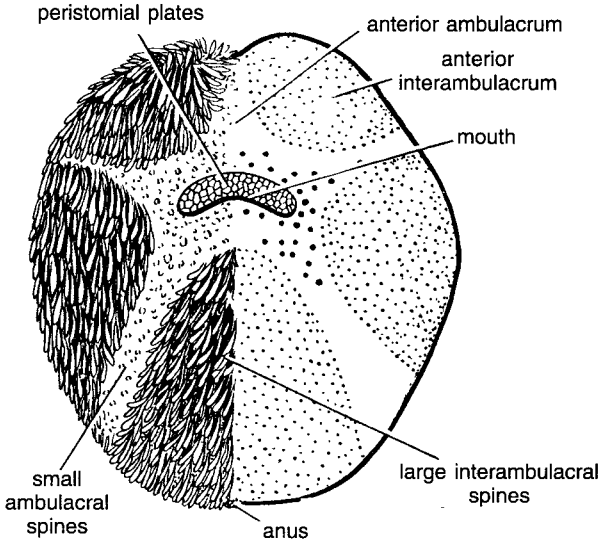


Fig. 202. *Echinocardium.* Oral view.

(6) Aristotle's lantern is absent.
(7) Ambulacral areas bear **short tube feet** and **short spines** called **ambulacral spines**.
(8) Inter-ambulacral areas bear **long spines**.
(9) Development includes **echinopluteus larva**.

Identification : Since the specimen contains 4-well developed petaloid and all above features, hence, it is ***Echinocardium***.

203. *Cucumaria*

Classification :

Phylum.....Echinodermata → Coelomate, pentaradiate and spiny-skinned animals with water vascular system.
Sub-phylum.....Eleutherozoa → Non-pedicellate and free-living.
Class.....Holothuroidea → Body orally and aborally elongated.
Order.....Dendrochirota → Oral tentacles tree-like (dendroid).
Genus.....*Cucumaria* (The sea cucumber)

Habit and habitat : ***Cucumaria*** is inhabits approximately 200 fathoms deep wholly or partially buried in the mud. It feeds on detritus and plankton.

Distribution : It has cosmopolitan distribution and specially found in Europe, U.S.A. and India.

Comments :

(1) **Commonly** called as **sea cucumber**.
(2) Body is elongated horizontally along the **oral aboral axis**. Colour of the body may be whitish, reddish or brown.
(3) Oral end contains a whorl of 10 dendritic bushy, **pinnately branched tentacles** surrounding the terminal month. Tentacles are modified tube feet.
(4) Anterior region is called as **collar** which contains **mouth** at anterior extremity.
(5) Rest of the body differentiated into 5 **ambulacral** and 5 **inter ambulacral zones**. Ambulacral grooves are covered and run longitudinally.
(6) **Tube feet**, when present, usually possess suckers and are either arranged in rows or are irregularly scattered.
(7) Body wall which is dermo-muscular contains very small separate **ossicles**.
(8) There is a single genital aperture, middorsally situated between the bases of two adjacent inter-ambulacral tentacles near mouth.
(9) Animal rests on the so-called ventral surface, which is flattened and paralleled with oral aboral axis of the body, and is pentaradiate. It has 3 ambulacral areas **trivium** and forms sole. Dorsal surface with 2 ambulacral areas is called as **bivium**. **Anus** is aboral with paired respiratory trees.
(10) Larva are **Auricularia Doliolaria**.

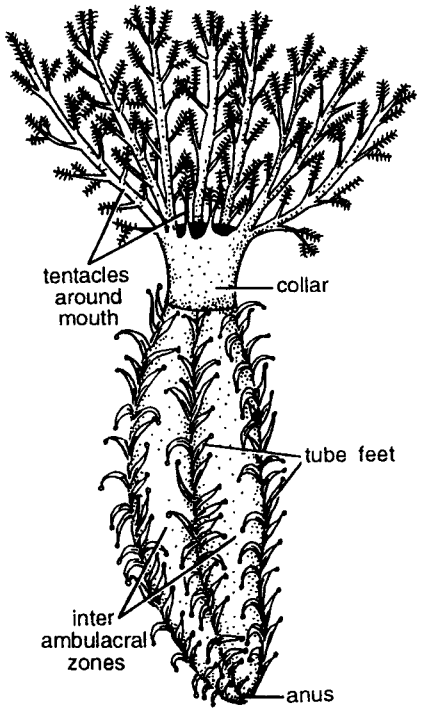


Fig. 203. *Cucumaria.*

Identification : Since the specimen contains whorl of pinnately branched **tentacles** and all above features, hence it is ***Cucumaria***.

204. *Holothuria*

Classification :

Phylum.....Echinodermata
Sub-phylum.....Eleutherozoa
Class.....Holothuroidea } → Characters same as those of ***Cucumaria***.
Order.....Aspidochirota → Oral tentacles shield-shaped.
Genus.....*Holothuria* (Sea cucumber)

Habit and habitat : ***Holothuria*** is found near seacoasts and is measuring about 30 cm. The animal feeds on microorganisms and moves very slow on the sea bottom by the muscular contractions of the body wall and with the help of its tube feet.

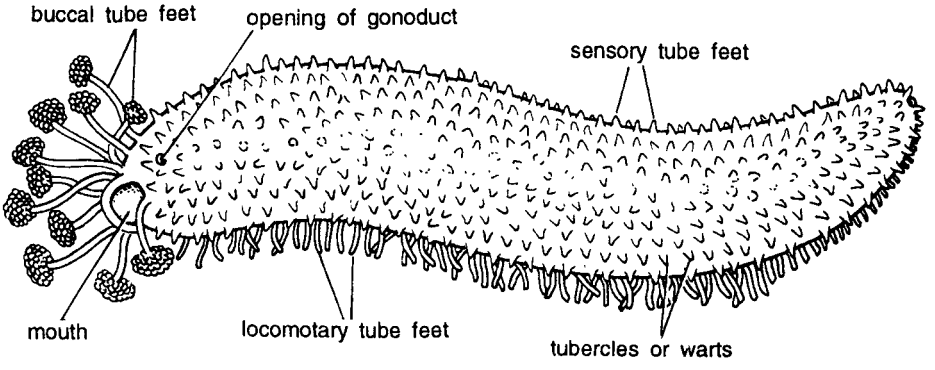


Fig. 204. *Holothuria.*

Distribution : It is found in India, Florida and West Indies.

Comments :

(1) **Commonly** called as **sea cucumber.**
(2) Body is elongated along the **oral** and **aboral axis** horizontally.
(3) Oral end has large **mouth** surrounded by tactile **buccal tentacles** for collecting food.
(4) **Madreporite** is internal polian vesicles 1 to many. **Water vascular system** well developed.
(5) **Tube feet** contains suckers and are present in rows. Body divided into **ambulacral** and **interambulacral areas.**
(6) Dermo-muscular body wall is embedded with small **calcarious ossicles.**
(7) **Pedicellariae** or spines absent.
(8) **Respiratory tree** and **cuviers tubes** are present internally.
(9) **Ambulacral grooves** are covered and run longitudinally.
(10) Sexes are separate. Development includes **Auricularia larva** which develops into **Doliolaria** before metamorphosis into adult.

Identification : Since the specimen contains small buccal tentacles and all above features, hence it is ***Holothuria.***

205. *Thyone*

Classification : Same as that of ***Cucumaria.***

Genus.....*Thyone*

Habit and habitat : ***Thyone*** is a marine and burrowing animal in shallow waters. It is found buried in muddy and sandy bottoms.

Distribution : It is found in U.S.A. (Vineyard Sound and Southwards).

Comments :

(1) **Commonly** called as **sea cucumber.**
(2) Body is ovate or elongated.
(3) **Oral end** contains a large mouth, surrounded by 10 dendritic oral tentacles, which can be considerably extended. Tentacular region is followed by introvert.
(4) Colour may be dull brown or black or red above and whitish below.
(5) Body divided into **ambulacral** and **interambulacral** area.
(6) Tube feet are distributed over the entire body surface without definite arrangement in the ambulacral region.
(7) **Respiratory** trees present but **cuvierian** tubes absent.

(8) **Haemal system** simple. Haemocytes in the coelomic fluid contain haemoglobin. Stomach in the form of muscular sac.

(9) **Water vascular system** is present. Sexes are separate. Development includes **Auricularia** larva.

Identification : Specimen contains small locomotory podia and all above features, hence it is ***Thyone***.

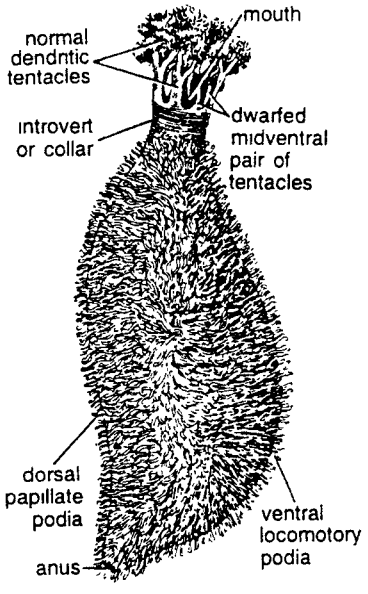


Fig. 205. *Thyone.*

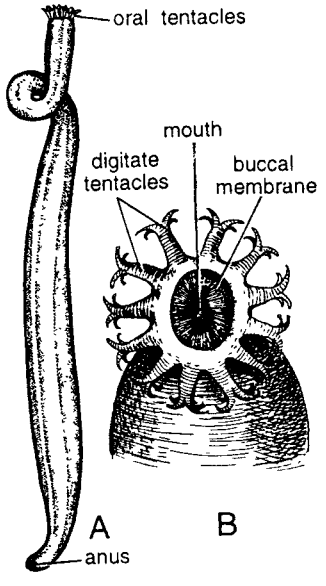


Fig. 206. *Synapta.* **A.** Entire animal, **B.** Anterior end or head magnified.

206. *Synapta*

Phylum.....**Echinodermata**
Sub-phylum.....**Eleutherozoa** } → Characters same as those of ***Cucumaria***.
Class.....**Holothuroidea**
Order.....**Synaptida** → Without tube feet.
Genus..... ***Synapta***

Habit and habitat : ***Synapta*** inhabits under stones and occasionally in the sand near low water mark.

Distribution : It is found in Europe, Pacific coast and Bermuda.

Comments :

(1) ***Synapta*** is a whitish elongated, worm-like, semitransparent and burrowing holothuroid. Size few to 60 cm.

(2) **Mouth** and **anus** are found at opposite ends.

(3) Mouth is enclosed by **buccal membrane**. Mouth opening is surrounded by 10 to 25 small **bipinnate oral tentacles**. Tentacles capture large and small **zoophytes**.

(4) Tube feet, respiratory tree, ossicles and **cuverian** tubules are absent.

(5) **Longitudinal muscle bands** are distinctly seen through transparent body.

(6) Some peculiar anchor plates are found in the thin body wall.

(7) When irritated, the animal show **autotomy** i.e., breaks into two or more pieces, which regenerate into new individuals.

Special features : ***Thyone*** is famous for its power of autotomy and regeneration. When irritated, the bodywall ruptures and organs are eviscerated (ejected out). The animal regenerates the missing part.

Identification : Since the specimen has transparent body and all above features hence it is ***Synapta***.

MINOR PHYLA

On the basis of presence or absence of a true coelom minor phyla are divided into two groups.

(A) Minor Acoelomate Groups

1. Mesozoa, 2. Ctenophora, 3. Endoprocta, 4. Nemertinea (Rynchocoela), 5. Acanthocephala, 6. Nematomorpha, 7. Rotifera, 8. Gastrotricha, 9. Kinorhyncha, 10. Nematoda.

(B) Minor Coelomate Groups

1. Ectoprocta, 2. Brachiopoda, 3. Phoronida, 4. Chaelognatha, 5. Priapulida, 6. Sipunculida, 7. Echiuroidea, 8. Brachiata. Some of the representatives of the above phyla are discussed below.

207. *Bonellia*

Classification :

Phylum.....Echiuroidea → Traces of segmentation, coelomate, bilaterally symmetrical.

Genus.....*Bonellia*

Habit and habitat : ***Bonellia*** is a marine and burrowing echinoid. It lies buried in the mud.

Distribution : It is found in Italy, Mediterranean Sea, Atlantic and Pacific coasts, Europe and U.S.A.

Comments :

(1) It exhibits very interesting case of sexual diamorphism with **giant female** and **dwarf male** without segmentation. Body divisible into anterior **proboscis** and posterior trunk.

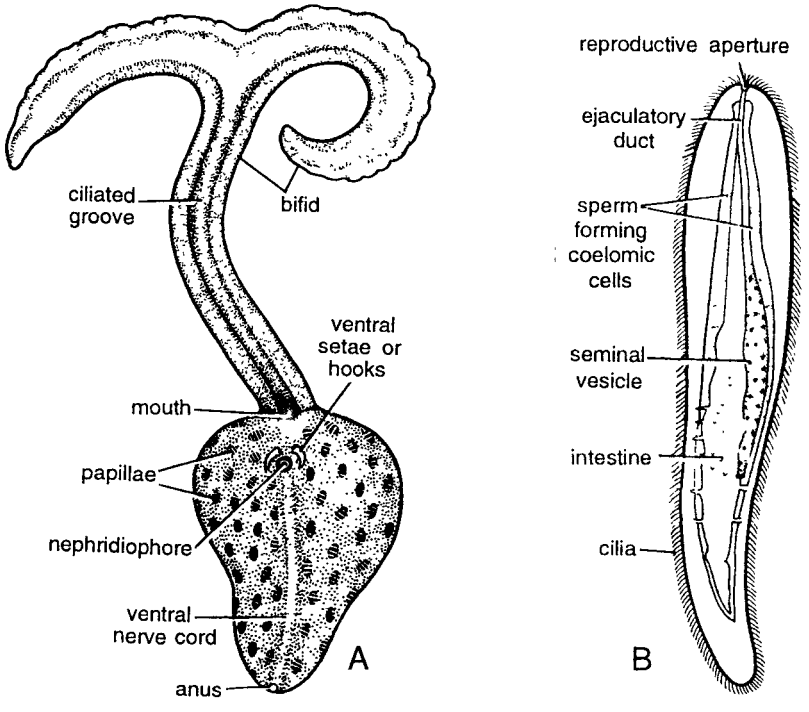


Fig. 207. *Bonellia.* **A.** Female, **B.** Male.

(2) Female is 5 cm long, ovoid in shape and green in colour due to the presence of a pigment called **bonellein**. The formation of the head is peculiar. The **proboscis** is very much elongated forming long spatulate in front of the mouth.
(3) **Proboscis is bifid** measuring 60 to 90 cm in length and homologous to prostomium of annelids.
(4) Grooved ventral surface of the proboscis is ciliated through which micro-organisms are collected as food. The **mouth** is found at the base of proboscis and the **anus** at opposite end.
(5) Excretory organs are a pair of anal vesicles, one or two nephridia which act as gonoduct.
(6) There is a **closed blood vascular system**.
(7) Ovoid body is covered by minute papillae. The parapodia and the cephalic appendages are absent.
(8) A pair of hook-like ventral setae are present near the anterior end.
(9) **Male** is very small, tuberllarian like, **ciliated** and without proboscis. It has **reproductive aperture, ejaculatory duct, sperm forming coelomic cells, seminal vesicle and intestine.**
(10) In early stages male enters the pharynx of female and **lives permanently in nephridium** after attaining sexual maturity. **Fertilization is internal.**

Identification : Since the specimen contains a bifid proboscis and all above features hence it is ***Bonellia.*** Traces of segmentation, coelomate, bilaterally, symmetrical.

208. *Echiuris*

Classification :

Phylum.....Echiuroidea → Traces of segmentation, coelomate, bilaterally, symmertical.
Genus.....*Echiuris*

Habit and habitat : ***Echiuris*** is a marine worm living in the sand and mud or between stones usually near the shore.

Distribution : It is found in Atlantic and Pacific coasts, Europe, Italy, Mediterranean Sea and California.

Comments :

(1) Body is thick and cylindrical without or indistinct segmentation. Parapodia and cephalic appendages are also absent.
(2) Formation of the head is peculiar. It is elongated, cylindrical, spoon-shaped in front of the mouth. It is called as **proboscis.**
(3) **Proboscis** is homologous with prostomium of annelids. Ventral surface of the proboscis is grooved and ciliated for traping micro-organisms for feeding.
(4) Body surface is covered by **minute papillae** arranged in regular transverse rings.
(5) A pair of **hooked setae** is found near the **anterior** and **posterior** ends.
(6) **Mouth** is found at the base of the proboscis.
(7) Anus has 2 rings of setae.
(8) **Nephridiopores** of the anterior nephridia open ventrally close behind the anterior setae. Nephridia act as gonoducts.
(9) Body wall is highly muscular and coelom is **spacious.**
(10) Sexes are separate. Development is indirect and larva is trochophore.

Identification : Since the specimen has spatulate proboscis and all above features, hence it is ***Echiuris***.

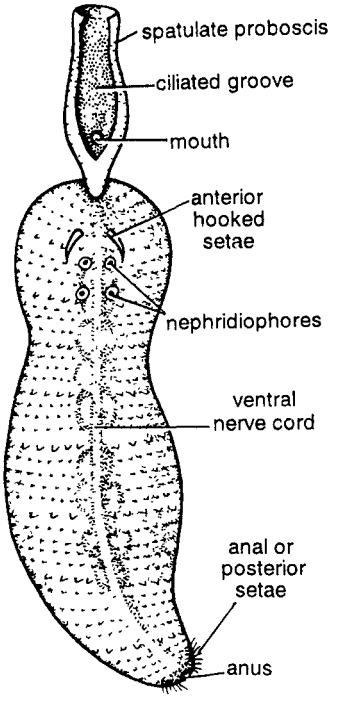


Fig. 208. *Echiuris.*

209. *Sipunculus*

Classification :

Phylum.....Sipunculoida → Metamerically segmented, coelomate and bilaterally symmetrical.
Genus.....*Sipunculus* (Peanut worm)

Habit and habitat : ***Sipunculus*** is a burrowing sipunculid, found in sand at moderate depths. They live in the sand or mud, either free or in tubes or in snail shells.

Distribution : It is found in Europe and U.S.A. (Beufort, North Carolina, Key West).

Comments :

(1) **Commonly** called as **peanut worm.**
(2) Body is pale brown and cylindrical, about 40 cm long and covered by a thick, chitinous transparent and iridescent cuticle containing minute papillae. Appendages absent.
(3) Body is very contractile, unsegmented and without metameric appendages, spines or bristles and it is differentiated into anterior narrow **retractile proboscis** and a posterior **broad trunk.**
(4) **Proboscis** contains minute papillae, while rest of the body does not possess papillae.
(5) Proboscis contains mouth surrounded by **tentacular fold** without isolated tentacles. Mouth is borne at the end of retractile proboscis below which is a smooth zone. Below smooth zone is posterior **papillary region of introvert.**
(6) Body wall is highly muscular. The posterior part of the body is marked by a series of **squarish areas due to crossing of transverse and longitudinal muscles.** Papillae are absent is this area.
(7) Body cavity is traversed by muscle fibres and connective tissue fibres.

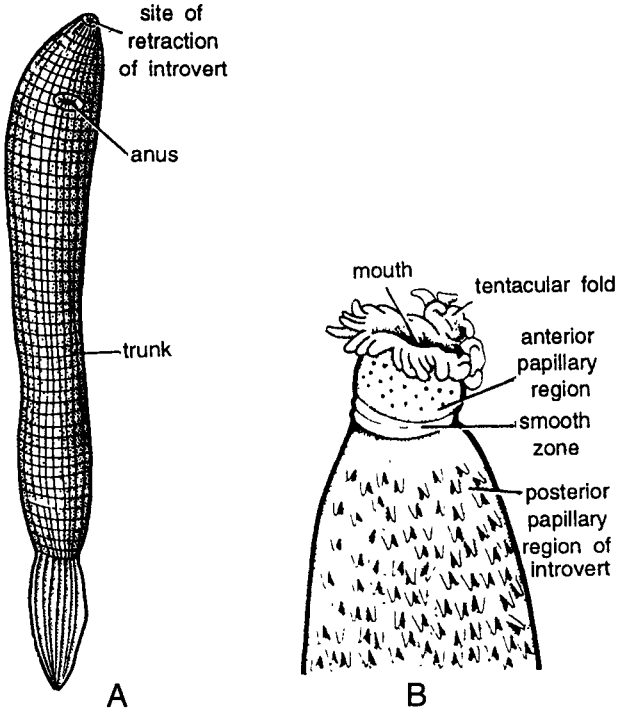


Fig. 209. *Sipunculus.* **A.** Entire animal, **B.** Head end enlarged.

(8) There are no definite gonads but gametes are produced seasonally from germinative cells on connective tissue. The nephridia function as gonoduct.
(9) Sexes are separate, but no sexual dimorphism. Fertilization is external and larva is a modified trochophore.
(10) Fertilization in external and larva is modified **trochophore.**

Identification : Since the specimen contains retractile proboscis and all above features, hence it is ***Sipunculus.***

210. *Priapulus*

Classification :

Phylum.....Priapulida → Introvert proboscis.
Genus.....*Priapulus*

Habit and habitat : ***Priapulus*** is a marine, cylindrical, burrowing and unsegmented animal. It burrows in sand or mud at moderate depths in the colder seas.

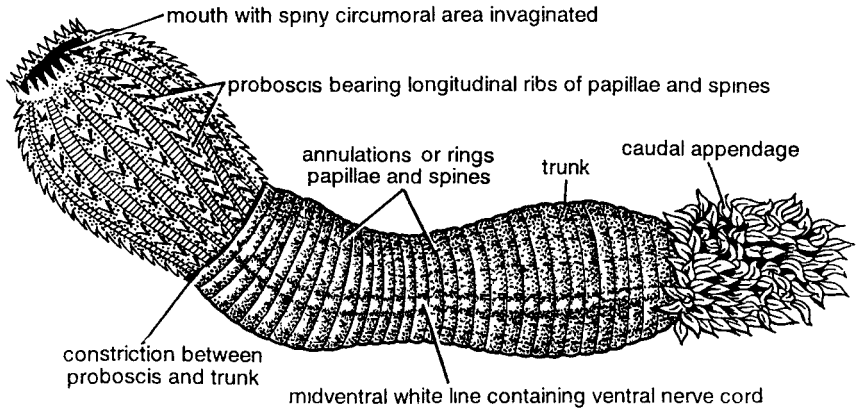


Fig. 210. *Priapulus.*

Distribution : It is found in Arctic sea.

Comments :

(1) Body divisible into **proboscis**, **trunk** and **caudal appendages.**
(2) Proboscis has **longitudinal ribs of papillae** and spines. A **constriction** separates **proboscis** and **trunk.**
(3) No pre-oral segment. Mouth terminal and surrounded by **spiny circumoral areas.**
(4) Body wall contains an outer cuticular and an inner longitudinal muscle layer.
(5) There is a perivisceral coelom which extends into the posterior papillae.
(6) There are no blood vascular system and excretory system. Excretion is efffected by the genital ducts and their branches.
(7) Products of gonads are passed to the exterior by ducts of doubtful origin opening close to the anus.
(8) Body is unsegmented but is marked with many superficial annulations.
(9) **Mid ventral nerve cord** is like white line, non-ganglionated and without sense organs.
(10) Sexes separate. Caudal appendage has **spines.**

Identification : Since the specimen has proboscis having ribs of papillae and all above features, hence it is ***Priapulus.***

PHYLUM BRACHIOPODA

Classification

Brachiopoda includes 2 classes.

Class I Inarticulate (Ecardines)
Order 1. Atremata
Ex. *Lingula*
Order 2. Neotremata
Ex. *Crania, Discinia.*

Class II Articulata (Testicardines)
Ex. *Magellania, Terebratella.*

211. *Lingula*

Classification :

Phylum.....Brachiopoda	→	Lophophore contains coiled arms.
Class.....Inarticulata	→	Shell valves without hinge.
Order.....Atremata	→	Pedicel passage formed by both shells.
Genus.....*Lingula*		

Habit and habitat : ***Lingula's*** dozen living species are limited to the tropical and sub-tropical waters of the Indo-West Pacific area living in vertical burrows in sandy survibottom.

Comments :

(1) It has great **evolutionary significance** that it has survived for long 350,000,00 years.
(2) Animal consists of **stalk** and **shell valves** and remains erect in the burrows.
(3) When not disturbed, it protrudes through the shell, with valves slightly opened.
(4) Two valves are nearly equal and convex and contain **setae**.
(5) **Lophophore** is of the **spirolophous** type.
(6) Digestive gland opens by 4 ducts into the stomach. Intestine is longest in brachiopods. Sexes are separate.
(7) Japanese eat ***Lingula***.

Identification : Since the specimen has stalk and two equal shell valves and all above features, hence it is ***Lingula***.

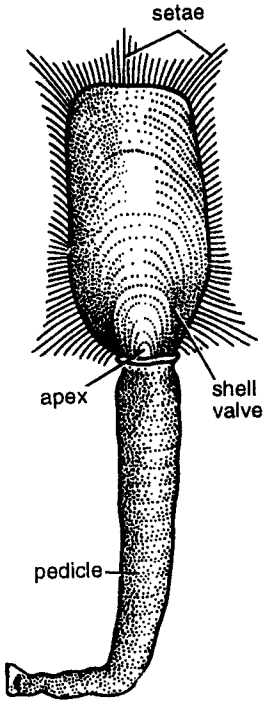


Fig. 211. *Lingula.*

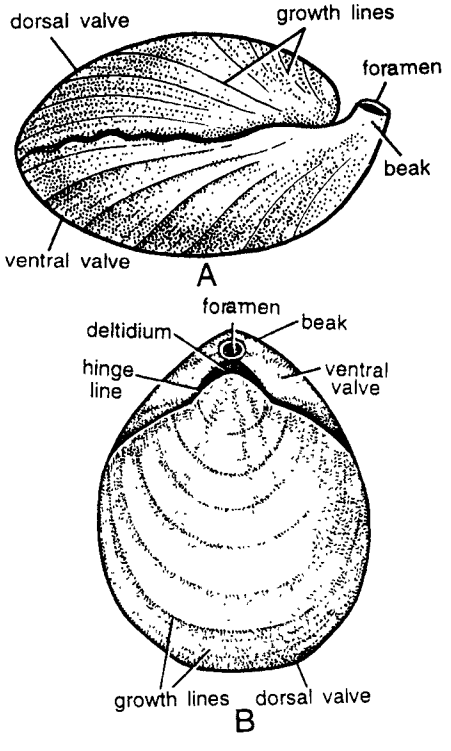


Fig. 212. *Magellania.* **A.** Side view, **B.** Dorsal view.

212. *Magellania*

Classification :

Phylum.....Brachiopoda	→	Lophophore contains coiled arms.
Class.....Articulata	→	Shell valves articulate by hinge.
Genus.....*Magellania*		
Species.....*tenticularia*		

Habit and habitat : ***Magellania*** is exclusively a marine animal, preferably in cool waters and abundantly found in Japan, Southern Australia, the Mediterranean. Arctic and Antarctic. These sedentary forms are never found in colonies.

Comments :

(1) Animal comprises of two unequal pinkish shell valves.
(2) Body is enclosed by unequal bivalve **dorsal** and **ventral shell valves.**
(3) Posteriorly the ventral shell projects as a conical **beak** perforated by an **aperture** through which fleshy **peduncle** extends and attaches permanently to the **bottom** of the sea.
(4) Shell in dorsal view reveals **lines of growth, hinge line, deltidium, foramen, beak** and part of **ventral shell.**
(5) W-shaped **lophophore** between mantle lobes is supported by slimy calcareous shell loop. Lophophore has long ciliated tentacles for the capture of the prey.
(6) Blood vascular system is poorly developed and consists of a dorsal longitudinal vessel within dorsal heart from which vessels radiate to end blindly.
(7) Nephridia lie on either side of the intestine, and they open into coelom by **nephrostome.** Nephridia act as gonoducts.
(8) Nervous system comprises of a gonglionated circum-oesophageal ring from which peripheral nerves arise.
(9) Sexes are separate. The gonadial products are discharged through the excretory ducts (gonoducts).
(10) The larva resembles somewhat to **trochophore.**

Special features : Brachiopods, have long fossil history. They resemble with molluscs but differs from molluscs in having unequal shells and lophophore.

Identification : Since the specimen has beak in ventral shell valve and all above feature, hence it is *Magellania.*

PHYLUM HEMICHORDATA

Natural history

Hemichordates are small soft-bodied creatures, living singly or in group on sandy and muddy sea bottoms or in open water. The body and coelom are divided into three regions with paired gill-slits and nervous tissue in both dorsal and ventral epidermis. Certain tissue as an anterior projection from mouth cavity was formerly interpreted as a **notochord** and thus placing the group with **phylum Chordata.** Recent studies cast doubt on such interpretation and **so-called earlier notochord** is termed the **buccal pouch.** Now this group is placed under **independent phylum Hemichordata.** Between hemichordates and chordates there are resemblances in the pharyngeal gill-slits and the collar cord of the nervous system— its origin form dorsal epidermis. The embryo and early larvae of **hemichordates** and **asteroid echinoderms** are much alike in ciliated bands, digestive tracts, form, derivation of anus from blastopore (deuterostome) and enterocoelous coelom. The above features strongly suggest a common origin.

Classification

Phylum Hemichordata is divided into 2 classes —
Class I Enteropneusta – burrowing animals
Ex. *Balanoglossus, Saccoglossus. Ptychodera.*
Class II Pterobranchia - encased body
Order 1 Rhabdopleurida. Ex. *Rhabdopleura.*
Order 2 Cephalodiscida.
Ex. *Cephaludiscus, Atubaria.*

213. *Balanoglossus*

Classification :

Phylum.....Hemichordata	→	Marine, enterocoelous coelomate. Notochord confined to head region.
Class.....Enteropneusta	→	Several gill-slits, intestine straight, solitary.
Genus.....(i) *Balanoglossus*	→	Acorn worm.
(ii) *Glossobalanus* **(Tongue worm)**		

Geographical distribution : World-wide or cosmopolitan.

Habit and habitat : It is a marine animal, adapted for burrowing life in the sandy bottom. The animal lives inside the U-tubes (tubicolous). Most of them live in shallow water but a few go deeper upto approximately 15,000 feet. They burrow slowly by soft proboscis.

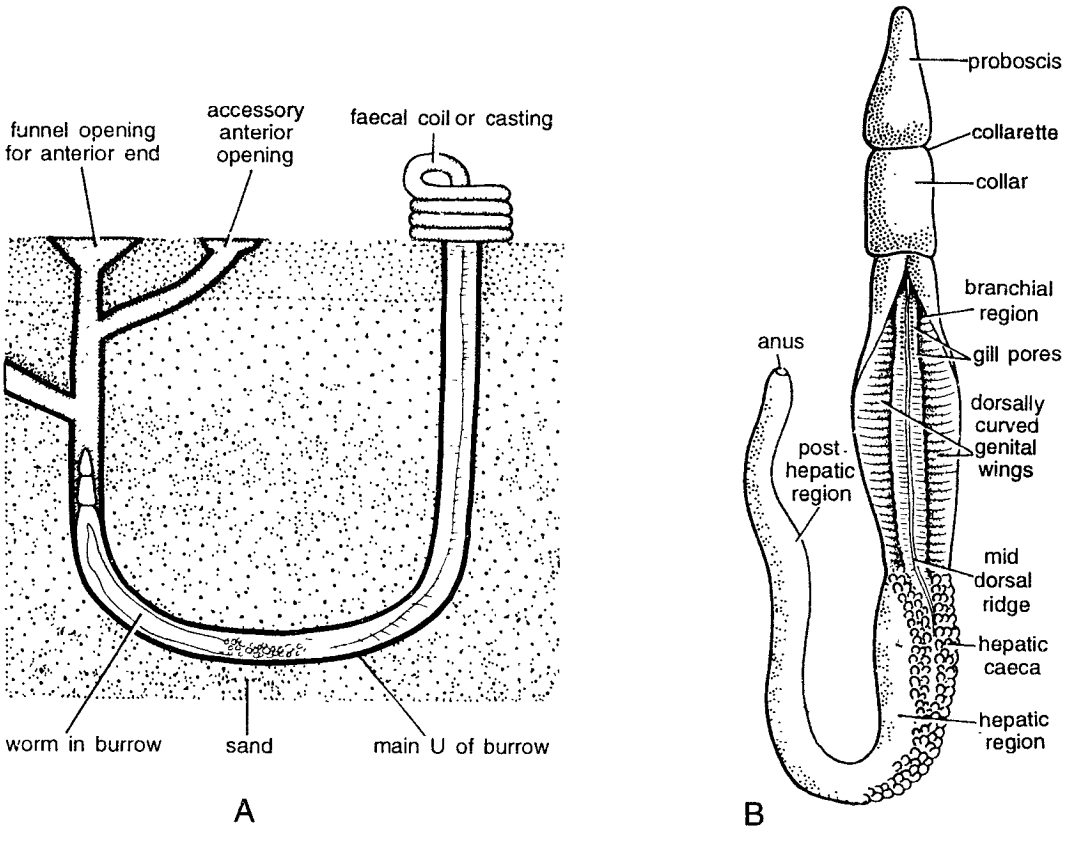


Fig. 213. *Balanoglossus.* **A.** Animal inside the tube, **B.** Entire animal.

Comments :

(1) ***Balanoglossus*** is **commonly** called as '**Acorn worm.**' It lives in a **U-shaped burrow** and at one opening of burrow fecal castings may be seen. U-tube burrow at other end has opening for anterior end and also another additional opening.

(2) It measures 10 cm to 2.5 meters, depending on the species.

(3) It is bilaterally symmetrical, **triploblastic deuterostome** with worm-shaped body divisible into three regions–**anterior proboscis** or **prosoma, middle collar** or **mesosoma** and **posterior trunk** or **metasoma.**

(4) **Proboscis** is conical, **collar** is funnel like, while **trunk** is cylindrical.

(5) Proboscis contains **heart vesicle, central sinus** and **buccal diverticulum**. It has thick muscular body wall and its cavity or coelom opens to the exterior by the proboscis pore.

(6) **Collar** contains the **mouth** and **collar coelom** which opens by a pair of collar pores on dorsal surface.

(7) Trunk region contains most of the internal organs, such as **pharynx, gonads** or **hepatic region. Pharynx** and **gonads** constitute **branchio-genital region**. Posteriormost part is **abdomen.**

(8) **Branchio-genital region** is composed off : (i) **genital wing having gonad** (ii) **branchial region containing paired gills** and (iii) **hepatic region having hepatic caecae.**

(9) Alimentation is complete and circulatory system usually contains **contractile sac of heart.**

(10) Sexual dimorphism. **Fertilization external** and development includes **tornaria larva**. It possesses power of regeneration.

Special features : ***Balanoglossus*** and allied forms have phylogenetic importance. Certain tissue in the form of anterior projection from the mouth cavity was formerly interpreted as a **notochord** and thus placing this group within the Phylum **Chordata**. Recent studies show such structure mainly as **buccal**

pouch and now the hemichordates are not included with the chordates but as separate phylum **Hemichordata**. It shows affinities with (i) Chordates (Bateson, 1885), (ii) Echinoderms (Metshinkoff, 1869), and (iii) Annelida (Spangel, 1893). Gill-slits, nerve cord and the so-called notochord are identical with chordates. Hyman (1959) objected its so-called notochord. Blastopore, ciliated bands and enterocoelus coelom are common features both in Hemichordates and Echinoderms. It resembles with Annelids also in having segmented body. It may be concluded that invertebrate features out weigh the chordate features and Pience hemichordates are included in invertebrates but under separate Phylum **Himichordata**.

Identification : Since the specimen contains short proboscis and all above features hence, it is ***Balanoglossus***.

214. *Saccoglossus*

Classification : Same as that of ***Balanoglossus***.

Genus.....*Saccoglossus*

Geographical distribution : It is found in New Zealand, Australia, Indopacific and Atlantic coasts and North America.

Habit and habitat : It is marine, burrowing and tubicolous animal. These burrow in sand flats near low tide, line, living in semipermanent tunnels lined with mucous secretions. The mouth, which apparently cannot be closed, lies ventrally between the proboscis and collar. As the worm burrows much of the sand is swallowed.

Comments :

(1) It is vermiform hemichordate.
(2) Body regionated into proboscis **(prosoma)** collar **(mesosoma)** and trunk **(metasoma)**.
(3) **Proboscis** is exceptionally longer than any other enteropneust.
(4) **Collar** slightly overhangs the beginning of trunk, covering three of **four gill-slits**.
(5) **Trunk** is differentiated into three regions. In the **anterior part** numerous pairs of gill-slits open externally near the middorsal line. **Middle part** has gonads which are grey in female and yellow in male. **Posterior region** has only posterior part of intestine and tapers gradually to anus.
(6) **Hepatic sacculations** and genital ridges. So well developed in ***Balanoglossus***, are absent.

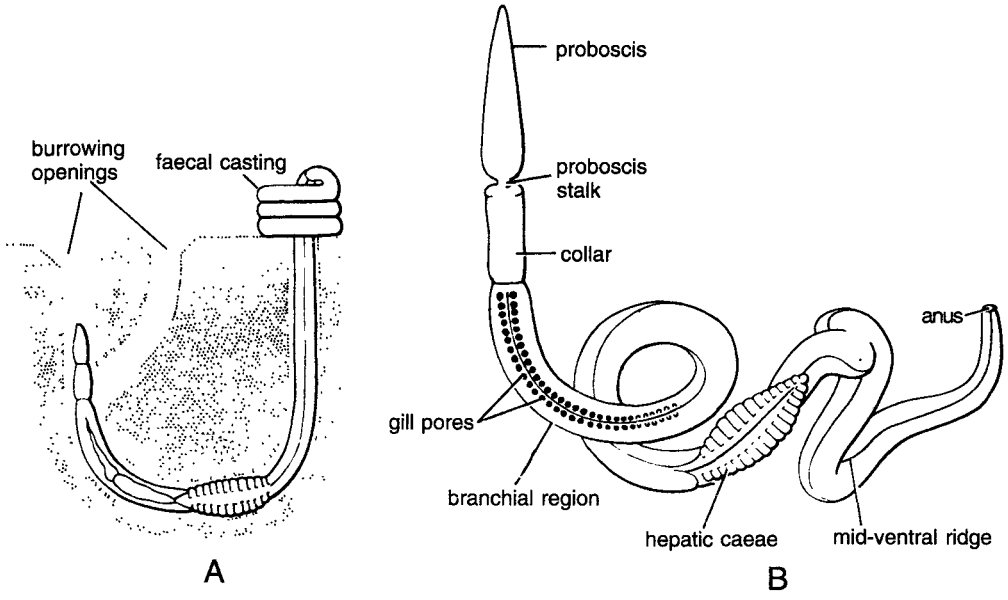


Fig. 214. *Saccoglossus.* **A.** Worm in its burrow, **B.** Entire animal out side its burrow.

(7) Synapticulae are absent in pharynx and such tongue bars hang freely in gill-slits.
(8) Its affinities etc., are similar to those of ***Balanoglossus***.

Identification : Since the specimen has long proboscis and all above features, hence it is ***Saccoglossus***.

215. *Rhabdopleura*

Classification :

Phylum.....Hemichordata	→	Marine, enterocoelous. Notochord confined to head region.
Class.....Pterobranchia	→	Small hemichordates with encased body. U-shaped intestine.
Order.....Rhabdopleurida	→	Colonial, no gil-slits; 1 gonad.
Genus.....*Rhabdopleura*		

Geographical distribution : It is mainly found in southern hemisphere especially resported from Norway and Ireland coasts.

Habit and habitat : It is a marine and colonial hemichordate, found 5 to 6 meters deep. The colony is formed on hard substratum and also in association with mollusc shells, bryozoans and tunicates.

Comments :

(1) Colony consists of **zooids** enclosed into **erect** tubes which are much more elongated than zooids.
(2) Colony contains erect coenoecium extended **zooids**, contractile stalk, decumbent **coenoecium**, retracted zooids, **pectocaulus** and young buds.
(3) Each zooid is composed of **stalk, trunk sac, oral lamella, pigment stripe, cephalic shield, arms** and **tentacles.**
(4) There is a **lophophore** with one pair of arms, one gonad, but without gill-slits.
(5) Alimentary canal is U-shaped.
(6) Most of the zooids are sterile, but male and female specimens may be observe.
(7) Sexes united. Development includes a free-swimming larva.
(8) Zooids are formed by budding, but the buds do not break off from the stolon and remain permanently attached to form a colony.

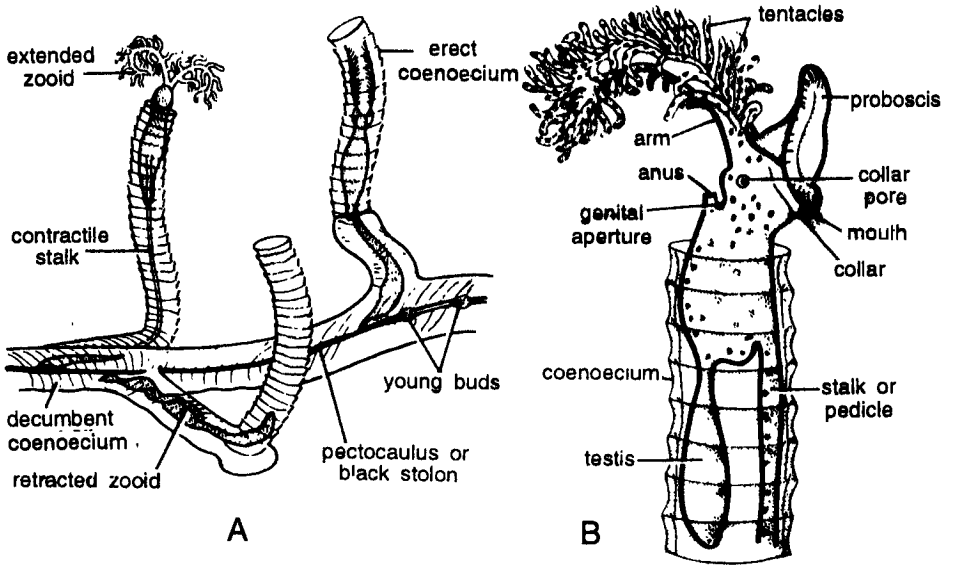


Fig. 215. *Rhabdopleura.* **A.** Part of colony, **B.** Magnified zooid.

Special features : ***Rhabdopleura*** is a colonial hemichordate with organic continuity between individuals that are produced by a sexual budding from one individual.

Identification : Since the specimen contains extended zooids and all above features, hence it is ***Rhabdopleura***.

216. *Cephalodiscus*

Classification :

Phylum.....Hemichordata	→	Marine enterocoelus coelocomate, Notochord confined to head region.
Class.....Pterobranchia	→	Small hemichordates with encased body. U-shaped intestine.
Order.....Cephalodiscida	→	Solitary or colonial, 2 gill slits, 2 gonads.
Genus.....*Cephalodiscus*		

Geographical distribution : ***Cephalodiscus*** is found in antarctic and sub-antarctic region and restricted to archibenthal and sub-littoral zones. It has been reported from India, Japan, Sweden, Borneo, Malayasia, Archipelago and Pacific Ocean.

Habit and habitat : It is a marine colonial animal, found at a depth of 50 to 60 meters. The animal was first discovered by Challanger (1876) at a depth of approximately 245 fathoms in Magellan Strait. Antarctic and Indian oceans have abundant number of this animal.

Comments :

(1) Colony of ***Cephalodiscus*** is composed of several unconnected animals, or zooids, which are enclosed in a common case known as **coenoecium**.

(2) Zooids have no organic connections with each other, but they can move freely in the chambers.

(3) Zooids are microscopic and differentiated into **protosome** or **cephalic shield**, **mesosome** or **collar** and **trunk**.

(4) **Protosome** or **proboscis** is flexible and contains **heart**, **buccal diverticulum** and the **central sinus**.

(5) Protosome is shield-shaped and continuous with collar, which bears two groups of bilaterally arranged **arms** which contain **tentacles**.

(6) Trunk is divided into anterior sacciform part, containing alimentation and genital organs, and posterior slender adhesive stalk. Anus is present ventrally.

(7) Digestive tube is U-shaped.

(8) Breeding seasonal, sexes are separate.

(9) A sexual reproduction takes place by the budding of the stolon. New individuals detach for free existence but maintaining colonial relationship.

Special features : Zooids or individuals separate but aggregated into a common housing.

Identification : Since the specimen has coenoecium and all above features, hence, it is ***Cephalodiscus***.

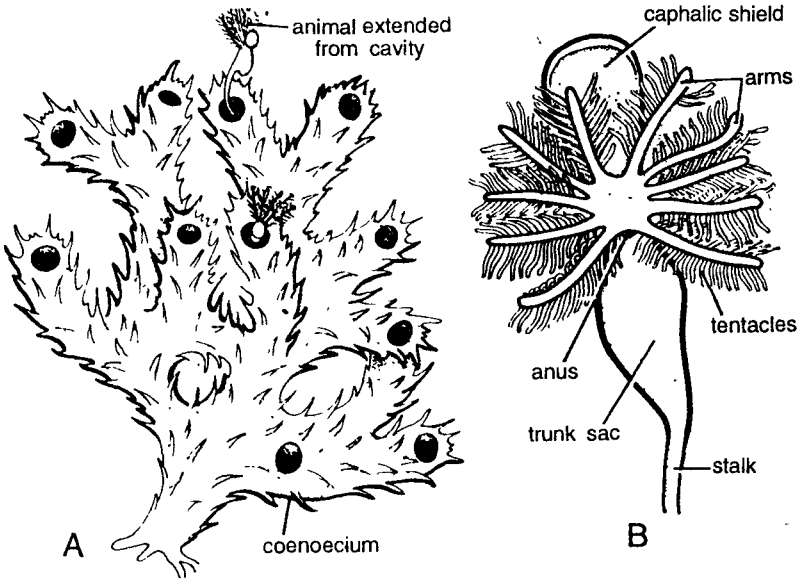


Fig. 216. *Cephalodiscus.* **A.** Part of colony, **B.** One zooid magnified.

Microscope and its Practical Use

3

Without microscopes there could be no study of Cytology, Histology and Histochemistry. Beginning from light (optical) microscope, development of microscopy has taken along three types to increase our knowledge : (i) use of light for microscopes, (ii) use of electrons instead of light as the agent for microscopic vision, and (iii) use of X-rays to examine microscopic details. The following description deals with the evolution of microscopes.

History of Simple Microscopes

1000— **Alhazan**, an Arabian physicist, used a segment of a glass as a magnifier.

1276— **Roger Bacon** referred to convergent lenses being used as a simple microscope.

1610— **Galileo** examined insects with a simple magnifying glass.

1673, 1683 — **Antony van Leeuwenhoek**, a Dutch linen weaver, made a simple microscope, with minute phono-convex and biconvex lenses, magnifying 30 to 200 diameters. In 1683, he observed bacteria, sperms and protozoans in his simple microscope and communicated his findings to the Royal Society of England.

1738, 1908 — **Lieberkuhn, Wollaston, Coddington, Paul Mayer** and **Henker** and **von Rohr** worked and improved simple microscopes.

History of Compound Microscopes

1590— **Hons** and **Zacharias Janssen**, Dutch spectacle makers, combined two simple microscopes to form a compound microscope.

1610— **Galileo** constructed a compound microscope.

1611— **Kepler** combined a convex objective with a convex ocular.

1621— **Willebrod Snellius** found an oblique light passing through two transparent media is not only refracted but the relationship between the sine of angle of incidence and the sine of angle of refraction is constant.

1625— **Giovanni** coined the term microscope.

1665— **Robert Hooks** made compound microscope.

1666— **Sir Isaac Newton** broke up white light into component colours with a prism.

1667— **Cherubin d'Orleans** designed first binocular microscope.

1672, 1704— **Newton** formulated *Corpuscular Theory of Light.*

1738— **Lieberkuhn** introduced solar microscope and also made colour corrections to microscope lenses, the first tendency toward **achromatism.**

1800— **Thomas Young** corrected lenses for **astigmatism.**

1851— **Riddell, J.L.** designed binocular microscope for all powers.

1873— **Ernst Abbe** designed a chromatic sub-stage condenser. In 1877, he formulated his theory of microscopic vision.

1886— **E. Abbe Schott** and **Carl Zeiss** perfected a complete series of **Apochromatic objectives,** one of the greatest achievements in microscopy. The combination of mineral fluorite with new types of optical glass had produced lenses which gave superb images practically free from residual colours. A series of eyepieces of compensating type were computed to compensate for the chromatic difference in magnifying power purposely left uncorrected in the **apochromatic** objectives. With Abbe's apochromats **photomicrography** was also started.

1897, 1901— **Sir J.J. Thomson** discovered electron. **H. Siedentopt** and **R. Zsigmondy** devised **ultra-microscope** of the **Tyndall** effect.

1927— **C.J. Davisson** and **L.H. Germer** described electron diffraction, proving that electrons travel in a wave motion and behave like light waves.

1932— **M. Knoll** and **E. Ruska** constructed first magnetic **electron microscope.**

1932— **F. Zernike** of Holland discovered phase principle and advanced its use to compound microscope for unstained objects.

1948, 1953— **Kirkpatrick** built X-ray microscope. **Professor Zernike** was awarded the Nobel Prize in Physics for his development of the phase contrast microscope.

Hostory of Light Microscopes

In the light microscopy the most important components are the lenses because resolution of the microscope is dependent upon their quality. The power of resolution also depends upon the wavelength (I) and the numerical aperture (NA) of the objective lens. More specifically the limit of resolution is dependent upon the ability of the lens system to collect light and the wavelength of the light utilized. The limit of resolution is determined according to the following relationship :

$$\lambda \text{ (lambda)} = \frac{0.61A}{NA}$$

The value 0.61 is a constant representing the minimum detectable difference in contrast and 1 in the wavelength of light. At 4000 Å wavelength the limit of resolution of light microscope does not exceed 0.17 microns with 1.4 NA. The numerical aperture is : NA = h. Sin a.h. is the refractive index of the medium and sin a the sine of the semiangle of aperture. The limit of resolution is inversely proportional to the resolving power. The higher resolution power will carry smaller limit of resolution. Since sin a cannot exceed 1, the resolution index of several optical materials will not exceed 1.6. The maximum NA of lenses using oil immersion is about 1.4. From the above formula it is easy to calculate that the limit of the light microscope cannot exceed 17000 Å using monochromatic violet light of 1 = 4000 Å and with white light the resolving power is about 2500 Å. Since in above formula the NA is limited, it is obvious that only way to increase the resolution is to reduce the limit of resolution. This idea leads to discovery of phase contrast and electron microscope.

1. Simple Microscope

The simple microscope may consist of combination of 1 to 3 lenses of varying degrees.

Kind of simple microscope

In ascending order of **corrections** and **preferences,** the types are as follows :

1. The double convex lens : Uncorrected. Single, double or triple combinations to magnify 2x, 10x. They are cheap combinations. ***Utility***—It is commonly used by layman and artisan as pocket magnifier or as watchmaker's loupses. **Single low power lenses** like round or rectangular reading glasses, with black rim are used for examination of negatives, contact plates with fine detail, crystallized mineral, botanical and zoological specimens, bacterial colonies, etc.

For best result and for persons with normal eyesight, the lens should be kept approximately 15 cm away from the specimen and the eyes 6.5 cm above the reading glass.

2. The double magnifier : It consists of two separated plano-convex lenses and by placing convex surfaces so that they face one another. The distortion and colour errors are reduced and it becomes partially corrected lens.

3. The triple aplanat : Three lenses cemented together by balsam-one convex and two flint lenses. It is useful where compound microscope is not available.

4. Dissecting microscope : This microscope is composed of basal foot, short limb fitted with a screw for focusing, rectangular or squarish glass stage and a reflecting mirror fitted below the stage for adjustment of light.

Magnification

A 10x lens will furnish an image ten times the diameter of the object as it naturally appears when held at 25 cm from the eye.

Correct handling

The correct way to use a simple microscope is to place the eye close to one side of the lens and then bring the specimen near to the opposite side of the magnifier until the image is in sharp focus.

2. Compound Microscope

The compound microscope is a combination of two simple microscopes, the objective (the lens closer to object) and the eyepiece (the lens closer to eye). The initial magnification of the objective multiplied by the magnification of the eyepiece gives the total magnification in diameters if the draw tube is set at standard mechanical tube length of 160 to 170 mm.

Various adjustments of compound microscope

The modern microscope has attained great mechanical efficiency due to the following reasons :

Optical bench system : The limb of the stand consists of a single piece with body tube slide at the upper end and the sub-stage slide at the lower end, so that all optical parts above and below the stage are in accurate alignment for the life of instrument.

The microscope is streamlined. Body of the microscope is inclined.

There is provision for rapid interchange of sub-stage condensers for light and dark fields.

Parts of compound microscope

The compound microscope consists of the following parts :

1. Body tube : It carries the objective or the revolving nosepiece at lower end and the eyepiece at the upper end of draw-tube. The objective may be 1x, 10x, 40x and 90x, while eyepieces are generally 5x, 6x, 8x, 10x, 12x, 15x and 20x. The body tube may be of the following kinds :

(1) The straight monocular body tube.
(2) The inclined monocular body tube.
(3) The straight binocular body tube.
(4) The inclined binocular body tube.
(5) Quadruple revolving inclined tubes.

2. Foot of microscope : The foot supports the limb and rests on the table. The foot is of two kinds :

(a) The tripod foot **:** This design combines stability with minimum weight. The inclination joint is above the stage; therefore, centre of gravity of the microscope is high, thus making the instrument very steady.

(b) The horse-shoe foot **:** It is unscientific but suitable for stands without tilting axis. The centre of gravity is low because the inclination joint is below the stage.

3. The stage .: The stage is squarish or rectangular with 10 to 12 cm sides attached to the limb by means of a broad rigid fork or bracket. It is made up of metal or metal covered with hard rubber or bakelite with finely finished surface. The stage is fitted with spring clips or sliding bar. The stage may be fixed or rotating circular stage with centering screws. Generally fixed stage is used in student compound microscope.

4. The sub-stage : The sub-stage is directly attached to the lower end of the limb. The laboratory and student microscopes are furnished with coarse adjustments by rack and pinion. The sub-stage is meant for allowing the accurate

focusing of the condenser and to supply precise means of quickly centering any light or dark field condenser to the optic axis of the microscope.

5. Coarse adjustment : The coarse adjustment is a paramount for the rapid and precise focusing of the object. The adjustment has a large head. Turning the pinion heads in a clockwise direction moves the body tube downwards, while turning anti-clockwise moves the body tube upwards.

6. The fine adjustment : The mechanism of fine adjustment is contained in the limb on either side in the form of horizontal buttons parallel to the coarse adjustment heads. It is graduated and can be moved up and down. The fine adjustment is very essential for a perfect image of the object. Only a fractional revolution of fine adjustment is needed as the coarse adjustment sharply focuses all the objects.

7. Mirror : The concave mirror is fitted below the stage at some distance to reflect the light rays into the sub-stage condenser.

Care of the microscope

(1) Microscope should be kept covered when not in use. A cellulose or plastic cover is preferred for laboratory.
(2) All the parts of the microscope should be cleaned.
(3) Lens paper or muslin cloth is used to clean the lenses, eyepieces and objectives.
(4) Do not move coarse adjustment when slide is observed in high magnification.

3. Reverse Type of Research Microscope

In 1929, Bausch and Lomb introduced radical changes in the designing of the microscope by reversing the position of the limb, so that it is away from the microscopist, with clear access to the objectives, the specimen, the mechanical stage adjustments and sub-stage provided to give greater convenience and comfort during prolonged observations. The following reverse microscopes are in use :

(1) Bausch & Lomb Research microscope.
(2) Spencer Research microscope with binocular body of variable inclination.
(3) E. Leitz Ortholux Research microscope with all mechanical adjustments low and close together with light source within.

4. Binocular Microscope

The binocular microscopes were designed very early. They are of two main types.

1. The mono-objective binocular microscope is very less in use.

2. The Greenough wide field stereoscopic binocular microscope has the following features :

(1) Upper limit of magnification 100x.
(2) Numerical aperture of objectives approximately 0.1.
(3) Long working distance, erect image and full stereoscopic relief.

The low power binocular dissecting microscope was designed by Greenough in 1897. The instrument consists of a combination of two separate and converging microscopes mounted equidistant from the vertical so as to include an angle of 15° to 16°. The body tubes contain matched objectives and eyepieces which are focused simultaneously on the same area of object, each eye viewing the field from different angle. Porro prisms are mounted between each objective and eyepiece so that the image is erect. These features provide a unique instrument, which helps low power studies of several objects, illuminated by reflected light, the various parts and layers being revealed in beautiful and deep stereoscopic relief. The natural non-reversed image and the third dimensional effect are advantages which make the Greenough binocular microscope invaluable and practically essential for dissecting and fine mounting under the microscope.

Various kinds of the above microscopes are :

(1) American optical Spencer cycloptic stereoscopic microscope for incident light and transillumination. The objectives are built in and the optics coated.
(2) American optical Spencer low power binocular microscope with a revolving nosepiece.
(3) Bausch & Lomb low power binocular microscope fitted with a sliding objective change and a fluorescent tube light source.
(4) Reichart wide field binocular microscope with a revolving drum nosepiece. The stage may be lowered and clamped.

(5) Carl Zeiss, Jena, wide field binocular microscope with built-in-objective lenses and attached light source.

5. Low Power Dark-field Binocular Microscope for Differential Colour Illuminations

Any low power binocular microscope can be easily converted into dark-field binocular with a low power condenser and stops for dark-field and differential colour illuminations. The simple requirements are as follows :

1. Sliding sleeve : The mounted bottom lens of an Abbe condenser in a sliding sleeve. The sliding sleeve is affixed to a circular aperture cut in the centre of a duplicate plate, the whole slipping underneath the regular glass stage and adjustments made so that when the plate is pushed in as far as it will go, the condenser is central to the optical axis.

2. Black patch stop : 17 mm diameter : Rheinberg colour stops, 18 mm diameter, rings to fit stop carrier with clear opening of 17 mm. Best colours for differential colour illumination are blue-green (wratten 45, H) and blue violet (49, C) for central stop and yellow (wratten 9, K_3) and green (58, B) for the rings.

3. The regular lamp : The lamp condenser should be adjusted for parallel light, the ground glass inserted in the light beam and the sub-stage condenser moved nearer or farther away from the object until the field of view is brilliantly and evenly illuminated.

Dark field and differential colour illumination combined with the third dimensional and wide field advantages of the low power binocular give exceedingly beautiful results with a wide variety of specimens including :

(1) Living organisms in water.
(2) Unstained organisms mounted in fluid (Polyzoa, fish parasites, brine shrimps, etc.).
(3) Stained organisms in resinous media.
(4) Diatoms *in situ* on algae mounted in clarite or balsam.
(5) Polycistina and Radiolaria inclusions in amber and minerals.
(6) Coloured rock sections.
(7) Animal or plant mineral analysis (incineration process).
(8) Mineral and chemical crystals, etc.

Applications of low power wide field binocular microscope

(1) Preliminary examination of all known and unknown materials and segregating the same.
(2) Fine dissecting and the selective mounting of specimens.
(3) Examination of paraffin ribbons for damaged sections, etc.
(4) Low power fluorescence microscopy.
(5) Entire small embryological specimens.
(6) Histology, botany, palaeontology, minerology.
(7) Dermatology-skin.
(8) Bacterial colonies.
(9) Insect identification.
(10) Plant pathology.
(11) Rock sections, etc.

6. Comparison Microscope

The comparison microscopes are of utmost importance to **criminologists**. Both known and unknown specimens are compared in the cleft and right halves of one field of view and the two images photographed simultaneously. The bullet comparison microscope has played a very important role in crime detection, used in law courts.

Standard comparison microscope consists of :

1. Two identical microscopes of similar make and model : The stands are aligned side by side with the optic axes 150 to 160 mm.

2. Paired objectives : 10x, 40x and oil immersion lens.

3. Paired eye-pieces.

4. Comparison eye-piece : This special eye-piece connects the two microscopes clamping around each draw tube. The housing contains an arrangement of prisms, whereby half of the left microscope field and half of the right microscope field are brought together to the left and right respectively.

5. Sub-stage condensers, stages for specimens, lamps and transmitted lights (Mazda bulbs) are also needed.

Bullet comparison microscope

Extremely useful in the field of **Forensic Ballistics**. A specially designed comparison microscope with rotating bullet holders made it possible for the first time to prove conclusively whether a particular bullet had passed through the barrel of a suspected gun.

Application of the comparison microscope

1. **Criminology** : (1) Matching of lands and grooves in the bullet.
(2) Marks made by a suspected knife or tool compared with marks on a wood or metal surface.
(3) Examinations and photography of suspected documents for overwritings, inter lineations, erasures and other changes, detection of forgeries.
(4) Comparisons of handwriting, typewriting, inks and colours.
(5) Comparisons of blood cells, hairs and crystals.
2. **Academic** : (1) Comparison of known and unknown insects.
(2) Comparison of drugs, starches and crystals.
(3) Comparison of small organisms, stained tissues and pathological tissues.

7. Slit, Immersion and Reflecting Ultramicroscope

An ultramicroscope comprises of an illuminating dark field optical system designed to examine, count and indirectly measure colloidal particles from 100 to 10 millimicrons diameter, which are not visible with standard optics and transmitted light. It is **used** to measure **colloidal particles.**

The students must have become familiar with the construction of common light microscopes like simple and compound. Most of the slides can be studied under these microscopes. From Echinodermata upto Mammalia, animals are not microscopic, whereas, from Arthropoda down to Protozoa, most of the animals are microscopic besides virus, prokaryotic and eukaryotic cells. We require, physical instruments to study histology, cytology, submicroscopic morphology, ultrastructure and molecular biology. Common dimensions to measure the biological structures at different levels include centimeter, millimeter, microns and angstroms (Å). Most of the molecular and atomic structures are less than 10Å. There has been continuous improvement in the **light microscopy** leading to **electron microscopy** because it is the latter which has ultimately **resolved** the biological structures at atomic and molecular level.

Besides making themselves familiar with limits and dimensions in biology, students must know laws and principles on which light and electron microscopy are based.

8. Phase-contrast and Interference Microscopy

The material under examination is processed in a specific manner to produce necessary contrast in conventional light microscope. The eye differentiates colour or variations in wavelength and also in intensity of visible light. Phase contrast and interference microscopy is based on the fact that biological structures are highly transparent to visible light causing phase changes in transmitted radiations. If the refractive index of the material is higher than that of the medium, there is a delay or **retardation** called as **phase change**.

Zernike developed phase contrast microscope. In this microscope the most lateral light passing through the objective is retarded by 1/4 wavelength with respect to median light passing the object. One annular phase plate which introduces the above wavelength variation is fixed in the back focal plane of the objective besides one annular diaphragm in the sub-stage condenser. The phase plate comprises of a transparent disk having annular groove or raised area to coincide with the direct image of the sub-stage condenser. The phase-effect is due to the interference between the direct geometric image of the central part of the objective and the lateral diffracted image. In **bright** or **negative contrast** two sets of rays are added and the object becomes brighter than the surroundings. In **dark** or **positive contrast** two sets of rays are subtracted making the image of the object darker than the surroundings. The minute phase changes within the object are amplified and translated into changes of amplitude.

The observation of the living cells has been greatly facilitated by the development of phase contrast microscope. It is especially useful for observing cells cultured *in vivo*. Extraordinary

cytological details like events during cell division, cell movement, mitochondrial flow, pinocytosis, cell inclusions, membrane formation and fibrillar expansions can be easily recorded by phase contrast microscope using time-lapse motion pictures.

The interference microscope is based on the same principle as the phase contrast microscope but it has wider applications and gives quantitative data.

9. Electron Microscope

Electron microscope totally modernised the concept of structure at cellular and molecular level and now instead of structure it is **ultrastructure** which has become most fashionable study. It is electron microscope through which human eye can see and measure the ultramicroscopic particles. Its resolving power is much greater than that of the light microscope. In this microscope streams of electrons are deflected by an electrostatic or electromagnetic field in the same way that a beam of light is refracted through lens.

In order to increase the **contrast** produced by **electron scattering** and to prevent damage to the tissues, the material to be studied is **fixed** in osmium tetraoxide and formaldehyde. Other fixatives are freeze-drying in a vacuum, potassium permanganate and glutaraldehyde. After fixation, the specimen is embedded in a plastic material such as methacrylate or in resin (Araldite), and ultrathin sections are cut on a specially designed microtome with glass or diamond knives. The ultrathin section is placed on a very thin 150Å membrane made from colloidion (nitrocellulose), fermvar (polyvinyl fermol), carbon, aluminium or beryllium. The membrane supported by fine-mesh steel or copper grid is placed in the electron microscope for observations.

The body of the electron microscope is very complex. Since the electrons travel long distances in a vacuum the instrument must be completely enclosed in a vacuum. The source of **electrons** is a cathode filament. By means of a magnetic coil acting as a **condenser**, electrons are focused in the plane of the object and then deflected by another magnetic coil acting as **objective lens** to magnify image of the object. The magnified image is received by a third **magnetic lens** which acts as an ocular or projection lens again magnifying image from the objective. The final image could be seen on a fluorescent screen recorded on a photographic plate.

The mechanism of image formation the light and electron microscopes differ. In the former image formation depends mainly on the degree of light absorption in different zones of the object, while in the latter, it is due to electron scattering. The electrons collide against atomic nuclei in the object, and are dispersed. They fall outside the aperture of the objective lens. The image on the fluorescent screen results from the absence of those electrons blocked by the aperture. Electron scattering depends on the thickness, molecular packing and atomic number of the object. The higher atomic number results in greater dispersion. The **wavelength** of a stream of electrons is due to the acceleration voltage. It can be calculated by De Broglie formula :

$$\lambda = \frac{12.2}{\sqrt{v}} \text{Å}$$

where v = 50,000 volts and λ = 0.0535A. In the electron microscope the resolution is so high that the image from the objective can be greatly enlarged. For instance, initial magnification of 100x objective, the image can be resolved to 200x and with projector coil to 20,000x. Through intermediate lens, 1,60,000x magnification may be attained and the micrographs may be enlarged to 1,000,000x or more photographically. Thus such high magnification completely **resolves the biological ultrastructures.**

4 General Method of Microscopic Preparations

Experimental studies, of morphological, histological and physiological aspects of animals, come under the domain of Practical Zoology. For undergraduate students of Indian Universities, the practical work pertaining to Zoology includes :

(1) Microscopic preparations of slides.
(2) Mountings.
(3) Culture of animals.
(4) Study of prepared slides.
(5) Museum specimens.
(6) Dissections.
(7) Cytology.
(8) Ecology.
(9) Physiology and biochemistry.

The larger specimens such as **prawn**, **pila** and **cockroach** are preserved in preservatives like formalin or alcohol for the study of their external features and they do not need any elaborate process. But for the study of microorganisms, smaller animals and histological studies of tissues, an elaborate technique is employed for making their permanent preparations. These smaller objects are mounted in balsam on a slide. There is a series of processes by which a living organism or its tissue is made fit for microscopic examination in a permanent state. The utility of permanent preparation is that the animal cell or tissue remains as such without undergoing major changes. The permanent preparation includes:

(1) **Killing and narcotization.**
(2) **Fixing.**
(3) **Washing.**
(4) **Staining.**
(5) **De-staining or removal of excess of stain.**
(6) **Dehydration or removal of water.**
(7) **Clearing or de-alcoholization.**
(8) **Mounting on slide.**

1. Killing and Narcotization

The first step in permanent preparation is killing instantaneously in order to prevent the change in form of the object as it had in living condition and immediately fixing the object.

Sometimes killing is preceded by **narcotization**. The narcotics used are chloroform, menthol, ether, alcohol, acetone, etc. The purpose of narcotization and killing is important as to have the same form and chemically constructed tissue or organisms as it had during its lifetime. In certain cases, for smaller animals, killing is heating done by the slide.

2. Fixing

Fixing is done with various fixative agents for histological elements. Fixative is essential in every type of microscopic preparations, either for sections or for whole mounts and also in larger specimens. The function of fixation is manifold :

(1) The tissues become hard and hardening resists further post-mortem changes.
(2) Fixative agent coagulates and renders insoluble elements of tissues which are dissolved in further processing.
(3) The fixative agent renders insoluble the various constituent elements of cells, alters their refractive indices and thus makes them optically differentiated under the microscope. Because of Brownian motion there is no possibility of seeing the finest cellular structures in unfixed material but we must bear in mind that fixed details are the coagulation artifact of the living structures.

Various fixative agents generally used are absolute alcohol, 90% alcohol plus glycerine, picric acid, corrosive sublimate, formol, osmium tetraoxide and nitric acid with or without water. Depending upon the material, corrosive sublimate or alcohol (100% or 90%) is recommended for whole mounts, Carnoy's fluid for cytological studies and other fixatives for histochemical studies.

3. Washing

Washing is essential as by this process the uncombined and excess of fixative agent is removed. The presence of fixative agent in tissues or cells will inhibit good staining. The washing agent depends upon the type of fixative agent used. As alcoholic picric acid in water is removed by 70% alcohol. Formol and corrosive sublimate are washed with water distillate. Sublimate is washed in alcohol.

4. Staining

The tissues or cell components are stained in various dyes. The dye makes the tissues distinct in its histological sphere. The various dyes are **Orange G. Bordeaux red, Sudan's Congo red, Alizarine oxyquinoine, methylene blue, neutral red, borax carmine, haematoxyline, picro-indigo carmine, eosin and Gower's carmine.** Mainly two kinds of stains are used :

(1) **Nuclear stains.** Stain the nuclear parts of the cells, such as Delafield's or Erhlich's haematoxylin.
(2) **Cytoplasmic stains** such as borax carmine, picro-indigo carmine, Gower's carmine and eosin, etc., which stain cytoplasm.

For general staining borax carmine is used. Aqueous stains are prepared in water whereas alcoholic stains are prepared in alcohol. When a single stain is used the process is called as **simple** or **single staining**. In some cases two stains, i.e., nuclear and cytoplasmic are used and this is called as **double staining.** Generally single stain is used for whole mounts but for protozoans etc., both cytoplasmic and nuclear stains are used. For cytological and histochemical studies different stains used will be discussed in vertebrate practical book.

5. Destaining

The removal of excess of stain is called as **destaining** or **differentiation**. De-staining agents are acid alcohol or acid water. The acid alcohol is used with alcoholic stains while acid water is used with aqueous stains.

6. Dehydration

This process is meant for removal of water from the tissues. The dehydration prevents putrefaction or decaying and maintains the same shape and size of tissues or cells. The moisture or water in tissues absorbs various germs of destructive nature so that the tissue may be destroyed, hence the necessity of dehydration. Dehydration is done by passing the mounting material through various grades of alcohol, such as 30, 50, 70, 90 and 100% alcohols. The tissue is soaked in gradually increasing strengths of alcohol. The lower grades of alcohol, such as 30, 50 and 70% alcohols, are prepared either from 90% or absolute alcohol. The dehydration is carried out in corked or glass-stoppered tubes.

7. De-alcoholization or Clearing

After dehydration, transparency in tissues is obtained by treating with a clearing agent, which removes alcohol and makes the tissue clear and transparent. The clearing agents are cedar wood oil, clove oil, xylol and benzol, etc. Xylol is most commonly employed and it makes the tissues hard and brittle. Clove oil is a superior clearing agent specially in the whole mounts. It also possesses a higher index of refraction than balsam mounting media.

8. Mounting

Mounting forms the end of permanent preparation. The choice of mounting media is not much but they should have the same refractive index as that of the cleared tissue. The refractive index of such a stained, dehydrated and cleared cells in N=1.54. Canada balsam or D.P.X. have almost the same refractive index. Mounting is an easy process. The tissue is kept over glass slide in a drop of balsam and cover-slip is lowered slightly. After mounting, the slide may be kept for drying in a hot chamber. The excess of balsam on the slide, as generally happens with beginners, should be removed with cotton soaked with xylol or 90% alcohol. This should be done when the balsam has dried. For much better finishing the edge of the cover-glass may be ringed with a cement such as gold seal or a varnish. The air bubbles present in balsam under cover-glass should be removed by gentle heating.

During all the chemical bathing of tissues, two changes of each reagent are necessary. The time of keeping tissue in various reagents may vary from 5 to 15 minutes.

9. Precautions and Instructions

(1) The articles, such as slides, coverslips and instruments should be perfectly cleaned.
(2) The working place should be kept in order.
(3) During dehydration, the tissues should be kept in tightly closed cork or glass stoppered tubes. The opened tube will spoil material by absorbing moisture from atmosphere. Even breathing closely with dehydrating tube is undesirable.
(4) The change of solution should be done very quickly, reducing time of exposure to atmosphere to minimum.
(5) The chemicals used once should not be reutilized.
(6) The Canada balsam used should be clean, dust-free and not viscous.

10. Chart for Single Staining

Fix the material
↓
Wash in tap water
↓
Dehydrate with 30% alcohol
↓
50% alcohol
↓
70% alcohol
↓
Stain in borax carmine or
Eosin or Picro-indigo carmine
↓
De-stain in acid alcohol
↓
Wash with 70% alcohol
↓
Dehydrate with 90% alcohol
↓
100% alcohol
↓
De-alcoholize or clear in clove oil or xylol
↓
Mount in Canada balsam D.P.X.
Time : 5-15 minutes in each reagent.

11. Chart for Double Staining

In this nuclear and cytoplasmic stains are used. The former is used first.

Fix the material
↓
Wash in tap water
↓
Stain haematoxylin
↓
De-stain in acid water
↓
Wash in tap water (Bright blue colour in nuclei)
↓
Dehydrate with 30% alcohol
↓
50% alcohol
↓
70% alcohol
↓
Stain in eosin
↓
Wash with 90% alcohol
↓
100% alcohol
↓
Clear or de-alcoholize with xylol or clove oil
↓
Mount in Canada balsam or D.P.X.
Time : 5-15 minutes in each reagent.

Culture Methods

5

The science of culture plays an important role in the biophysical and biochemical studies. Various methods are known of culturing invertebrates in artificial media.

Phylum Protozoa

1. ***Amoeba*** **:** Amongst other species inhabiting soil and sea, ***Amoeba proteus***, a fresh-water form is the largest in size and is cultivated by the following methods :

(a) Collect few ***A. proteus*** and keep them on the bottom of a clean petri dish by a micropipette. Add well or rain water and few grains of wheat, cover the dish and keep at a dark place in a cool room. ***A. proteus*** sticks to wheat grains and after sometime multiplies and gives rise to numerous daughter animals.

(b) Hay infusion **:** This method is applied for soil and freshwater ***Amoeba***. Boil about 12 gm of hay stems in a large flask in 100 cc of distilled water for about 45 minutes. Decant the liquid and add few drops of sodium hydrate to make it alkaline. Sterilize in an autoclave. After cooling pour the liquid into smaller glass-stoppered dishes and inoculate them with 500 mg of any soil of pure ***A. proteus***. After a day or two numerous amoebae will develop.

Alternative method for hay infusion is to boil few grains of wheat (3 to 4) and few hay stems in 100 cc of distilled water for 10 minutes. On cooling inoculate with amoebae which multiply to large numbers.

2. ***Paramecium*** **:** It is abundantly found in the ponds and ditches in decaying vegetation. Boil 20 grains of wheat plus 20 to 25 hay stems in 500 cc of distilled water for about 10 minutes. Keep it in a dark and cool place for about four days and then inoculate it with few paramecia, by a micro-pipette. Within few days the culture contains numerous paramecia.

3. ***Vorticella*** **:** Culture method is the same as in the case of ***Amoeba***.

4. ***Euglena*** **:** It is abundantly found in the ponds, ditches, pools, lakes, puddles or rain water containing decaying nitrogenous matter like urine and faeces of animals.

Boil 25 grains of wheat in distilled water. Cool and add half-pint milk, plug with cotton wool, let the medium stand until rich bacterial scum is formed. Stir and inoculate it with ***Euglena*** by micro-pipette,

and keep it in light window. The culture will contain several ***Euglena*** within few days.

Phylum Porifera

Sea and freshwater sponges may be kept in an aquarium for about a week for study.

Phylum Coelenterata

Of all the coelenterates, ***Hydra***, ***Actinia***, ***Astrangia***, ***Bougainvillia*** and ***Obelia*** are artificially cultivated.

1. ***Hydra*** **:** It is collected from weeds and decaying leaves from ponds, ditches and may be cultured in a large aquarium containing pond mud at bottom ane few water plants, leaves, etc. Small crustaceans and such as ***Daphnia*** or ***Cyclops*** may be added to the aquarium at regular periods.

Phylum Platyhelminthes

Freshwater planarians : Common planarians such as ***Dugesia*** may be collected from ponds and streams by keeping a piece of liver or beef in a jar and placing it in water near stones, etc. Keep planarians in water in clean dishes, where they survive for longer periods. For feeding, pieces of beef may be added twice or thrice a week.

Trematodes and cestodes may be cultured in physiological saline for few days. No well defined method is known so far.

Phylum Annelida

1. ***Nereis*** **:** It can be maintained only for a few days.

2. Earthworms : Earthworms may be cultured for about a fortnight in wooden boxes containing grass cutting filled with moist loamy soil or mud covered with glass sheet.

3. Leeches : They can be kept in aquarium containing water for 1 to 5 years in a cool and shady place. They should be fed twice a year on the blood of mammals or frogs.

Phylum Arthropoda

1. ***Daphnia*** **:** These are easily maintained in an aquarium. ***Daphnia*** are abundantly found in ponds or ditches. They may be collected and kept in an aquarium with constant supply of green algae as food. Yeast also serves as food for ***Daphnia***.

2. ***Gammarus*** **:** It easily lives and breeds in an aquarium containing mud and decaying vegetation.

3. Cockroach : They are well maintained in a wooden cage with dark atmosphere. They feed on bread and flour paste, etc.

Phylum Mollusca

1. Marine molluscs : Only smaller forms may be kept for 4-5 days in sea water at sandy places.

2. ***Pila globosa*** **:** The common apple snail may be cultured and maintained in large aquaria having thick water vegetation or water plants and mud at bottom. The water should be changed after certain interval. Smaller forms such as ***Litmnaea*** may breed and live in aquaria without much care.

Phylum Echinodermata

All echinoderms are marine and only ***Asterias***, ***Echinus*** and ***Ophioderma*** can be maintained in aquaria. They are fed on fish pieces and dead animal tissues.

Preparation of Permanent Stained Slides

6

These pages deal only with the fixing, staining and mounting of smaller animals and whole mounts, while their characters have been dealt within Chapter 7.

Phylum Protozoa

[I] Slowing Protozoa

Except few, many protozoans move very fast. For proper examination, they must be slowed down. This can be done in three ways :

(1) Protozoans are slowed in 10% methyl cellulose solution. Dissolve 10 gm of methyl cellulose in 50 cc of water-boil-cool and make up to 100 cc The solution slows down the movement.

(2) 2% sodium carboxymethyl cellulose solution is also good for slowing down protozoan movement. Boil 2 gms of sodium methyl cellulose-cool.
With either methylcellulose or sodium-methylcellulose make a ring over a slide and add drop of water containing-protozoans. The protozoan's movement is slowed down.

(3) Nickel sulphate acts as an anaesthetic. Keeping protozoan for 15 minutes in this solution restrict their movement.

[II] Examination of protozoans in hanging drop

The best way to examine protozoans is to keep them in drop of water on a coverslip. Invert the coverslip in a cavity slide and seal it with very hot vaseline. Examine under microscope.

[III] Vital staining of protozoans

Certain organelles in protozoans can be seen by vital staining in living protozoans under phase contrast microscope. The vital dyes kill the organisms after sometime. Prepare 0.01% aqueous dye solution (Dissolve 0.01 gm of dye in 100 cc of distilled water). Mix this solution with equal volume of fluid containing protozoans. Examine under above microscope over a slide. Neutral red colours food vacuoles. Janus green B dyes mitochondria. Brilliant cresyel blue colours number of other structures. Sudan black B and sudan IV colours lipids. Indian ink and carmine colours food vacuoles.

[IV] Preparation of blood films for protozoan blood parasites *(Plasmodium, Leishmania)*

The clinical examination of protozoan parasites in blood involves 3 steps :

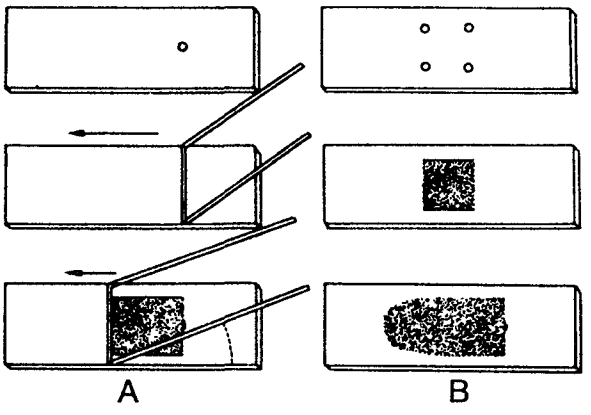


Fig. 1. A. Thin blood film, **B.** Thick blood film.

(1) Preparation of thin and thick blood film.
(2) Staining, and
(3) Microscopic examination.

1. Preparation of blood film : There are two types of films which are being prepared in the laboratory : (i) Thin blood film and (ii) thick blood film.

(a) Thin blood film **:** Wipe the tip of middle finger of the patient with cotton soaked in 90% alcohol. Let the finger tip dry.

With a sterilized surgical needle, prick the pulp of middle finger. The blood comes out.

For making a thin blood film, take a small drop of blood, not longer than a pin's head, on a clean slide, at a distance of about half an inch from its right edge.

Hold another slide by right hand and apply over drop of blood at an angle of 45°. Lower the angle to 30° and push the spreader slide forward as shown in diagram till the blood is exhausted and a thin film is formed.

Thin film is characterized by these points : (i) it is even and uniform, (ii) its margins do not extend up to the edge of slide, and (iii) It contains a single layer of blood cells.

Let the film dry. Label and mark it with glass marking pencil.

(b) Thick blood film **:** Take a clean slide. Take blood from the pulp of the middle finger or suspected patient. Keep a large drop of blood in the middle of slide. Spread its blood with the help of a needle in half an inch area. Let the blood dry

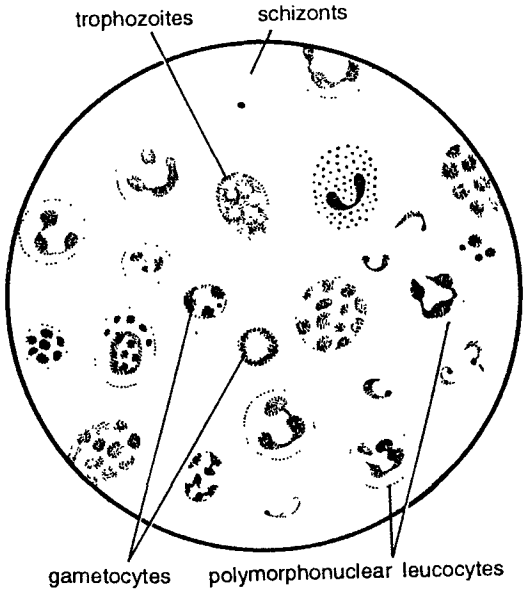


Fig. 2. *Plasmodium vivax* in thick blood film.

in half an hour period at room temperature. Quick drying may be done by placing the slide in an incubator. Dehaemoglobinize the blood film before staining. Dehaemoglobinization is done by flooding the slide with a mixture of glacial acetic acid and tartaric acid. When completely dehaemoglobinized, the film looks greyish instead of reddish. Stain the **thick blood** film (Fig. 1) in **Leishman's stain.**

2. Staining : Keep above prepared slide containing thick or thin blood film over the table.

Pour **Leishman's stain** over the blood film and allow it to remain for 30 seconds.

After 30 seconds wash the slide under tapwater and let the slide become dry. Keep the slide in such a position that excess of stain is drained off and examine it under microscope.

3. Microscopic examination : ***(a) Malarial parasite*** **:** Blood of malaria patient should be taken after 2 or 3 days of high temperature and chill in case of ***P. vivax, P. malariae*** and ***P. ovale,*** stages of schizogony are found in peripheral blood and hence can be easily demonstrated both during fever and without fever. In case of ***P. falciparum***, the stages disappear from peripheral blood during afebrile condition. Therefore, in ***P. falciparum,*** blood should be taken during few hours of fever.

Both thin and thick blood films be made.

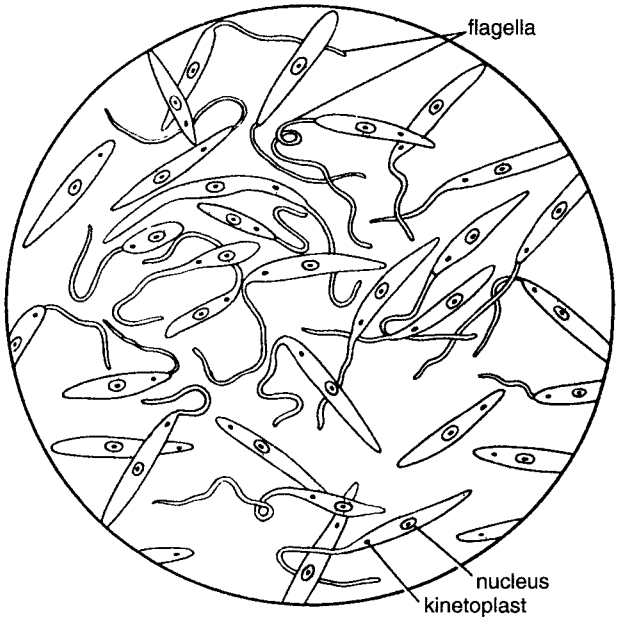


Fig. 3. *Leishmania donovani* in thick blood film.

***P. vivax* stages in thick blood film** (Fig. 2). Microscopic examination of the thick blood film reveals the following stages :

Bluish cytoplasm with **reddish nucleus**, detached in ring form in trophozoites.

Brownish rounded **gametocytes**.

Bluish **schizonts** and **polymorphonuclear leucocytes.**

(b) Leishmania donovani : Thick blood film is made by same method as in case of ***Plasmodium vivax***. The flagellar stages of ***L. donovani*** could be observed both under low and high magnification (Fig. 3).

[V] Preparation and examination of some free living and parasitic protozoans

1. *Amoeba* : *(a) Examination of living Amoebae* : Collect some water from the side of pond. Keep one or two drops of water and some water vegetation on a slide. Try to locate the moving Amoebae which can be seen on glass slide making slow movement.

(b) Permanent preparation : By a micro-pipette take few Amoebae on an albumen coated slide. Suck excess of water. Fix Amoebae in Schaudinn's fixative. After few minutes transfer to 90% and 100% alcohols. For staining, bring the slide in distilled water through descending series of alcohol 100%-90%-70%-50%-30% and then tap water-distilled water. Add a drop of Ehrlich's haematoxylin over the slide for 1 to 2 minutes. Wash the slide in distilled water. If over stained, destain in acid water. Then again wash in distilled water. Then wash in tap water or in 1% ammonia solution. The slide turns blue. Dehydrate through ascending series 30%-50%-70%-90%-100% alcohols. Clear in xylene. Mount in D.P.X. Let the slide become dry. Examine under microscope. Label the slide writing name of animal and date.

2. *Paramecium* : *(a) Examination in living condition* : Take a clean slide. Through the micro-pipette put a drop of water from the culture medium of ***Paramecium***. Examine the slide under low magnification of the compound microscope or under stereoscopic microscope. Observe the fast moving ***Paramecia*** and their cytopharynx.

(b) Permanent preparation : Free-living and fast-moving protozoans are first made non-motile on a glass slide coated with albumen. Then the small drop of culture containing ***Paramecia*** on the slide is mixed with an equal drop of 1% of Agar solution melted (1 gm of Agar in 100 cc of water distillate) at 45°C. The two solutions become jelly like. The animal may survive for 30 minutes. They are fixed by a drop of Schaudinn's fixative or with 90% alcohols. Pass the slide through descending grades of alcohol 90%-70%-50%-30% and distilled water. Stain both nuclei and cytoplasm by double staining. Stain first with Ehrlich's haematoxylin. De-stain in acid water and wash in tap water. Again dehydrate in ascending grades of alcohol. After 90% alcohol stain in cytoplasmic Eosin. Keep in 100% alcohol, clear in xylol and mount in D.P.X.

(c) Feeding experiment : ***Paramecium*** is a ciliary feeder and also a selective feeder. The cilia of the body direct the food particles into the cytopharynx or gullet. The food consists of bacteria etc. The food is collected into a membranous vesicle. The vesicle is formed just below the gullet. When the vesicle become filled with food it is detached and is called as **food vacuole**. In ***Paramecium*** the food particle is circulated in the body by more or less definite path by slow streaming movement of endoplasm called as **cyclosis**. The food vacuole is carried posteriorly and then anteriorly. Digestion and

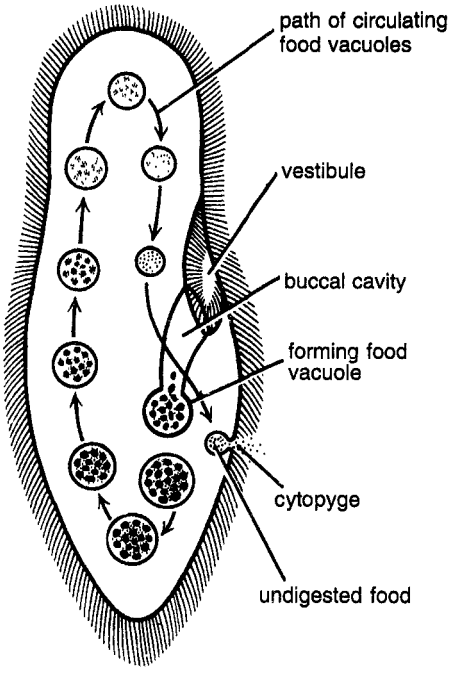


Fig. 4. *Paramecium.* Showing cyclosis.

assimilation take place during the journey of the food vacuole. First it is alkaline, then acidic and again alkaline.

For observing cyclosis take a drop of culture medium of ***Paramecium*** over a slide. Add a little yeast Congo red in drop of water. The Congo red is taken into food vacuole. Observe cyclosis under low magnification along with movement of Congo red in food vacuole (Fig. 4).

3. ***Vorticella*** **:** The sedentary protozoans, such as ***Vorticella,*** are placed over albumen coated slide, fixed in **Schaudinn**'s or 90% alcohol and then stained, dehydrated and mounted as in case of ***Amoeba***. In fixative, protozoans should be kept for about 15 minutes.

4. Rectal ciliates of frog : ***(a) In living condition*** **:** The rectal ciliates, found in the rectum of frog, are ***Opalina, Balantidium*** and ***Nyctotherus.*** Take a living frog and chloroform it. Dissect open its abdomen. Make a gentle cup upto cloaca carefully. Take out rectum and cut it open in 0.78% normal saline in a small dish or watch glass. The ciliates coming out of rectum can be seen as moving objects. Observe living rectal ciliates under a stereoscopic binocular microscope.

(b) Mounting **:** Transfer the rectal ciliates on a clean slide. Before transferring them, apply a pin head **Meyer's albumen** over the slide and rub with finger. Albumen helps to stick the protozoans on glass surface. Mark the upper surface of the slide with glass marking pencil. Fix the protozoans by adding a drop or two of 90% alcohol. Let it become dry. Then pass through descending series of alcohols 90%-70%-50%-30% distilled water. On the surface of the slide add few drops of haematoxylin for 1 minute. Wash first with distilled water, then with tap water. If there is excess of stain, destain with acid water. Wash with tap water. Nuclei stain blue. Dehydrate in ascending series of 30%-50%-70% and 90% alcohols. Stain in eosin. Wash and destain in 90% alcohol and then keep in 100% alcohol for 5 minutes. Clear in xylene and mount in D.P.X. Let the slide become dry and observe under microscope.

5. ***Monocystis*** **:** It is a parasitic Protozoa found in the seminal vesicles of earthworm. A living earthworm is dissected in a dish. The seminal vesicles are taken over an albumin-coated slide and a thin paste is made of seminal vesicles. Observe **trophozoite, gametocyst** and **sporocyst** stages under microscope, if infected. Immediately place the slide into Schaudinn's fluid or 90% alcohol for fixation for about 15 minutes. Then transfer the slide into 70%, 50% and 30% alcohols, distilled water and stain in **Haematoxylin** and **Eosin.** Dehydrate and mount in Canada balsam.

Phylum Porifera

6. Gemmules : Gemmules are preserved in 90% alcohol. Take gemmules and pass through 70% alcohol, stain in Borax carmine, dehydrate and mount in Canada balsam.

7. Spicules : For extraction of spicules, boil a small portion of sponge in 15 to 20% potassium hydroxide solution in a test tube till cells are dissolved. The spicules settle in the bottom. Decant the potassium hydroxide solution and wash the spicules several times in tap water, ascending series of alcohol (30%, 50%, 70%, 90% and 100% alcohols). De-alcoholize or clear with xylol and then mount on a slide after pipetting the spicules.

The freshwater and marine sponges are fixed in 90% alcohol which also acts as a preservative.

Phylum Coelenterata

Coelenterates are first narcotized in water mixed with menthol crystals or magnesium sulphate. Decant the narcotizing liquid and fix the animals by adding drop by drop Formol (commercial). They are preserved in 70% alcohol or 5% formalin solution.

8. *Hydra* and **2. *Obelia*** : These and other coelenterates are stained with borax carmine or Ehrlich's haematoxylin. For borax carmine staining, transfer directly from 70% alcohol to borax carmine stain and de-stain in acid alcohol. Dehydrate in 70, 90 and 100% alcohols, clear in xylol-alcohol, then in pure xylol and mount in Canada balsam.

The alternative stain is haematoxylin. The animals are transferred to water either from formalin or from 70% alcohol through 50% and 30% alcohols. The animals are gained with haematoxylin, de-stained in acid water, dehydrated in 30%, 50%, 70%, 90% and 100% alcohols, de-alcoholized in xylol and mounted in Canada balsam.

Besides ***Hydra*** and ***Obelia,*** other small coelenterates, such as ***Bougainvillia, Pennaria, Sertularia,*** polyps, medusae and tentaculocysts, etc. are best seen after staining. It is always better to overstain the tissues and then de-stain for better results. The material should be kept for 30 minutes to 1 - 2 hours in staining agent. Coelenterates may also be stained in picro-indigo carmine with same process as applied in borax carmine.

Phylum Platyhelminthes

Phylum Platyhelminthes includes three classes, namely, Turbellaria, Trematoda and Cestoda. The methods of permanent preparation of the members belonging to the above passes differ.

Class 1. Turbellaria

9. Planaria : ***(a) Living examination*** : Common forms are ***Dugesia*** (fresh-water planarian). They may be collected from ponds or streams, under the stones and leaves. Keep these planarians in a watch glass and observe under the microscope about their movement.

(b) Mounting : Common forms are fresh-water planaria or ***Dugesia.*** Planarians may be collected from ponds or streams, under the stones and leaves. For fixation, place the living flatworm on slide with a little grease. Then very gently keep a coverslip over it and press till the animal assumes its natural shape. Then bind the slide and coverslip with a thin cotton thread. Keep the slide in a dish containing fixative agent, preferably A.F.A. (Acetic-alcohol-formol) or 90% alcohol for 2 to 12 hours depending on the size of the specimen. Wash the fixative and separate coverslip from slide very gently. Transfer the specimen to 70% alcohol. Stain in Aceto-carmine or borax carmine or Cower's carmine, de-stain in acid alcohol, wash in 70% alcohol, dehydrate in 70%, 90% and 100% alcohols, clear in xylol and mount in Canada balsam. Alternative stain is **Erhlich's haematoxylin**. Bring the material in water through 50% and 30% alcohols and then stain in haematoxylin. De-stain in acid water; wash in tap water. Turn the stain blue in 1% solution of ammonia in 70% alcohol, dehyalite clear and mount in Canada balsam.

Class 2. Trematoda

10. Liver fluke : ***(a) Study in situ*** : The sheep liver flukes (***Fasciola hepatica***) and cattle liver fluke (***Fasciola gigantica***) are found in the bile duct and liver of their respective hosts. Liver flukes *in situ* can be collected from the slaughter houses where sheep and cattle (buffalows) are slaughtered. Take infected liver and examine the flukes protruding through the bile ducts. The infected portion can be fixed and preserved in 5% formaline solution. Before fixing the infected liver in formaline, collect some flukes in separate petridish containing normal saline for mounting.

(b) Mounting : It is found in the bile duct of sheep. For obtaining flukes cut the bile duct in the liver of infected sheep. Collect the flukes in 0.78% saline at a temperature of 39°C. Few living specimens are injected with a suspension of **Prussian blue** in water for digestive and excretory systems. Inject in the excretory pore by a hypodermic needle. For fixation, keep the worm between two slides with

cotton and grease, tie them with a thin cotton thread and keep the slide in A.F.A. (Acetic-alcohol-formol) or 90% alcohol for 12-24 hours. Remove the parasite and stain in **borax carmine** or **Gower's carmine** or **Aceto-carmine** de-stain in alcohol, dehydrate in 70%, 90% and 100% alcohols, clear in xylol and mount in Canada balsam.

Class 3. Cestoda

11. Tapeworm : The tapeworms are, exclusively intestinal parasites of vertebrates. For obtaining complete worms, cut the entire intestine with blunt end of a scissors. Transfer the worms in a dish containing tap water after washing for relaxation of proglottids for about 10 minutes. Fix and preserve the worm in 5% commercial formalin. For staining, wash the proglottids in water. Stain in Erhlich's or Delafield's haematoxylin or Aceto-carmine de-stain in acid water, wash in tap water for turning blue or in 1% ammonia solution in 70% alcohols, dehydrate in 30%, 50%, 70%, 90% and 100% alcohols, clear in xylol and mount in Canada balsam.

Phylum Nemathelminthes

Nematodes are fixed in hot or boiling 70% alcohol and preserved in 90% alcohol. For microscopic studies, they are cleared and mounted in **lactophenol.** For clearing worms are directly transferred to lactophenol from alcohol. The smaller worms as pinworms may be stained in picro-indigo carmine.

Phylum Annelida

The mountings include **ovary, setae, nerve ting, nephridia of earthworm**, parapodium of ***Nereis*** and ***Heteronereis***, etc. These structures are taken out from preserved animals, washed in water, passed through 30 and 50% alcohols, then kept in 70% alcohol. Stain in borax carmine or picro-indigo carmine, de-stain in acid alcohol, wash in 70% alcohol, dehydrate in 90 and 100% alcohols, clear in xylol and mount in Canada balsam.

The following procedure applies for minor dissection :

12. *Pheretima* (Earthworm) : *(a) Setae in situ* : *In situ* means mounting of setae intact with body wall. Boil a piece of skin from ventral side in 15 to 20% solution of potassium hydroxide for 5 to 10 minutes. Remove the muscle fibres, wash in water several times, and pass through 30%, 50% and 70% alcohols. Stain in borax carmine and the rest method is as above.

(b) Ovary : Take a full-sized, preserved earthworm and open it dorsally. Cut the intestine, invert it and ventrally below the heart look for the ovaries which are seen as white dots. Take them out, verify under the microscope, stain, dehydrate and mount as usual.

(c) Nephridia : There are three kinds of nephridia-integumentary, pharyngeal and septal. Pharyngeal nephridia may be taken from the dorsal surface of the pharynx. They look like septal nephridia, coil but nephrostome is absent. The septal nephridia may be studied both in preserved and fresh earthworm. In preserved specimens, take out a septum with forceps behind 15th segment. Stain in borax carmine and prepare a permanent slide as usual.

(d) Blood glands : Dissect the freshly chloroformed earthworm. Locate the blood glands around pharyngeal region (4th, 5th and 6th segments). They are in the form of red glandular small sac-like structures. Take out few glands, fix in corrosive sublimate, wash, stain in borax carmine, dehydrate, clear and mount.

(e) Spermatheca : Take a preserved earthworm, dissect and search for four pairs of spermatheca in 5th, 7th, 8th and 9th segments. Take out few spermatheca, wash, stain in borax carmine, dehydrate, clear and mount.

13. *Nereis* : *(f) Parapodium* : The parapodia of ***Nereis*** and ***Heteronereis*** are stained in borax carmine and mounted in Canada balsam.

14. *Hirudinaria* (Leech) : *(g) Jaws* : Dissect the chloroformed leech and cut open the buccal cavity. Take out carefully all the three jaws in a petridish. Add corrosive sublimate to fix them. After 5 minutes transfer the jaws in another

petridish. Wash them with distilled water. Dehydrate upto 70% alcohol and then stain in Borax carmine solution. If excess of stain, destain in acid alcohol. Again wash in 70% alcohol. Dehydrate clear and mount in D.P.X. If the jaws are taken from a preserved leech, then there is no need to fix them. Stain, dehydrate, clear and mount.

(h) Salivary glands : The pharynx is surrounded by large number of salivary glands. Take 10 to 15 salivary glands, fix in corrosive sublimate, wash stain, dehydrate, clear and mount in D.P.X. Fixation is not needed in case of preserved leech.

(i) Nephridium : Take the preserved leech dissect the leech mid dorsally. Remove alimentary canal and botroyoidal tissue carefully and expose the testicular nephridia on the lateral side. Carefully take out testis sac, initial lobe, main lobe and excretory vesicle, 3 or 4 nephridia along with testis sacs should be taken. Wash, stain in Borax carmine, dehydrate, clear and mount in D.P.X.

Phylum Mollusca

Class 1. Pelecypoda

1. Gill-lamella of *Unio* : Take gill-lamina and separate its two folds or lamellae on a slide with the help of forceps. Cut a portion from the gill-lamella, wash, stain in borax carmine, dehydrate, clear in xylol and mount in Canada balsam.

For more microscopic studies, cut microtomical sections.

Class 2. Gastropoda

1. Osphradium of *Pila* : It is a sensory structure found suspended from the mantle at the base of the left muchal lobe. In a longitudinal hand section, stained in borax carmine and mounted in Canada balsam, internal structures are clearly seen.

2. Radula of *Pila* : Remove the shell, locate the position of buccal mass anteriorly, remove the muscles over the buccal mass and take out entire buccal mass. Remove very carefully the muscles and separate the brownish and chitinous radula, stain in picroindigo carmine or in borax carmine, dehydrate, clear and mount.

Phylum Echinodermata

1. Pedicellaria of starfish : Pedicellaria are bivalve stalked structures found on the surface of the body between the spines. These are small structures. Locate them with the help of the hand lens, stain, dehydrate, clear and mount.

2. Tube feet of starfish : Tube feet are found in the ambulacral groove. Take out few tube feet by forceps, stain in borax carmine dehydrate, clear and mount.

Phylum Arthropoda

Class 1. Crustacea

The common animal of practical importance are ***Palaemon***, ***Penaeus***, ***Cyclops***, ***Artemia*** and ***Daphnia***, etc. The mounting structures are :

1. Hastate plate of prawn : In preserved freshwater prawn (***Palaemon***), remove the carapace on the dorsal side and take out the cardiac stomach embedded in the large digestive gland or hepatopancreas. Make an incision on dorsal side of the stomach to open it and expose hastate plate on its floor. Stain in borax carmine or picro-indigo carmine and mount in Canada balsam.

2. Statocyst of prawn : It is a hydrostatic or balancing organ found in the precoxa of each antennule of prawn. For obtaining statocyst, remove one of the antennules, handle its precoxal concavity up. Make an incision on the upper surface, remove the exoskeletal covering and muscles. Statocyst is found embedded in the muscles inside precoxa. Cut a section of the vesicle, remove sand particles by a brush and wash in water. Keep in 30%, 50% and 70% alcohols. Stain in borax carmine and make a permanent preparation.

3. *Cyclops* and 4. *Daphnia* : Collect them from ponds or ditches and fix in corrosive sublimate. Wash in water, dehydrate with 30%, 50% and 70% alcohols stain and mount.

5. *Nauplius*, 6. Zoaea and 7. Megalopa : The larval forms, after fixation in corrosive sublimate or formalin, are stained in borax carmine and mounted as in case of ***Daphnia*** and ***Cyclops***.

Class 2. Arachnida

1. Pectin of scorpion : The sternum of the second mesosomatic segment in scorpion contains a pair of comb-like pectines. It may be dehydrated and mounted in Canada balsam.

2. Book-lungs of scorpion : There are four pairs of whitish book-lungs in pulmonary chambers situated inside mesosomatic segments communicating with stigmata. Take out book-lungs from a preserved specimen, stain in borax carmine and make a permanent slide. Book-lungs are very carefully taken out, because lamellae are easily separated.

Class 3. Insecta

1. Salivary glands of cockroach : There is a pair of whitish glandular, diffused salivary glands in thorax on the sides of crop. Lift the crop and on the sides these glands are seen in fresh chloroformed cockroach. Take out the glands with hypopharynx, fix in corrosive sublimate, wash in water and bring in 70% alcohol through 30% and 50% alcohols. Stain in borax carmine, dehydrate, clear in xylol and mount in balsam.

2. Mouth parts of cockroach : From a freshly chloroformed specimen take out mouth parts, dehydrate and mount in Canada balsam.

3. Spiracle of cockroach : Spiracles represent openings of trachea. In cockroach there are 2 pairs of thoracic and 8 pairs of abdominal spiracles. Stretch the abdomen ventrally, locate spiracular openings, cut few spiracles, and make permanent mount.

4. Trachea of cockroach : Dissect the cockroach and remove abdominal segments. The symmetrically arranged trachea in the form of silvery white tubes are seen. Take few pieces of trachea, stain in picro-indigo carmine, dehydrate, clear and mount.

Though arthropods are transparent, but they are treated with potassium hydroxide and stained in a chitin stain preferably in carbol fuchsin. Most of the dark-coloured specimens may be treated with chlorinated alcohol. Add few crystals of potassium chlorate and few drops of concentrated hydrochloric acid in a tube. When fumes arise, fill the tube with 70% alcohol. In this chlorinated alcohol, the dark-coloured specimens become white and transparent.

Study of Prepared Slides

7

General Instructions to Draw and Study the Prepared Slides

(1) Study the prepared slides under low magnification and if required under the high magnification.
(2) Don't move the focus and the magnification without the permission of the teacher.
(3) Don't move the slide.
(4) Before drawing the slide, study it well with the help of practical text book to understand the structural details.
(5) In the case of whole mounts of the microscopic adult animals, don't forget to give classification.
(6) Classification is not required in the case of sections of the animals.
(7) In the case of sections, body wall layers along with the specific structures must be drawn.
(8) Don't forget to mention specific characters in the case of slides. For example, mention must be made about botryoidal tissue in a T.S. passing through leech.
(9) Use H.B. or 2B pencil.
(10) Draw proportionate diagrams.

PHYLUM PROTOZOA

Diagnostic characters

Unicellular eukaryotic animals. All the physiological activities are performed with in a single cell by specialised part of cytoplasm called as cell organelles.

(1) Unicellular and microscopic first animals.
(2) All the biological activities performed by different cell organelles.
(3) Body divided into ectoplasm and endoplasm.
(4) Terrestrial, aquatic, free–living or parasitic.

Classification

Sub-phylum 1. Plasmodroma

1. Cilia absent.
2. Locomotion by pseudopodia or flagella.

CLASS I. MASTIGOPHORA (=FLAGELLATA)

1. Simple, primitive.
2. Locomotion by flagella.

Sub-class A. Phytomastigophora or Phytomastigina

1. Flagella 1 or 2.
2. Presence of chlorophyll bearing chromatophores.

Order 1. Chrysomonadina
1. Stigma present, Gullet absent.
2. Chromatophores 1 to 2.
Ex. *Chrysoamoeba, Dinobryon.*

Order 2. Cryptomonadina
1. Rigid pellicle, Gullet present.
2. Chromatophores 2.
Ex. *Cryptomonas.*

Order 3. Euglenoidina
1. Thick and firm pellicle.
2. Gullet leading into reservoir.
3. Green chromatophores numerous.
Ex. *Euglena.*

Order 4. Phytomonadina (= *Volvocida*)
1. Rounded colony consisting of a large number of somatic cells or zooids.
2. Nutrition holophytic. Green or colourless chromatophores.
Ex. *Chlamydomonas, Volvox.*

Order 5. Dinoflagellata
1. Two flagella (small and large).
2. Some bioluminescent.
Ex. *Noctiluca, Ceratium.*

Sub-class B. Zoomastigophora
1. Flagella 1 or many.
2. Chlorophyll bearing chromatophores absent.

Order 1. Rhizomastigina
1. Small and amoeboid.
2. Locomotion by both flagella and pseudopodia.
Ex. *Mastigamoeba.*

Order 2. Protomonadina
1. Flagella 1 or 2.
2. Kinetoplast present.
3. Solitary or colonial, parasitic in blood.
Ex. *Trypanosoma, Leishmania.*

Order 3. Polymastigina
1. Two to eight flagella.
2. Intestinal parasites.
Ex. *Giardia, Trichomomas.*

Order 4. Hypermastigina
1 Several flagella.
2. Parasitic form.
Ex. *Trichonympha.*

CLASS II. SARCODINA (= RHLZOPODA)
1. Locomotion by pseudopodia.
2. Nutrition holozoic or saprozoic.

Order 1. *Lobosa* (= *Amoebina*)
1. Locomotion by short lobose pseudopodia.

Sub-order 1. Gymnamoeba (= Nuda)
1. Body amoeboid.
2. No skeleton.
Ex. *Amoeba, Chaos (= Pelomyxa) Entamoeba.*

Sub-order 2. Thecamoeba (= Testacea)
1. Body enclosed in a one chambered shell of silicon or calcium carbonate.
2. Pseudopodia protruding through definite openings.
Ex. *Arcella, Difflugia.*

Order 2. Foraminifera
1. Single or multichambered shell.
2. Reticulopodia emerge through one or more openings.
Ex. *Globigerina, Polystomela (= Elphidium).*

Order 3. Heliozoa
1. Spherical sun animalcules.
2. Pointed, straight, radiating pseudopodia (axopodia).
Ex. *Actinophrys, Actinophaerium.*

Order 4. Radiolaria
1. Silicious or strontium phosphate spicules in ectoplasm and endoplasm.
Ex. *Collozoum, Acanthometra, Lithocircus.*

Order 5. Mycetozoa
1. Adult a sheet of multinucleate streaming protoplasm.
2. Myxomycetes of botanists.
Ex. *Badhamia, Didymium.*

CLASS III. SPOROZOA
1. Exclusively endoparasitic.
2. Locomotory organelles absent.

Sub-class A. Telosporida
1. Spores without filaments, naked or encysted.
2. Trophozoites with one nucleus.

Order 1. Gragarinida
1. Internal parasites.
2. Trophozoite extracellular.
Ex. *Monocystis, Gregarina.*

Order 2. Coccidia
1. Intestinal parasites.
2. Mature trophozoites intracellular.
Ex. *Eimeria (= Coccidium).*

Order 3. Haemosporidia
1. Blood parasites.
2. Trophozoites intracellular.
Ex. *Plasmodium.*

CLASS IV. OPALINATA
1. Cilia like organelles in oblique rows.
2. Nuclei many monomorphic.
Ex. *Opalina.*

Sub-phylum 2. Ciliophora
1. Cilia or sucking tentacles present.
2. Nuclei of two types.

Order 1. Holotricha
1. Free swimming ciliates.

Order 2. Spirotricha
1. Cilia generally sparse and compound.
2. Adoral cilia begin at right of peristome and passing around to left.
Ex. *Balantidium, Nyctotherus, Stentor.*

Order 3. Peritricha
1. Body typically bell shaped.
2. Adoral cilia begin to left of peristome and pass to right.
Ex. *Vorticella.*

1. *Chrysamoeba*

Classification :

Phylum.....Protozoa	→	Unicellular.
Sub-phylum.....Plasmodroma	→	Cilia absent, locomotion by pseudopodia.
Class.....Mastigophora	→	One or more flagella.
Sub-class.....Phytomastigina	→	Chromatophores present.
Order.....Chrysomonadina	→	Amoeboid forms.
Genus.....*Chrysamoeba*		

Habit and habitat : ***Chrysamoeba*** is one of the simplest, plant-like form, found in fresh-water without cuticle and skeleton.

Distribution : It is found everywhere.

Comments :

(1) Typically small mastigophora provided with a single **flagellum**, 2 yellow **chromatophores**, single **nucleus** and 2 or more **contractile vacuoles**.
(2) It occurs in flagellate and amoeboid forms.
(3) During swimming, body becomes oval but on substratum, it becomes amoeboid and may lose flagellum temporarily.
(4) **Pseudopodia** radiate from the cytoplasm.
(5) It manufactures its food by **photosynthesis**.
(6) Like ***Amoeba***, it also ingests solid food particles. Nutrition is **holozoic**.
(7) Chrysomonadina are supposed to be more **primitive** than ***Amoeba***, because amoebae do not contain flagella and feed only like animals.
(8) ***Chrysamoeba*** belongs to order chrysomonadina and the whole order exhibits strong amoeboid tendencies.

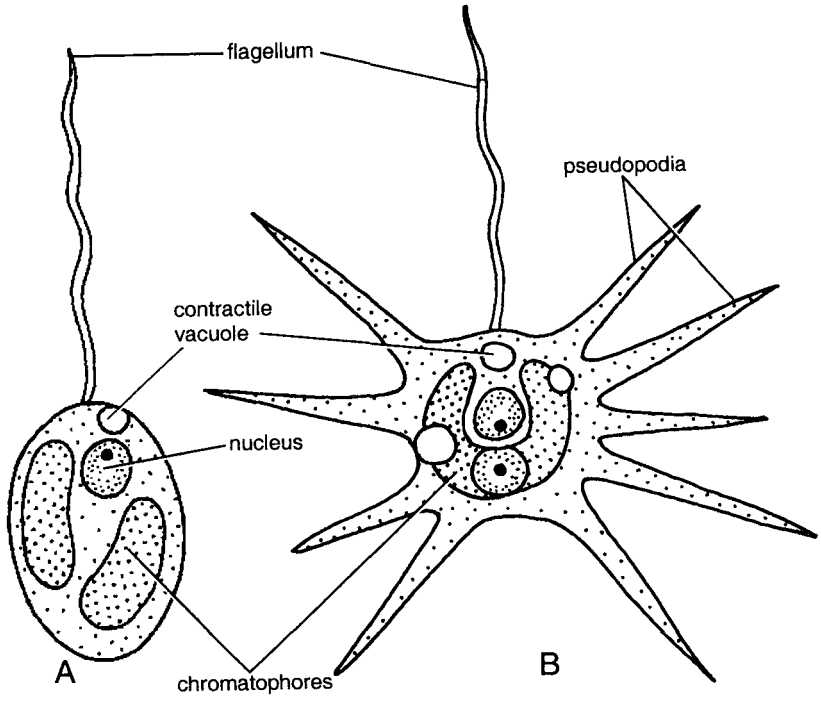


Fig. 1. *Chrysamoeba.* **A.** Flagellate, **B.** Amoeboid.

Identification : Since the animal contains radiating pseudopodia and all above features, hence it is ***Chrysamoeba.***

2. *Euglena*

Classification :

Phylum..... Protozoa	→	Unicellular.
Sub-phylum..... Plasmodroma	→	Cilia absent, locomotion by pseudopodia.
Class..... Mastigophora	→	One or more flagella.
Order..... Euglenoidina	→	Longer forms with one or more flagella.
Genus..... *Euglena*.		

Habit and habitat : ***Euglena*** is a solitary flagellate found commonly in fresh-water ponds, ditches, pods and slow running streams or in brackish water.

Distribution : Cosmopolitan.

Comments :

(1) Body of the animal is simple **fusiform, spindle shaped** plump like red or **green** coloured measuring 50 to 100 microns in length.
(2) Cytoplasm differentiated into **ectoplasm** and **endoplasm.**
(3) Outer covering is called as **pellicle** which is marked by **spiral striations** called as **myonema.**
(4) Cytoplasm below pellicle is differentiated into **ectoplasm** and **endoplasm.** Latter contains various **cell organelles.**
(5) Anterior end has funnel shaped **cytosome** which leads into a flask-shaped **cytopharynx.**
(6) On one side is a red mass of **hematochrome** called **stigmata** which is **photosensitive.**

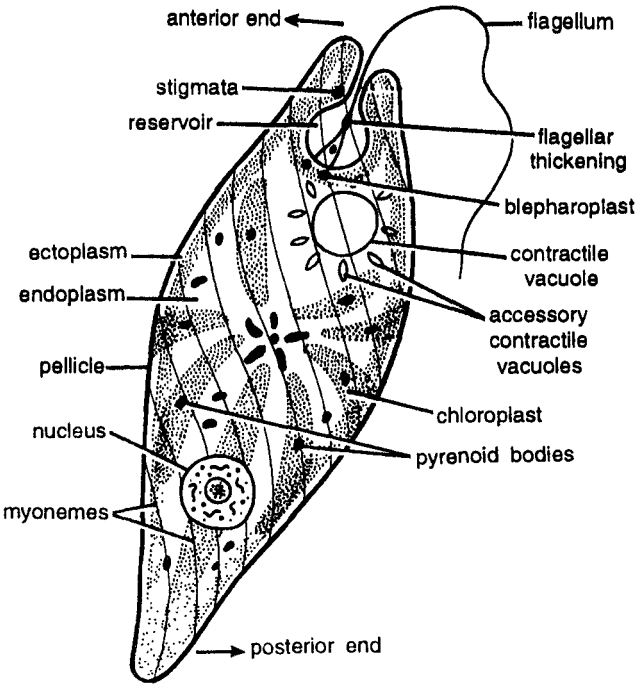


Fig. 2. *Euglena.*

(7) Just below the cytopharynx is a large contractile vacuole surrounded by accessory vacuoles.
(8) Endoplasm contains nucleus, **chloroplast** and other ultrastructural **organelles**.
(9) Just below cytopharynx there are 2 rounded **blepharoplasts**, each giving a small **flagella** which unite to form flagellar thickening from where a long flagellum arises projecting from **cytosome**. **Contractile vacuole** is surrounded by accessory contractile vacuoles.
(10) **Chloroplast** occurring in 7 to 8 thick bodies surrounding a central **paramylum granules** and scattered pyrenoid bodies. **Nucleus** contains **nuclear membrane**, **cell membrane**, **chromatid bodies**.
(11) Nutrition **holophytic** or **saprophytic** and reproduction by longitudinal division or encystment. ***Euglena*** does not take solid food but lives entirely by **autotrophic** and **saprozoic** nutrition. It is unique animal with floral mode of nutrition and faunal mode of life and reproductions.
(12) ***Euglena viridis***, ***E. rubra***, ***E. sanguinea*** and ***E. fusiformis*** are common species. They respond to various stimuli such as light, heat, etc.

Special features : ***Euglena*** is unique animal with floral mode of nutrition and faunal mode of reproduction.
Identification : Since the animal has chloroplast and all above features, hence it is ***Euglena***.

3. *Copromonas*

Classification :

Phylum..... **Protozoa**
Sub-phylum..... **Plasmodroma**
Class..... **Mastigophora**
Order..... **Euglenoidina**
Genus..... ***Copromonas***

→ Characters same as in ***Euglena***.

Habit and habitat : ***Copromonas*** is found in the faeces of vertebrate hosts such as frog, toad, pig and man (Fig. 3).
Distribution : Cosmopolitan.
Comments :
(1) Body pear-shaped with narrow anterior and broad posterior region.
(2) Colourless because of absence of cytopharynx.
(3) **Cytopharynx** long and narrow.
(4) Blepharoplast gives a long **flagellum**.
(5) Cytoplasm differentiated into **ectoplasm** and **endoplasm**.
(6) **Endoplasm** contains **nucleus**, **contractile vacuole** reservoir and **food** vacuoles.
(7) Nutrition **holozoic** feeding on bacteria.
(8) **Reproduction** asexual by binary fission and sexual by syngamy. Zygote becomes encysted.
(9) Cysts are ingested by frogs and other vertebrate host which become infected.

Identification : Since it has pear shaped body and all above features, hence it is ***Copromonas***.

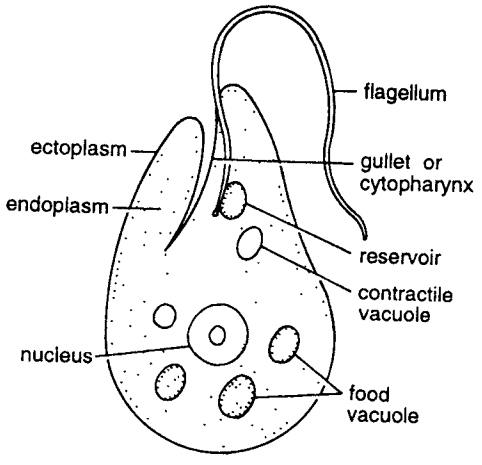


Fig. 3. *Copromonas.*

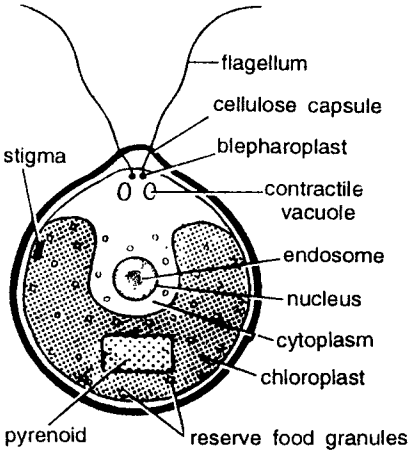


Fig. 4. *Chlamydomonas.*

4. *Chlamydomonas*

Classification :

Phylum..... **Protozoa**
Sub-phylum..... **Plasmodroma** } → Characters same as in ***Euglena***.
Class..... **Mastigophora**
Sub-class..... **Phytomastigina**

Genus..... ***Chlamydomonas*** → Algae-like flagellates.

Habit and habitat : ***Chlamydomonas*** is a solitary and typical representative of **phytomonadina**, commonly found in stagnant freshwater. Their number sometimes so becomes abundant that entire water looks green (Fig. 4).

Distribution : Cosmopolitan.

Comments :

(1) Body of the animal is **green** coloured and usually with a delicate **cellulose capsule.**
(2) Body may be **oval, flattened** or **cylindrical** and composed of closely-fitted, thick, delicate and transparent cell wall made up of cellulose.
(3) It swims rapidly by **2 whip-like flagella**, each originating separately from **blepharoplast.**
(4) Body is green due to the presence of **chlorophyll** in a cup-shaped **chloroplast**. A **pyrenoid** is embedded in the basal part of the chloroplast. Endoplasm contains **reserve food granules.**
(5) A reddish pigment or **stigma** lies anteriorly, while 2 **contractile vacuoles** are found near the base of **flagella.**
(6) Nutrition is plant-like or **holophytic**, i.e., they manufacture their own food, **saprozoic** or **mixotrophic.**
(7) It reproduces **asexually** by **binary fission** and **sexually** by the fusion of flagellate isogametes.

Special features : ***C. pulvisculus*** gives oily flavour in the water.

Identification : Since the specimen contains cup-shaped chloroplast and all above features, hence it is ***Chlamydomonas***.

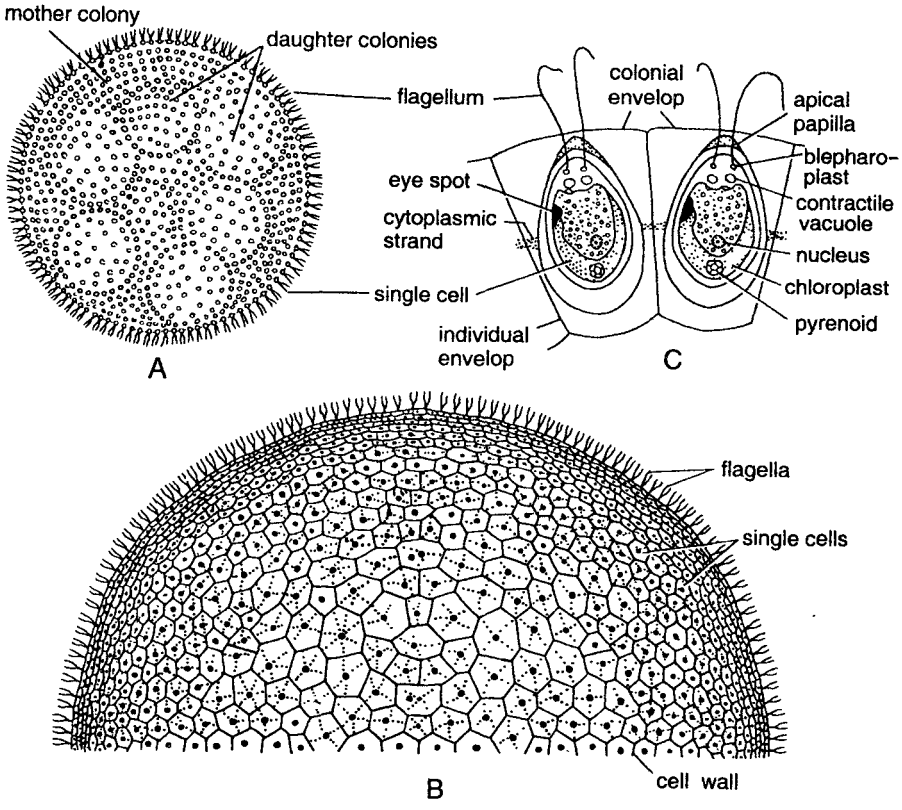


Fig. 5. *Volvox.* **A.** Mother colony, **B.** Single cell of colony, **C.** Two daughter cells of the colony.

5. *Volvox*

Classification :

Phylum.....**Protozoa**
Sub-phylum.....**Plasmodroma**
Class.....**Mastigophora**
Sub-class.....**Phytomastigina**
→ Characters same as in ***Euglena***.

Order.....**Phytomonadina** → Cellulose covering.

Genus.....***Volvox***

Habit and habitat : ***Volvox*** is a pelagic fresh-water, **colonial phytomonadina** found in ponds and lakes along with plankton (Fig. 5).

Distribution : It has **cosmopolitan** distribution.

Comments :

(1) Mother **colony** is formed by a large hollow sphere composed of hundred or thousands of **somatic** cells or called as **daughter coenobium**.

(2) Daughter **coenobium** are in the form of several ***Chlamydomonas*** like 500-50,000 zooids arranged in a single layer and embedded in **water jelly** called as **mother coenobium.**

(3) Each **zooid** is composed of two **flagella**, two **contractile vacuoles, cup-like chloroplast** and a single **nucleus**.

(4) Nutrition is **holophytic.**

(5) Colonies are polarised since they swim always in one region hence called anterior pole. Locomotion by combined action of flagella.

(6) Colony propagates by **binary fission**. The **zooids** may be somatic and reproductive. The latter zooids found posteriorly take part in reproduction.

(7) During **sexual** reproduction some specialized cells, called as **antheridia**, give rise to several biflagellate microgametes, while other cells, called as **archegonia**, give rise to non-flagellate macrogametes. Both fuse in water to form zygote that forms new colony after dormancy.

Special features : The colonial phytomonadina are of special academic interest. Although they do not come anywhere near to multicellular organization but with their anterior sterile somatic cells and posterior reproductive cells, differentiation of anterior and posterior poles, co-ordination of flagella of all the zooids in swimming and the cellular differentiation all speak an organization higher than that of a colony and approaching that of a multicellular individual.

Identification : Since the protozoan contains mother and daughter coenobium and all above features hence it is *Volvox*.

6. *Noctiluca*

Classification :

Phylum..... Protozoa	→	Unicellular.
Sub-phyllum..... Plasmodroma	→	Cilia absent, locomotion by pseudopodia.
Class..... Mastigophora	→	One or more flagella.
Sub-class..... Phytomastigina	→	Chromatophores present.
Order..... Dinoflagellata	→	Two flagella; holophytic or myxophytic nutrition.
Genus..... *Noctiluca*		

Habit and habitat : *Noctiluca* is the most common marine pelagic and **bioluminescent** form floating on the sea usually near the shores often in vast numbers. Sometimes, their number becomes so large that they form a thick scum on sea-surface covering several acres.

Distribution : It is abundantly found in the Atlantic and Pacific oceans.

Comments :

(1) **Body** more or less is a **gelatinous spherical** with indistinct grooves and measuring 1 mm in length.

(2) Body is covered by a stout **pellicle**.

(3) Cytoplasm is highly **vacuolated** and is differentiated into **ectoplasm** and **endoplasm**. Cytoplasm is further differentiated into **central cytoplasm** and **peripheral cytoplasm**.

(4) Mouth is elongated having pouch-like **cytopharynx**.

(5) Near the cytopharynx there is a ventral depression representing the **sulcus**. The sulcus bears a rudimentary **longitudinal flagellum** and communicates to the mouth near which springs a thick motile **tentacle** which projects beyond ectoplasm.

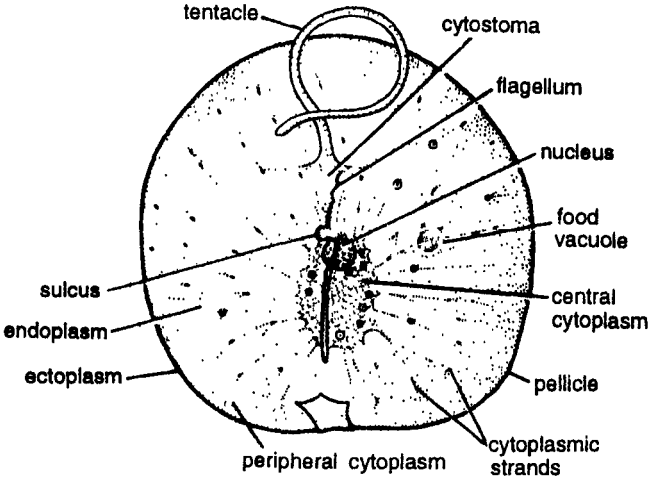


Fig. 6. *Noctiluca.*

(6) From the central **sulcus** and clump of protoplasm containing the nucleus various delicate strands run through the watery interior to the periphery.

(7) Nutrition is **holozoic**. The two flagella procure **food particles**.

(8) Reproduction is by gamete formation and fission or by swarm spore formation.

Special features : Whenever the **uniform light** is seen in the sea, it is undoubtedly due to dinoflagellates, which own the old mystery, **"the burning of sea"**. It emits greenish-white or bluish-white light when irritated. ***N. seintillans*** is so plentiful that the sea is coloured red or yellow by day and glows by night by **strong bioluminescent light**. The light is produced by the interaction of **luciferine** and **luciferase** contained in the cytoplasm.

Identification : Since the protozoan contains protoplasmic strands and all above features, hence it is ***Noctiluca***.

7. *Ceratium*

Classification : Same as in ***Noctiluca***.

Genus.....*Ceratium*

Habit and habitat : ***Ceratium*** is found in **fresh-water** as well as in sea (Fig. 7).

Distribution : It is common in U.S.A. (Woods Hole).

Comments :

(1) They are important members of '**ocean meadows**' on which other animals feed.

(2) Body is **green** or **brown** coloured.

(3) Body is composed of **cellulose plates** consisting of 2 **upper epithecal plates** and 2 **lower hypothetical plates**. Epithecal plates are produced anteriorly as **apical spine**. Two posterior hypothecal plates are produced on each side as **lateral spines**.

(4) Shell is grooved by a transverse groove and a longitudinal groove or **sulcus**.

(5) Transverse groove is called as **annulus**. Each transverse groove has a **spiral transverse flagellum** and longitudinal groove has a **posterior flagellum**. Each flagellum projects into cytoplasm.

(6) Beneath theca cytoplasm is differentiated into **ectoplasm** and **endoplasm** and the protozoan is triangular in shape. Endoplasm contains **starch granules, nucleus** and **chromoplast**.

(7) Internally endoplasm contains **starch granules, chromoplast, nucleus, annular** and **sulcal flagella**.

(8) Several species are holophytic containing **chromatophores**, which are green in fresh-water and yellow or brown in salt water.

(9) Nutrition **holozoic**. Several species are **bioluminescent**.

(10) Reproduction is by fission, which is interesting as they form interlocking chain by apical and posterior processes. Cyst formation also occurs.

Identification : Since the protozoan contains thecal plates and all above features, hence it is ***Ceratium***.

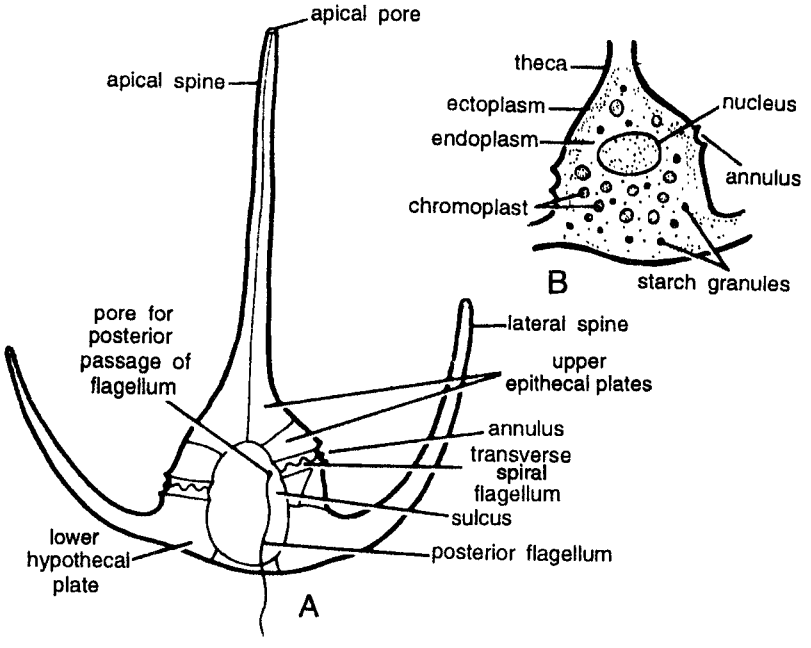


Fig. 7. *Ceratium.* **A.** External features. **B.** A part magnified.

8. *Trypanosoma*

Classification :

Phylum..... Protozoa	→	Unicellular.
Sub-phylum..... Plasmodroma	→	Cilia absent, locomotion by pseudopodia.
Class..... Mastigophora	→	Amoeboid with 1 to 3 flagella and parabasal body.
Sub-class..... Zoomastigina	→	Chromatophores absent.
Order..... Protomonadina	→	Amoeboid, with 1 to 3 flagella and parabasal body.
Family..... Trypanosomatidae	→	Blood parasites of vertebrates.
Genus..... *Trypanosoma*		

Habit and habitat : ***Trypanosoma*** is **polymorphic** blood or tissue parasite of man or other animals. They pass through a cycle in the gut of insects which serve as intermediary hosts (Vectors). Trypanosomes infecting man are ***T. brucei*** causing African trypanosomiasis (Gambian, Rhodesian and Rambezi forms of sleeping sickness), ***T. cruzi*** causing South African trypanosomiasis chaga's disease and ***T. rangli*** (Venzuelar non-pathogenic form). On the basis of host-specificity and virulence ***T. brucei*** is considered to exist in two strains (i) animal strain found in animals and (ii) human strain (formerly ***T. gambiense*** and ***T. rhodesiense***, comprising of Rhodesian sleeping sickness which is an acute stage of Gambian). It is also found in the intestine of leeches and various blood sucking insects which in many cases are known to convey the parasite to the vertebrate host by their bite.

Distribution : It is found in Africa, Nigeria, Congo, Rhodesia, Uganda, Northern Mozambique, Kenya and America.

Comments :

(1) **Body** of the protozoan parasite is irregularly elongated, leaf-like, flattened and tapering at both ends. It measures 10 to 40 microns and 2 to 10 microns in **length** and **breadth** respectively.

(2) Body is covered by a thin **pellicle** and the cytoplasm is differentiated into **ectoplasm** and **endoplasm**. Endoplasm contains reserve food granules.

(3) Parasite is complex in structure with well developed locomotary apparatus and **nucleus** adapted for special function. Nucleus contains **nucleolus**.

(4) On one side the edge of the body is thrown into irregular folds called as **undulating membrane**.

(5) There is a single **flagellum**, originating from a **basal granule**, and running along the edge of an undulating membrane. Associated with basal granule is another granule, variously called as **blepharoplast**, **kinetoplast**, **kinetonucleus** containing **chromatin**.

(6) Nutrition is **saprozoic**. All members are parasitic and **pathogenic**. Reproduction is by longitudinal binary fission.

(7) Infection of the above parasite stimulates the production of large number of IgM **immunoglobulin** rather than IgG and hence host is unable to react on the parasite. The host is also unable to produce protective **antibodies**.

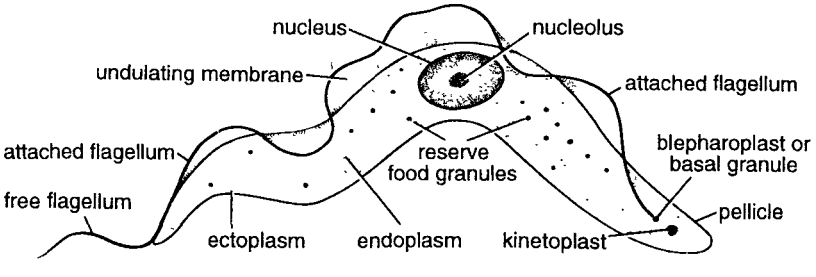


Fig. 8. *Trypanosoma.*

Pathogenecity : ***Trypanosoma gambiense*** and ***T. rhodesiense*** cause African and Rhodesian Sleeping Sickness respectively. ***T. brucei*** is found in African cattle and causes fatal disease called as **Nagana**. ***T. cruzi*** causes **Chagas's disease** in South and Central America. Man is infected by ***T. gambiense*** and ***T. rhodesiense***, which are transmitted by **tsetse fly** from one person to other. The parasite leaches cerebrospinal fluid and causes **sleeping sickness** in which a person goes on sleeping and ultimately dies, if not treated in preliminary stages.

Prophylaxis (Prevention) : (i) The insect vectors should be destroyed by insecticides (ii) survey, isolation and treatment of infected man.

Identification : Since the parasite contains undulating membrane with protruding flagellum and all above features, hence it is ***Trypanosoma***.

9. *Leishmania*

Classification : Same as in ***Trypanosoma***.

Genus.....*Leishmania*

Habit and habitat : ***Leishmania*** is another **pathogenic protomonad** responsible for serious disease among man, cattle, dog, sheep and horse. The disease is called as **Leishmaniasis**. It is found as intracellular parasite in the cells of liver, spleen, bone marrow, intestine and lymph glands in the reticulo-endothelial cells. ***Leishmania donovani*** is named after its discoverers-Leishman (1903) from U.K. and Donovon (1903) from Madras (Chennai).

Distribution : It is found in Asia and Mediterranean countries. Its endemicity is of wide occurrence in China, Africa, Southern Europe, South America, Russia and India. In India it is common in Assam, Bengal, along Ganges and Brahmaputra coast, Bihar and Orissa.

Comments :

(1) Above parasite is **polymorphic** existing in 4 forms : (i) ***Leishmania*** without blepharoplast and flagellum, (ii) **Leptomonas** with anteriormost **blepharoplast** and a **flagellum**, (iii) **Crithidia** with anterior sub-equatorial **blepharoplast** and **flagellum** and (iv) ***Trypanosoma*** with a posterior blepharoplast forming undulating membrane.

(2) ***Leishmania*** is a microscopic rounded or oval form, measuring 2 to 4 microns in diameter. The cytoplasm is differentiated into **ectoplasm** and **endoplasm**.

(3) Body is covered by a pellicle or **periplast**.

(4) Endoplasm contains an oval **nucleus**, rod-shaped or dot-like **kinetoplast** and a **parabasal body**. No **flagellum**.

(5) Life cycle is **digenetic** having two stages **Amastigote** form occurring in man and dog and **promastigote** in sandfly. It includes a blood-sucking sandfly of the genus ***Phlebotomus***.

(6) Reproduction is also by **binary fission**.

(7) Disease is communicated by the insect vector ***Phlebotomus argentipes*** and few related species.

Pathogenecity : ***Leishmania donovani*** causes a serious disease **visceral leishmaniasis** (VL) or '**Kalaazar**', a sort of fever, Cutaneous leishmaniasis (CL), muco-cutaneous leishmaniasis (CMCL), anthroponotic leishmaniasis (ACL), Zoonatic cutaneous leishmaniasis and post-kalazar dermal leishmaniasis (PKDL). ***Leishmania tropica*** causes **pathological changes**

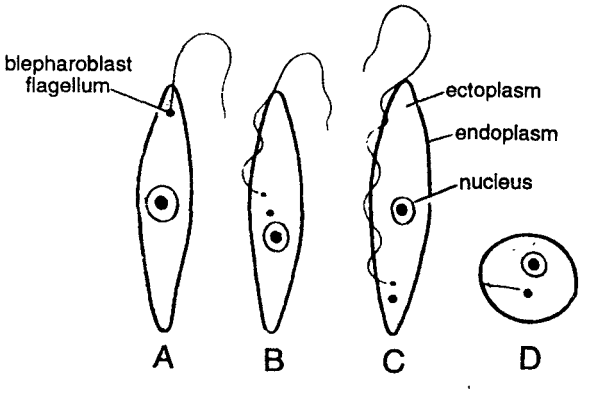


Fig. 9. *Leishmania* stages. **A.** *Leptomonas.* **B.** *Crithida,* **C.** *Trypanosoma,* **D.** *Leishmania.*

in skin. It also causes **cutaneous lesions, resulting** in **disfiguration** of **ears, face, forearms** and **lower legs** and causing Oriental sores or **Delhi boils.** ***Leishmania brassiliensis*** causes **muco-cutaneous lesions** or American leishmaniasis. The parasite causes various pathological changes the reticular-endothelial tissues of spleen, liver, lymph nodes and bone marrow become hyperplastic. Anaemia and jaundice also occur in leishmaniasis. The control measures comprise elimination of reservoir host. Vaccination with a culture of alive flagellates or an extract of spleen of Syrian hamsters infected with a ***L. tropica*** gives permanent **immunity**, antimony and local Atebrian intramuscular injections are given.

Identification : Since the parasite has rounded body without flagellum and all above features, hence it is ***Leishmania***.

10. *Trichomonas*

Classification :

Phylum.....Protozoa	→	Unicellular.
Sub-phylum.....Plasmodroma	→	Cilia absent, locomotion by pseudopodia.
Class.....Mastigophora	→	One or more flagella.
Sub-class.....Zoomastigina	→	Chromatophores absent.
Order.....Polymastigina	→	Intestinal parasites with 2 to 8 flagella and exostyle.
Genus.....*Trichomonas*		

Habit and habitat : ***Trichomonas*** is one of the most common **intestinal multiflagellate**, living in the intestine of all vertebrates and also in the intestine of leeches and termites. These are common flagellates of tropics and frequently observed in diarrhic stools. They exist only in the **trophozoite** phase and have no cystic phase. They feed on bacteria and yeasts, etc. in their place of occurrence.

Distribution : It has **cosmopolitan distribution.**

Comments :

(1) Body is **oval**, egg-shaped, slightly tapering posteriorly and is measuring 5 to 20 microns in length. Cytoplasm divided into **ectoplasm** and **endoplasm.**

(2) Animal contains 3 to 5 flagella arising from anteriorly situated 2 **blepharoplasts.**

(3) Each blepharoplast gives 2 **flagella.** From left blepharoplast a trailing **flagellum** arises which forms **undulating membrane.**

(4) **Parabasal body** is club-shaped and posteriorly directed.

(5) Parabasal body represent **Golgi** apparatus.

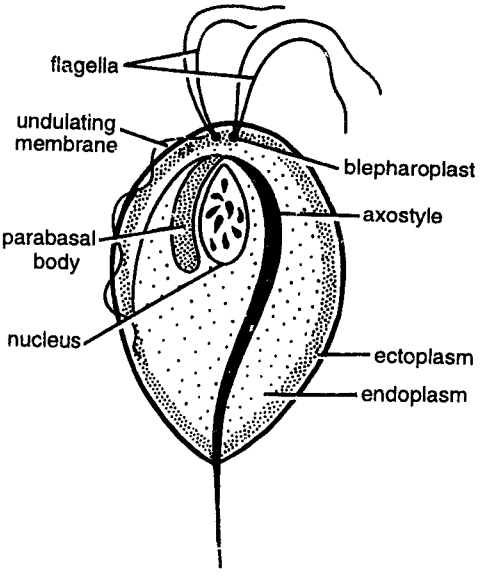


Fig. 10. *Trichomonas.*

(6) A free recurrent flagellum extends backwards projecting from posterior end and is called as **Axostyle.**

(7) **Cytosome** is ventrally situated in the broad anterior region.

(8) Feeding is saprozoic but most species ingest bacteria, yeast and other solid food.

(9) Reproduction is exclusively by **longitudinal binary fission.**

(10) No cyst formation as transmission occurs directly in the active, free, trophozoite stage.

Pathogenecity : In man, ***T. vaginalis***, ***T. hominis*** and ***T. buccalis*** are found in vagina, colon and buccal cavity respectively. The ***Trichomonas*** are not of much pathological importance except ***T. vaginalis***. This parasite is found in large number in the Leucorhoeic discharge of females. It causes **inflammation** of the **vaginal mucosa.**

Identification : Since the parasite contains thick axostyle and all above features, hence it is ***Trichomonas***.

11. *Giardia*

Classification : Same as in ***Trichomonas***.

Genus.....*Giardia*

Habit and habitat : ***Giardia*** is an important polymastigid flagellate, commonly found in the **intestines** of rats, mice, rabbits, guinea-pigs, dogs, cats and frogs. ***G. enterica*** is found in the small **intestines** of man, especially children (Fig. 11).

Distribution : It has world-wide distribution.

Comments :

(1) Body is **oval in** shape or half pear-shaped with broad forward anterior end and narrow posterior end.
(2) Body is strongly bilaterally symmetrical.
(3) Dorsal surface is convex and the flat ventral surface contains a slight concavity, forming adhesive disc and differentiated into **ectoplasm** and **endoplasm**.
(4) Cell organelles are more or less double with 2 **haploid nuclei**, 2 **parabasal bodies** and 8 **flagella**.
(5) **Axostyle** forms the median longitudinal axis of the body.
(6) **Cytopharynx** is absent and the **rhizoplasts** make complicated loops through the **cytostome**.
(7) Reproduction is by longitudinal binary fission. Oval cysts are formed regularly which contain four nuclei indicating the beginning of fission.
(8) An acid environment often causes the parasite to encyst. The **infective** ovoid **cysts** are passed out in the faeces and are means of transmission. They infect other human beings through contaminated food and water.
(9) ***Giardia*** in large number interferes with absorption of fats and fat-soluble vitamins.

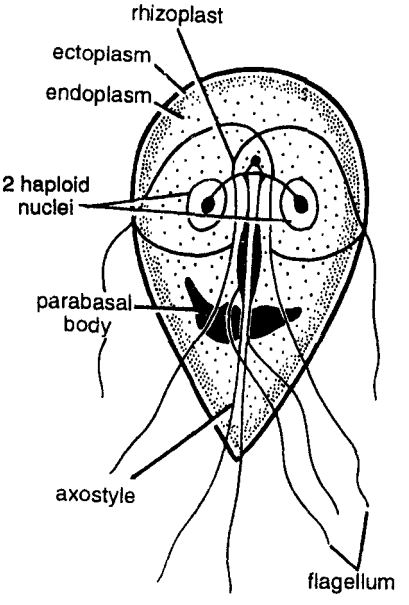


Fig. 11. *Giardia.*

Pathogenecity : At the place of attachment the parasite causes change in the intestinal epithelium resulting into malabsorption with persistent loose motion with irritative effects. The infection also causes **chronic enteritis**, **acute entero colitis**, **fever**, **anaemia** and **allergy**.

Identification : Since the parasite has 8 flagelles and all above features hence it is ***Giardia***.

12. *Trichonympha*

Classification :

Phylum.....Protozoa
Sub-phylum.....Plasmodroma
Class.....Mastigophora → Characters same as those of ***Trichomonas***.
Sub-class.....Zoomastigina
Order.....Hypermastigina
Genus.....*Trichonympha* → Several flagella.

Habit and habitat : ***Trichonympha*** is the most widespread Hypermastigina, found in the alimentary canal of termites and cockroaches as **symbionts** (Fig. 12).

Distribution : It is widely distributed all over the world.

Comments :

(1) Complex **multiflagellate parasitic Protozoa.**

(2) Body is large, more or less oval in shape, measures 50 to 300 microns in length, and is divided into 3 regions : a tapering anterior **flagellated rostrum**, bearing apical cap; an intermediate **bell-like** portion, bearing most of the flagella, and a rounded non-flagellated **posterior region.**

(3) All the flagella are connected through fibrils with a hemispherical **blepharoplast**, lying at the base of necked cap.

(4) Some flagella are arranged in longitudinal rows.

(5) Several elongated **parabasal bodies** and **axostylar filaments** run from rostral to hinder region of the body.

(6) Middle of the body contains **food granules** and single **nucleus.**

(7) **Reproduction** is by **longitudinal binary fission.** It also undergoes **encystment** under unfavourable conditions.

(8) It shows **symbiotic** relations with the insect host. The insects feed wood particles but cannot digest those. The flagellate fauna in the intestine converts the cellulose into soluble carbohydrates for their host.

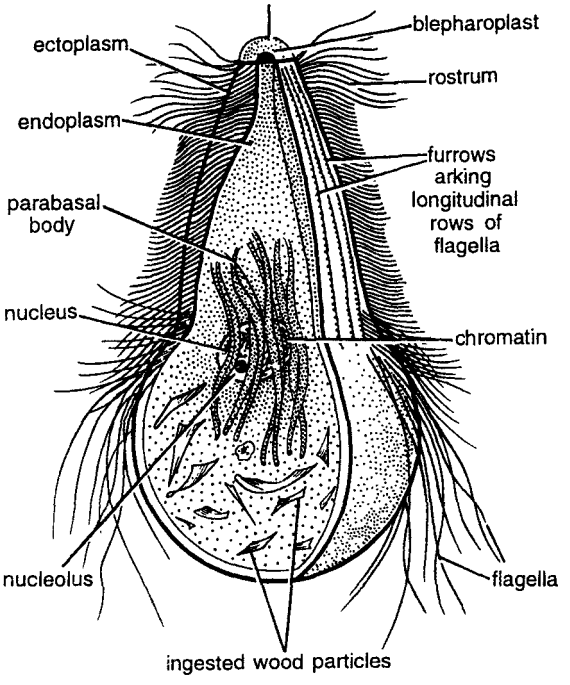


Fig. 12. *Trichonympha.*

Identification : Since the parasite has elongated parabasal bodies and all above features hence it is ***Trichonympha.***

13. *Amoeba*

Classification :

Phylum.....Protozoa	→	Unicellular.
Sub-phylum.....Plasmodroma	→	Cilia wanting locomotion by pseudopodia.
Class.....Rhizopoda	→	Locomotion and feeding by pseudopodia.
Order.....Lobosa	→	Ecto and endoplasm with short pseudopodia.
Sub-order.....Nuda	→	Test wanting.
Genus.....*Amoeba*		
Species.....*proteus*		

Habit and habitat : ***Amoeba*** is found among the sediments on the bottom or on the underside of aquatic vegetation in fresh-water ponds, lakes, ditches, slow-running streams and spring pools. It is abundantly found in the water, rich in organic bacteria and vegetation decay (Fig. 13).

Distribution : It is found all over the world.

Comments :

(1) Animal is of **irregular shape**, with simple or branched **pseudopodia** measuring 250 to 600 microns in diameter.

(2) In living condition it looks like whitish mass of irregular and translucent protoplasm with a very slow movement.

(3) Cytoplasm is differentiated into **ectoplasm** and **endoplasm.** Ectoplasm contains **ectoplasmic ridges.**

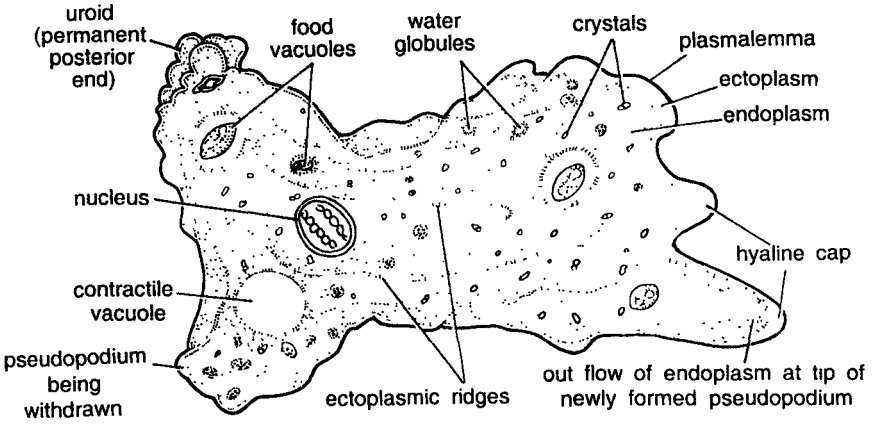


Fig. 13. *Amoeba.*

(4) Body of the animal is covered by a thin, delicate and permeable plasma membrane called as **plasmalemma**.
(5) **Endoplasm** contains **nucleus**, **food vacuole**, **contractile vacuoles**, **water globules** and **crystals**.
(6) Permanent posterior end is called as **uroid**.
(7) Withdrawl of pseudopodium and new pseudopodium containing endoplasm is present.
(8) Feeding may be studied by giving carmine. Nutrition is **holozoic**.
(9) Reproduction is by **fission** and **encystment**.
(10) ***Amoeba proteus*** moves by the formation of **pseudopodia** (Identification by shape and pseudopodia). Pseudopodia are blunt, finger like extensions of the ectoplasm containing endoplasm (lobopodium).

Special significance : ***Amoeba*** has unique phylogenetic significance and it is referred as immortal. Recently **certain free-living amoebae** have been found to be pathogenic causing **meningo encephalitis**.

Identification : Since the animal has pseudopodia and above features, hence it is ***Amoeba proteus***.

14. *Entamoeba histolytica*

Classification : Same as that of ***Amoeba***.
Genus.....***Entamoeba***
Species.....***histolytica***

Habit and habitat : ***E. histolytica*** is a **pathogenic** tissue invading **trophozoite** living in the mucous and submucous layer of the large intestine of man (Fig. 14).

Distribution : Cosmopolitan.

Comments :
(1) Parasite occurs in five stages such as (i) **atrophozooite**, (ii) **precystic**, (iii) **uninucleate**, (iv) **binucleate** and (v) **quadrinucleate**.
(2) **Trophozoite :** It is a tissue involving growing stage showing following features :
  (i) Cytoplasm is divided into **ectoplasm** and **endoplasm**.
  (ii) **Ectoplasm** translucent, hyaline forming **pseudopodium**.
  (iii) Endoplasm has granular content with **nucleus**, red blood **corpuscles**, **polymorphonuclear leucocytes**. **Nucleus** has nuclear membrane and **karyosome**.
  (iv) Mitochondria absent. Respiratory enzymes are present along **endoplasmic reticulum**.
(3) **Precystic stage :** It has blunt pseudopodia and nucleus containing chromosomes and nucleic acids (DNA).

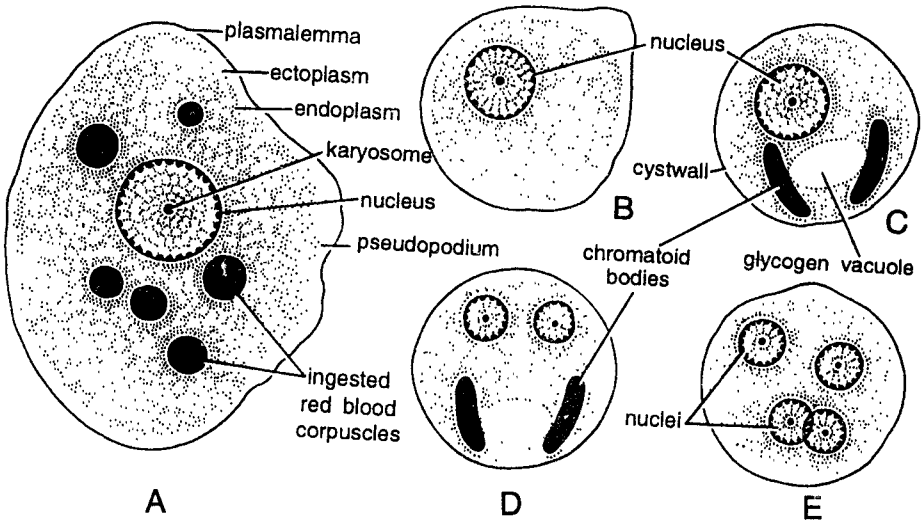


Fig. 14. *Entamoeba histolytica.* Stages of life cycle. **A.** Trophozoite, **B.** Pre-cystic stage, **C.** Uninucleate cyst, **D.** Binucleate cyst, **E.** Quadrinucleate cyst.

(4) **Uninucleate cyst :** Consisting of cyst wall, nucleus, glycogen granules and two **chromatoid bodies.** Chromatoid bodies are cytoplasmic aggregated RNA.
(5) **Binucleate cyst :** It has cyst wall, 2 nuclei, 2 chromatoid bodies and glycogen granule.
(6) **Quadrinucleate cyst :** It has cyst wall and 4 **nuclei.** It is infective stage.
(7) Mode of infection is oral. Man becomes infected by drinking **contaminated water** having **quadrinucleate** cyst.

Pathogenesis : Cyst reaching intestine is dissolved. Nuclei are set free and they invade mucosa. Nuclei divide and develop into trophozoites. Trophozoites cause (i) **intestinal ameobiasis,** and (ii) **hepatic amoebiasis.** In intestinal amoebiasis nodule formation, edema and uliceration commonly occur.

Identification : As the parasite has quadrinucleate cyst and all above features, hence it is ***Entamoeba histolytica.***

15. *Entamoeba coli*

Classification :

Phylum.....Protozoa
Sub-phylum..... Plasmodroma
Class..... Rhizopoda
Order..... Lobosa
Sub-order.....Nuda
Genus..... *Entamoeba*
Species.....*coli*

→ Characters same as those of ***E. histolytica.***

Habit and habitat : ***E. coli*** is found in the lumen of the colon as free parasite as endocommensale and non-pathogenic parasite in man. Living trophozoites are often found in diarrhoeic stool (Fig.15).

Distribution : World-wide prevalence specially in warm moist places, U.S.A. and Europe.

Comments :

(1) ***E. coli*** contains **trophozoite, precystic** and **cystic stages** (uninucleate, binucleate, tetranucleate and 8-nucleii stages).
(2) **Trophozoites** measure 15 to 40 microns in diameter and possesses viscous cytoplasm.
(3) Body differentiated into **ectoplasm** and **endoplasm.**

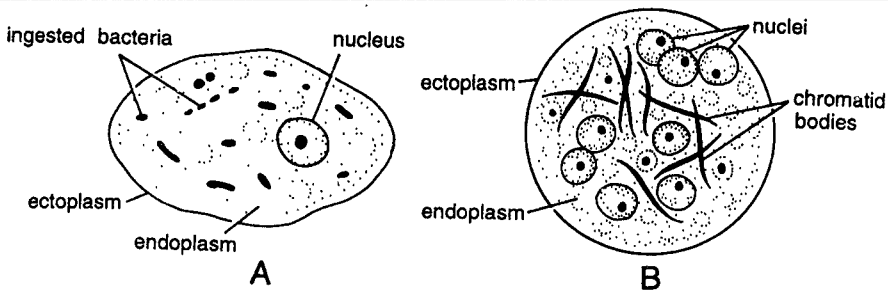


Fig. 15. *Entamoeba coli.* **A.** Trophozoite, **B.** 8-nuclear infective stage.

(4) **Endoplasm** contains **nucleus**, cytoplasm, chromatid bodies and small granules.
(5) ***E. coli*** does not ingest host tissues but its food vacuole shows **yeast cells**, **bacteria** and **cell debris** of host.
(6) Life-history of ***E. coli*** parallels with ***E. histolytica*** comprising trophozoite, precystic and 1 to 8 **metacystic stages**.
(7) 8-nuclear stage is the **infective stage**.
(8) **Binucleate, tetranucleate** and **8-nuclear stages** contain granular **cytoplasm, nuclei, glycogen granules** and **chromatoid bodies** (aggregation of RNAs).
(9) **Precystic, cystic** and **metacystic** stages measure 10 to 33 microns in diameter.
(10) Man gets infection by ingesting or drinking contaminated food or water. Cyst reach exterior through the faeces. Cyst reads in drinking water. **Mode of infection** normal.

Identification : Since it contains more chromatoid bodies and all above features hence, it is ***E. coli.***

16. *Entamoeba gingivalis*

Classification :

Phylum.....**Protozoa**
Sub-phylum.....**Plasmodroma**
Class.....**Rhizopoda**
Order.....**Lobosa**
Sub-order.....**Nuda**
Genus.....***Entamoeba***
Species.....***gingivalis***

→ Characters same as those of ***E. histolytica.***

Habit and habitat : ***E. gingivalis*** is a parasite of the **oral** or **mouth** cavity of man, women and children. It lives in the **gingival tissues** around teeth specially around **inflammatory tissues**. It also thrives well apparently unhygienic mouth or on **dental plates** if they are not kept meticulously clean.

Distribution : Cosmopolitan. In all population and almost in all countries (Fig. 16).

Comments :

(1) **Trophozoite** measures 5 to 35 microns in diameter.
(2) Cytoplasm differentiated into **ectoplasm** and **endoplasm**.
(3) **Pseudopodia lobase.**
(4) **Endoplasm** contains **nucleus, host, leucocytes, chromatoid bodies, glycogen, granules** and **food vacuoles.**
(5) **Nucleus** measures 2 to 5 microns in diameter, distinct **nuclear membrane** and condensed **chromatids.**
(6) **Reproduction** by **binary fission.** ***E. gingivalis*** can be cultured.
(7) Sometimes parasite has been obtained from the crypts and secretions of the **tonsil of man.** Various life-cycle stages are trophozoite, uninucleate stage, binucleate stage and 8-nucleate stage.

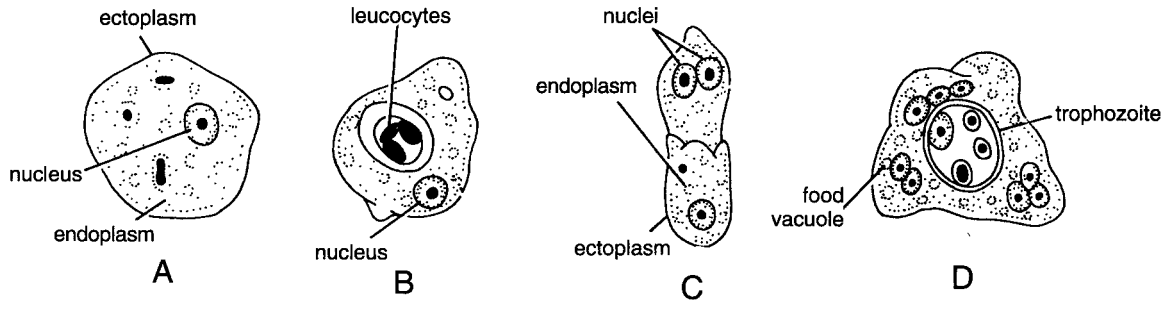


Fig. 16. *E. gingivalis.* **A.** Trophozoite, **B.** Uninucleate stage, **C.** Binucleate stage, **D.** 8-nuclear stage.

(8) Man acquires **infection** via **droplet spray** of mouth of infected individuals during close contact or through the water of **contaminated** glasses or dishes.

(9) **Pathogenesis :** ***E. gingivalis*** cause **inflammation** and swelling of **gums** which results into pain in gums. Infection is often associated with ***Trichomonas tenax***, oral **Spirochets and *Fusiforus bacilli*.**

(10) **Prevention :** Better oral hygiene is needed. Avoid drinking water from uncleaned glasses.

Identification : Since the parasite has lobose pseudopodia and all above features, hence it is ***Entamoeba gingivalis***.

17. *Arcella vulgaris*

Classification :

Phylum..... Protozoa	→	Unicellular.
Sub-phylum..... Plasmodroma	→	Cilia absent, locomotion by pseudopodia.
Class..... Rhizopoda	→	Locomotion and feeding by pseudopodia.
Order..... Lobosa	→	Ecto and endoplasm, with short pseudopodia.
Sub-order..... Thecamoeba	→	Body enclosed in shell.
Genus..... *Arcella*		
Species..... *vulgaris*		

Habit and habitat : ***Arcella*** is commonly found in **stagnant** fresh-waters containing much vegetation. It is also found in moist forest soils, moist sand and moss.

Distribution : It has **cosmopolitan** distribution.

Comments :

(1) It contains characteristic light-yellow to dark-brown **shell** or **test**, which is made up of intricately arranged **silicious prisms** set in a tectin base of reticular appearance.

(2) Ventral surface has an inverted, funnel-like depression, leading to central **mouth** or **pylome**.

(3) 1 to 6 small, hyaline, **finger-like**, simple or branched **lobopodia** are extended through the pylome, which function as locomotory and feeding organelles.

(4) **Cytoplasm** is differentiated into non-vacuolated **ectoplasm** and **endoplasm**.

(5) Body is attached to the inner test wall by ectoplasmic strands or **epipodia**.

(6) Characteristic feature is the presence of **chromidium** or a peripheral layer of **reticular** cytoplasm.

(7) Endoplasm contains various **reserve food particles**, **food vacuoles** and **contractile vacuoles** and **2 prominent nuclei**.

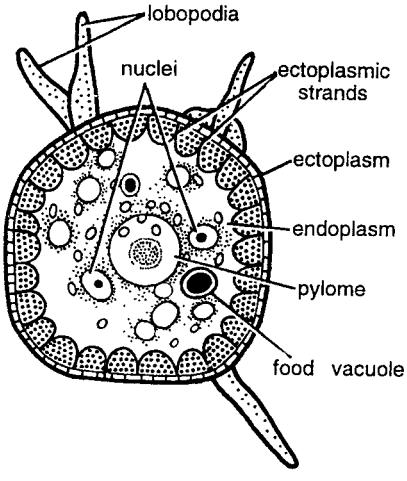


Fig. 17. *Arcella.*

(8) Nutrition is **holozoic**.
(9) Asexual reproduction takes place by **binary** fission and partial extrusion of the body through pylome.
Identification : Since the animal contains branched lobopodia, pyloma and all above features, hence it is ***Arcella***.

18. *Difflugia*

Classification : Same as in ***Arcella***.
Genus.....*Difflugia*
Habit and habitat : ***Difflugia*** is a common, free-living lobosa, found in small leaf-chocked, fresh-water puddies, ponds, ditches or even moist soil. It feeds on micro-organisms and ***Spirogyra***.
Distribution : It has world-wide distribution.
Comments :
(1) It possesses a beautifully-**symmetrical** pyriform or flask-shaped 0.2 to 0.6 mm **test**, usually made up of intricately placed foreign sand grains of a definite size set in an organic matrix. These particles are digested prior to fission.
(2) Depending on the species, shell may be bottle-shaped, jug-shaped, ovoid, spherical or oval. The skeleton is **single chambered** and **non-calcareous**.
(3) Test is covered by **spines** at the sides or hinder end.
(4) Anteriorly it has a slender neck and terminal mouth or **pylome**, around which 6 **lobose** and **mobile pseudopodia** are found.
(5) **Cytoplasm** is differentiated with the **ectoplasm** and **endoplasm**. The **endoplasm** contains **nucleus**, **food vacuoles** and **contractile vacuoles**.
(6) **Gas vacuoles** are absent.
(7) It looks vivid green due to the presence of ***Zoochlorellae*** in the cytoplasm.

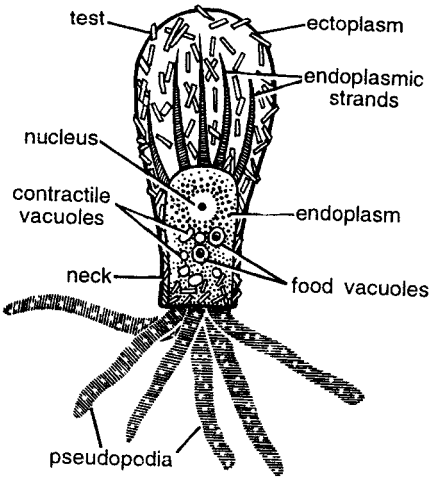


Fig. 18. *Difflugia.*

(8) It reproduces by **binary** fission and **multiple** fission.
(9) ***D. oblonga*** is very active in the spring and most of the summer, but becomes encysted in its test in late fall.
Identification : Since the specimen contains 6 lobose pseudopodia and all above features hence it is ***Difflugia***.

19. *Euglypha*

Classification :
Phylum.....Protozoa
Sub-phylum.....Plasmodroma } → Characters same as those of ***Arcella***.
Class.....Rhizopoda
Order.....Filosa → Filiform or thread like pseudopodia.
Genus.....*Euglypha*
Habit and habitat : ***Euglypha*** is a well-known, fresh water form (Fig. 19).
Distribution : It has cosmopolitan distribution found in sphagnum moss.
Comments :
(1) Protozoan has a membranous, **hyaline**, **flask-shaped** and elongated test, composed of closely-fitted, over-lapping, rounded and siliceous scales or **plates**, whose edges overlap making **hexagonal areas**.

(2) Test is colourless, elongated, cylindrical with broader anterior end and with usually a few long spines.
(3) Shell opens by **denticulate** mouth or **pylome**.
(4) Scales around mouth are produced into teeth-like processes.
(5) **Pseudopodia** are very fine, filiform **filopodia**, which are often branched.
(6) Cytoplasm is divided into **ectoplasm** and **endoplasm**.
(7) Endoplasm completely fills the test with no distinct demarcation of the ectoplasm.
(8) Endoplasm contains **shell plates**, **vacuoles**, and 1 to 2 **nuclei**, surrounded by perinuclear **chromidia** and contractile vacuole.
(9) It reproduces by **encystment**. Multiple fission is not evident.

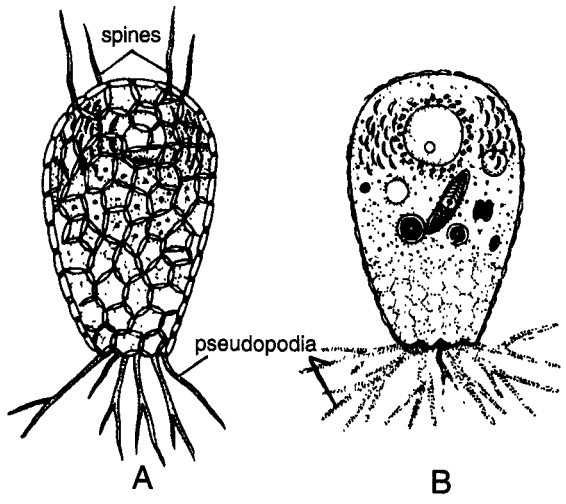


Fig. 19. *Euglypha alveolata.* **A.** Entire, **B.** Diagrammatic sagittal section.

Identification : Since the animal contains test, perinuclear chromidia and all above features, hence it is ***Euglypha***.

20. *Polystomella*

Classification :

Phylum..... Protozoa	→	Unicellular.
Sub-phylum..... Plasmodroma	→	Cilia absent, locomotion by pseudopodia.
Class..... Rhizopoda	→	Locomotion and feeding by pseudopodia.
Order..... Foraminifera	→	Chambered shell with slender anastomosing pseudopodia.
Genus..... *Polystomella (Elphidium)*		

Habit and habitat : ***Polystomella*** is a marine foraminiferan found at a depth of approximately 300 fathoms creeping about sea-weeds.

Distribution : It is a **deep-sea** form occurring in the littoral zone of the sea.

Comments :

(1) Body of the animal is enclosed in a small, **translucent**, oval or spherical yellow coloured **multichambered** shell, measuring 1 mm in diameter.

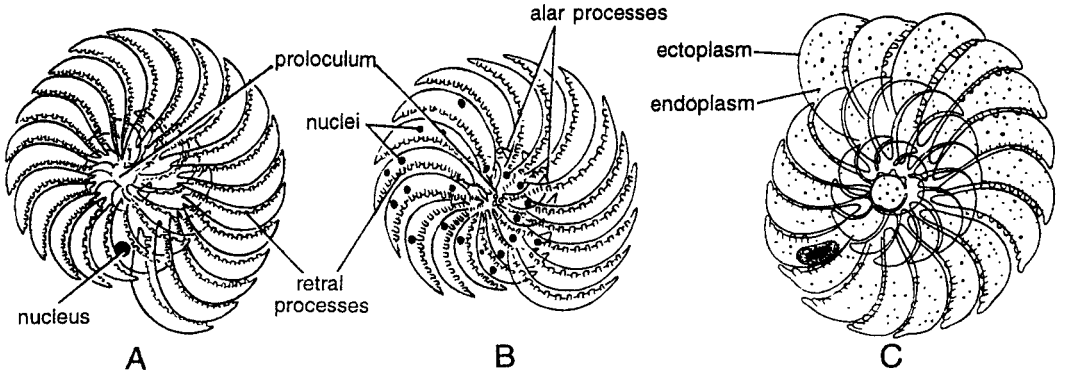


Fig. 20. *Polystomella,* **A.** Megalospheric form, **B.** Microspheric form, **C.** In living condition.

(2) Shell is made of calcium carbonate, silica and magnesium sulphate.
(3) Shell is coiled with V-shaped chambers, arranged spirally with beautifully chiselled surface. It is **polythalamous** or **multilocular** as it contains many chambers.
(4) Chambers are perforated by fine pores or foramina. **Cytosome** occupies all the chambers passing through the opening in the septa.
(5) **Protoplasm** is viscous and granular frequently with many small inclusions, lacks a distinct **ectoplasm** and contains one to many **nuclei.**
(6) From the chambers protrude several cytoplasmic processes, called as **retral processes**. The pseudopodia form a reticulum of filamentous threads. Animal starts life with one chamber termed as **proloculus** but with growth outflows from the main opening and secretes a new large chamber.
(7) Nutrition is **holozoic**. Animal feeds on diatoms and protozoans.
(8) Reproduction exclusively by **multiple division** involving alternation of generation.

Special features : ***Polystomella*** is **dimorphic** occurring in 2 forms : (i) **Megalospheric** form having single nucleus, large size with large proloculum. (ii) **Microspheric** form with many nuclei and small protoculus. (iii) **In living** condition **anastomosing** or branching **pseudopodia.**

Identification : Since the protozoan contains chambered shell and all above features hence it is ***Polystomella.***

21. *Globigerina*

Classification :

Phylum..... Protozoa	→	Unicellular.
Sub-phylum..... Plasmodroma	→	Cilia absent, locomotion by pseudopodia.
Class..... Rhizopoda	→	Locomotion and feeding by pseudopodia.
Order..... Foraminifera	→	Chambered shell with anastomosing pseudopodia.
Family..... Orbulinidae	→	Chambers are bulbous and spirally arranged.
Genus..... *Globigerina*		

Habit and habitat : ***Globigerina*** is one of the most common and abundant pelagic foraminifera.

Distribution : It has cosmopolitan distribution.

Comments :

(1) Peculiar rhizopod has **polythalamous,** calcareous and spiral **shell.**
(2) **Proloculus** is large (megalospheric) while other shells are ovoid and **spirally** arranged.
(3) Chambers of the shells are bulbous.
(4) **Cytosome** occupies all the chambers passing through the openings in the septa.
(5) From the shell, long, filamentous, viscous and contractile **pseudopodia** extend allround. They form pseudopodial network.
(6) Functionally pseudopodia are very important. They exhibit streaming movements. The food is caught and apparently paralyzed and digested at the point of capture.
(7) Their shells form one of the chief constituents of the **natural chalk.**

Special features : This form occurs in such countless numbers, that their empty shells falling to bottom accumulate to 2,500 to 4,500 meters deep, mixed with bottom mud. At still greater depth, the shells are

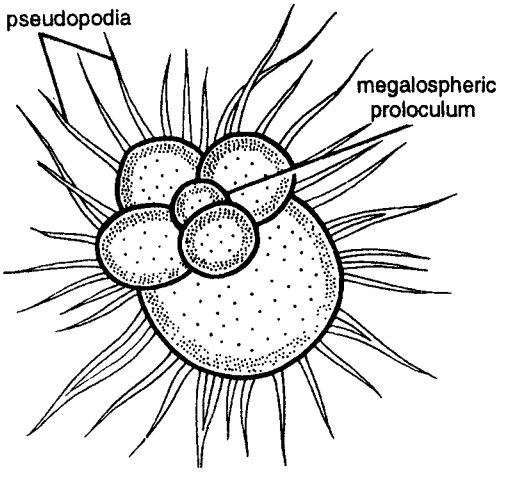
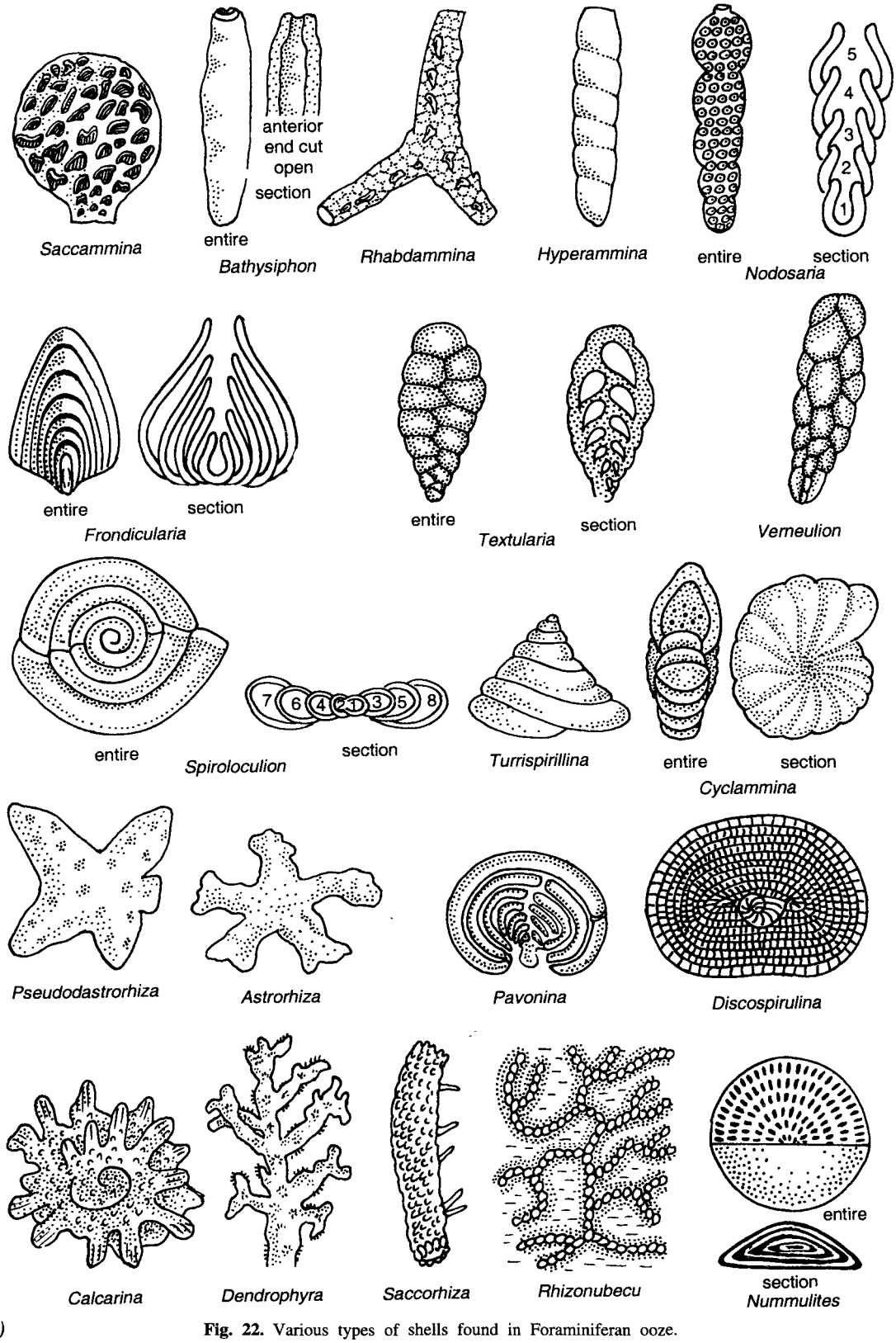


Fig. 21. *Globigerina.*



(Z–20)

Fig. 22. Various types of shells found in Foraminiferan ooze.

dissolved due to increased carbon dioxide and it has been found that about 50,000 foraminiferal shells may be found in one gram of ocean sand.

Identification : Since the protozoan contains spirally arranged bulbous shells and all above characters, hence, it is ***Globigerina.***

22. Foraminiferan ooze : Various Types of Shells

Classfication : Same as that of ***Globigerina.***

Habit and habitat : Foramina-bearing rhizopods are found in sea and fresh-water (Fig. 22).

Distribution : It has **cosmopolitan** distribution.

Comments :

(1) **Foraminifera** form small tests, composed of calcified, siliceous, gelatinous, chitinous material, sponge spicules and fragments of dead tissue.
(2) **Unilocular**, **multilocular** and **dimorphic** forms are found.
(3) **Shells** of dead foraminifera settle at the bottom, forming **foraminiferan ooze**, which cover about 4,80,00,000 square miles of present ocean bottom.
(4) Pre-cambrian shells of foraminifera have undergone fossilization forming rocks.
(5) **White chalk cliffs** of England, limestone beds of Paris and limestone ridges of North America are formed exclusively by foraminiferous shells.
(6) **Petroleum geologists** make a careful study of test-wells specimens to identify the **oil-bearing strata.**
(7) Various types of shells of the following genera are : ***Saccammina; Bathysiphon; Rhabdammina; Hyperammina; Nodosaria; Frondicularia; Textularia; Vermiculina; Spiroloculina; Turrispirilina, Cyclammina; Pseudastrorhiza; Astrorhiza; Pavonina; Discospirulina; Calcarina; Dendrophyra; Saccorhiza; Rhizonubecua; Nummulites.***

23. Radiolarian ooze

Classification :

Phylum..... Protozoa	→	Unicellular.
Sub-phylum..... Plasmodroma	→	Locomotion by pseudopodia or flagella.
Class..... Rhizopoda	→	Locomotion by pseudopodia.
Order..... Radiolaria	→	Skeleton of silicious granules.
Genus..... Radiolarian ooze		

Habit and habitat : These animals are exclusively deep sea forms (Fig. 23).

Distribution : Found in tropical and pacific oceans.

Comments :

(1) They look like **heliozoan** animals.
(2) Most of the animals contain **transparent** and symmetrical skeleton of silica and strontium sulphate.
(3) **Cytoplasm** divided into **cortex** and **medulla** through central capsule or chitinous membrane.
(4) Cortex vacuolated and pigmented having **symbiotic algae.**
(5) Cortex contains scattered siliceous spicules.
(6) Medulla has one to many **nuclei** and oil **globules.**
(7) When radiolarians die, their hard skeletons settle at the bottom of the sea and form **Radiolarian ooze.** In Pacific ocean the radiolarian ooze is found in 76,80,000 square miles.

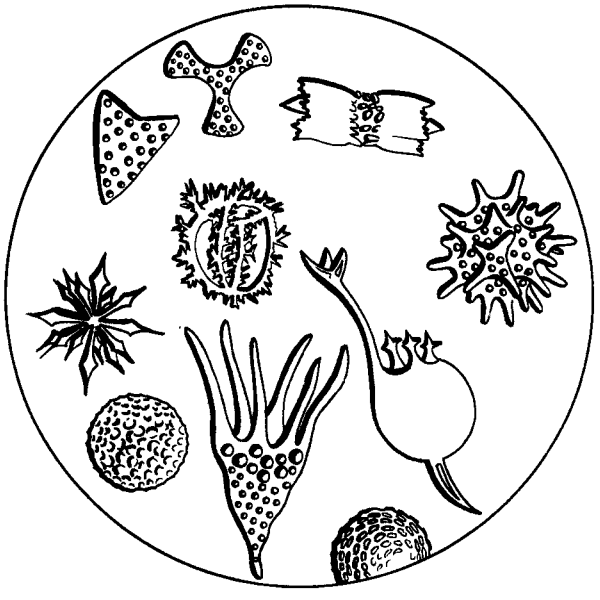


Fig. 23. Radiolarian ooze.

24. *Actinosphaerium*

Classification :

Phylum..... Protozoa	→	Unicellular.
Sub-phylum..... Plasmodroma	→	Cilia absent, locomotion by pseudopodia.
Class..... Rhizopoda	→	Locomotion and feeding by pseudopodia.
Order..... Heliozoa	→	Sun animalcules. Globular with stiff radiating pseudopodia.
Genus..... *Actinosphaerium*		

Habit and habitat : ***Actinosphaerium*** is a fresh water form, abundantly found among floating vegetation (Fig. 24).

Distribution : It has cosmopolitan distribution.

Comments :

(1) This **spheroid rhizopod** is commonly called as **sun animalcule**.
(2) Spherical cytosome is divided into a highly vacuolated **ectoplasm** or **cortex** and a denser granular central **endoplasm** or **medulla**.
(3) **Cortex** contains many **contractile vacuoles**.
(4) Distinct structures are **axopod pseudopodia** consisting of stiff axial rods clothed with a layer of streaming protoplasm.
(5) **Axial rods** comprising bundles of fibrils penetrate into medulla to terminate freely or on nucleus.
(6) **Endoplasm** or medulla is **multinucleated** and contains gelatinous secreted plates surrounded by tectinous lattice spheres, several nuclei and diatoms.
(7) Animals are very **slowly moving** because pseudopodia are meant for food capturing than locomotion.
(8) Nutrition **holozoic**. Small organism (food) when touches axopods, they adhere and quickly paralyze the prey or axopods having **food particles** shorten and convey to central mass.
(9) It reproduces by **binary fission** budding and gamete formation.

Identification : Since the animal contains ectoplasmic contractile vacuoles, radiating **axopodia** and all above features, hence it is ***Actinosphaerium***.

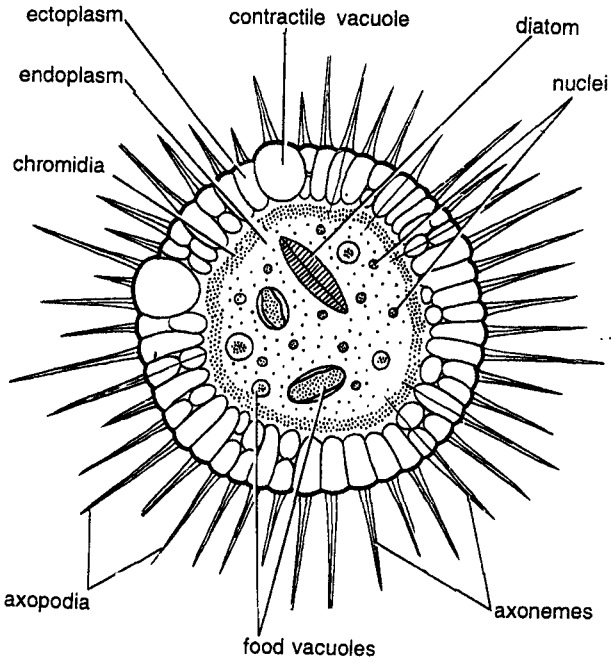


Fig. 24. *Actinosphaerium.*

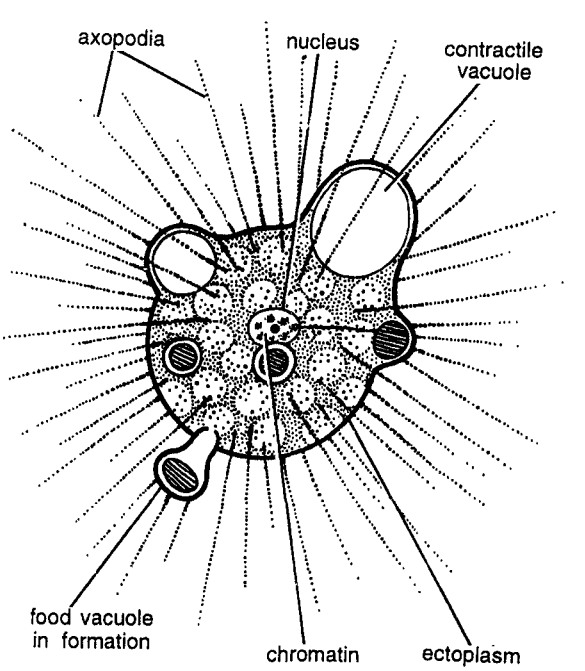


Fig. 25. *Actinophrys.*

25. *Actinophrys*

Classification : Same as that of ***Actinosphaerium***.

Habit and habitat : ***Actinophrys*** is a common, shell-less **Heliozoa**, found in sea as well as in fresh-water, floating among the vegetation or rolling over the bottom (Fig. 25).

Distribution : It has **cosmopolitan** distribution.

Comments :

(1) This **spherical rhizopod** is also known as **sun animalcule**.

(2) Spherical cytosome having frothy appearance is divided into thin **ectoplasm** and a denser granular **endoplasm**.

(3) It is **uni-nucleate** and measures 0.05 mm in diameter.

(4) **Pseudopodia** consisting of stiff **axial rods** or **axopods radiate** through the body in all directions. They are clothed with a layer of streaming protoplasm.

(5) Axial rods **(axopods)** converge from all sides on the nucleus.

(6) **Endoplasm** is gelatinous and contains various **vacuoles** and **food particles** besides a **single nucleus** which contains **chromatin**.

(7) **Sun animalcules** are very slowly moving protozoans, pseudopodia function to capture prey. Nutrition **holozoic**, whenever food or prey touches axopodia, they adhere to it. Axopodia paralyze the prey and at times shorten to convey to prey to central mass of cell.

(8) Reproduction by **binary fission**, **autogamy** or **paedogamy**.

Identification : Since, it contains axopodia around nucleus and all above features, hence it is ***Actinophrys***.

26. *Monocystis*

Classification :

Phylum..... Protozoa	→	Unicellular.
Sub-phylum..... Plasmodroma	→	Cilia absent, locomotion by pseudopodia.
Class..... Sporozoa	→	Internal parasites contractile vacuoles absent.
Sub-class..... Telosporidia	→	Trophozoite with one nucleus.
Order..... Gregarinida	→	Trophozoite extracellular.
Sub-order.....Eugregarinida	→	Schizogony absent, body undivided.
Genus..... ***Monocystis***		

Habit and habitat : ***Monocystis*** is the largest acephaline form, 4 mm in length and found as a parasite in seminal vesicles of earthworms (Fig. 26).

Distribution : Its has cosmopolitan distribution.

Comments :

(1) By preparing slide of the smear of seminal vesicle of earthworm following stages are observed under microscope.

(2) **Trophozoite stages :** Young trophozoites with attached sperm tail having **ectoplasm, endoplasm, myonemes, paraglycogen** granules and **nucleus.**

(3) **Mature trophozoite :** With sperm tails. They are cigar shaped measuring 200 microns in length and 70 microns in breadth. They have ectoplasm, endoplasm and nucleus along with myonemes.

(4) **Syzygy stage :** Two **manure trophozoites**, become reduced in size, attach themselves by their plasmamembranes and are called **Syzygy.**

(5) **Gametocyte stage :** Two syzygy stages become rounded and become surrounded by a **double walled secreted cyst wall** and are called as **Gametocyte stage.**

(6) **Gamete formation stage :** Young gamete stage-two **nuclei** of gametocytes repeatedly divide in young gamete stage. Later on the contact wall of both gametocytes disappears and gametes come closer. **Microgametes** and **macrogametes** could be differentiated.

(7) **Zygote :** Gametes fuse together to form zygote.

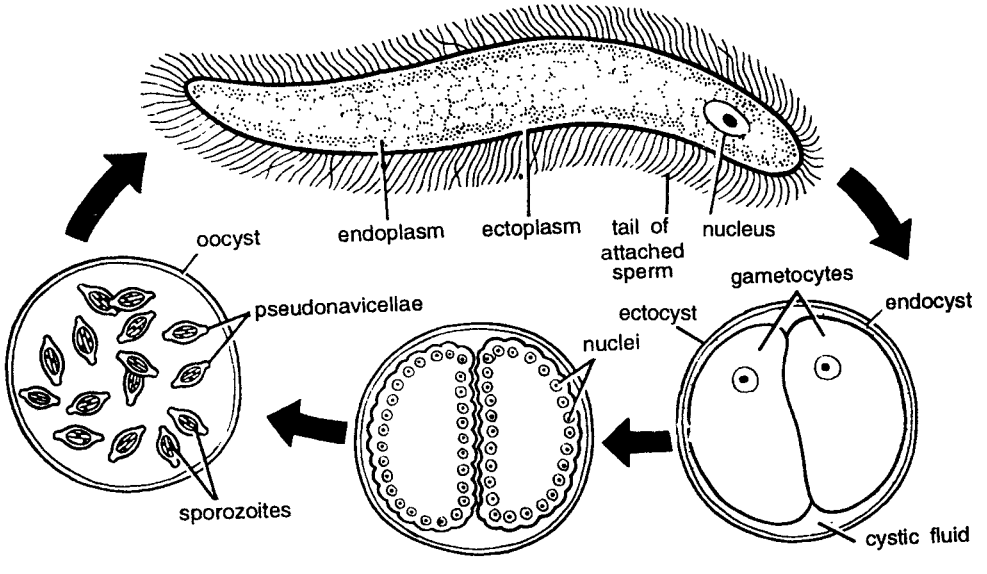


Fig. 26. *Monocystis.* Stages of life-cycle.

(8) **Zygote :** Divides into 8 **sporozoites** called as **sporocyst stage**, when earthworm dies. It liberates sporozoites which are eaten by fresh earthworms. Sometimes infected earthworms are eaten by birds and sporozoites come out as such along with faeces of birds. These sporozoites infect a new host.

Special features : Trophozoites of ***Monocystis*** is saprozoic. They move slowly by rhythmic contractions and expansions of myonemes. Fertility and reproduction of earthworm is not much affected by the presence of ***Monocystis*** in seminal vesicle.

Identification : Smear of seminal vesicle reveals above stages specially gametocyte and sporocyst stages hence it is ***Monocystis***.

27. *Gregarina*

Classification : Same as those of ***Monocystis***.

Genus.....*Gregarina*

Habit and habitat : ***Gregarina*** is an intracellular parasite found attached to the intestinal epithelial cells of cockroaches, meal worms, grasshoppers, crickets, crayfishes and centipedes (Fig. 27).

Distribution : Cosmopolitan.

Comments :

(1) ***Gregarina*** consists of **trophozoites, young trophozoites, syzygy** and **sporozoite** stages in the intestinal cells of above hosts.

(2) Various developing **young trophozoites** are attached to the intestinal cells.

(3) Adult trophozoite measures 130 to 450 microns in length and 100 to 120 microns in breadth.

(4) Adult trophozoite is composed of (i) anterior **epimerite** or cap having hooks for attack mail, (ii) middle **protomerete** and (iii) lower **deuteromerite**.

(5) Body of trophozoite contains **ectoplasm, endoplasm, nucleus** are glycogen granules.

(6) Outer most covering is **pellicle** having longitudinal **myonemes.**

(7) During conjugation two adult trophozoites or **sporont** attach together in head-tail tandem position called as **syzygy** upper one is called as **primite** and lower one **satellite**. Nucleii of both above divide forming gametes.

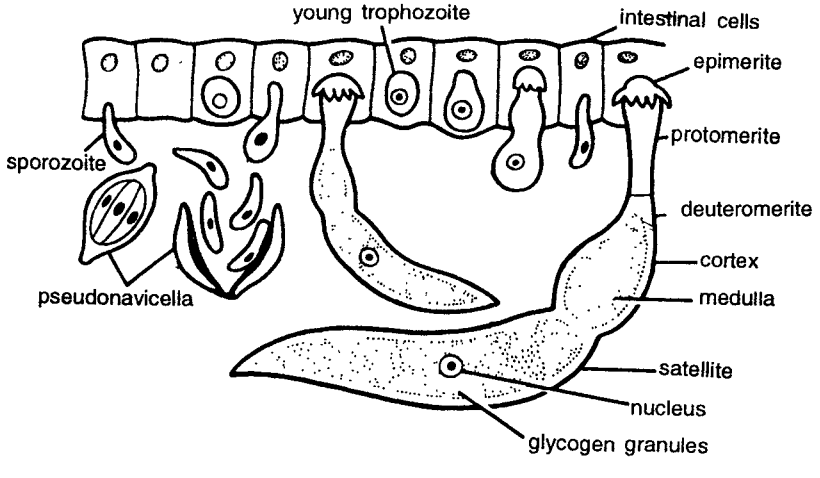


Fig. 27. *Gregarina.*

(8) Gametes fuse and form zygote. Each zygote divides and forms sporozoites or spore or **pseudonevicellas** stage having sporozoite is called **sporocyst** stage. Sporocyst bursts and sporozoites are liberated. They are passed to the exterior along with faeces of host. These sporozoites are eaten by new hosts and develop into adult parasite in the intestinal cells.
(9) Developing young **trophozoites** are seen in the intestine.
(10) Parasites destroy intestinal epithelial cells of the hosts.

Identification : Since trophozoite contains epimerate, protomerite, deuteromerete and all above features, hence it is ***Gregarina***.

28. *Eimeria* : *Coccidium*

Classification :

Phylum..... Protozoa	→	Unicellular.
Sub-phylum..... Plasmodroma	→	Cilia absent, locomotion by pseudopodia.
Class..... Sporozoa	→	Sexual reproduction by spores.
Sub-class..... Telosporidia	→	Spore cases simple.
Order..... Coccidia	→	Sporozoites capsulated.
Genus..... *Eimeria*		

Habit and habitat : ***Eimeria*** sp. is intracellular parasite inhabiting in the **epithelial lining** of alimentary canal and associated glands, liver, bile duct, kidney, testis, lining of blood vessels of several vertebrate host such as chick, rabbit, man and invertebrates (Fig. 28).

Distribution : Cosmopolitan.

Comments :

(1) **Life-cycle** consists of several asexual generation called **Merogony** and sexual generation called as **Anisogamy** in which **Sporozoites** are produced.
(2) **Life-cycle** takes place in the epithelial lining of alimentary canal or liver.
(3) **Mode of infection is oral :** Infective stage is sporozoite through soil or water sporozoites enter host through mouth. They reach epithelial cell of the intestine. Each sporozoite become rounded and changes into **Trophozoite**.
(4) **Nucleus** of trophozoite enlarges, divides mitotically repeatedly called **Merogony** and large number of **Merozoites** are released. **Merozoites** enter fresh cells to undergo fresh merogony. This is called **asexual schizogomy**.
(5) Asexual **merogony** occurs successively but under influence of immune **responses** (antibodies) the **merozoites** under transformation called as **sexual merozoites**.
(6) Sexual merozoites enter fresh cells of the epithelial lining, become rounded and differentiate into **microgametocyte** and **macrogametocyte**.
(7) Microgametocytes give rise to coma-shaped **microgametes** and **microgametocytes** give rise to **macrogametes**. Microgamete penetrates a macrogamete, fuses with it and forms **zygote**.
(8) Zygote is surrounded by a protein layer and becomes **Oocyst**. Oocyst is passed outside along with the faeces.
(9) Oocyst containing zygote divides and gives rise to 8 **sporozoites**. Sporozoites infect new host to continue the life-cycle.
(10) ***Eimeria stiedae*** is found in rabbit and ***Eimeria tenella*** in chicks.

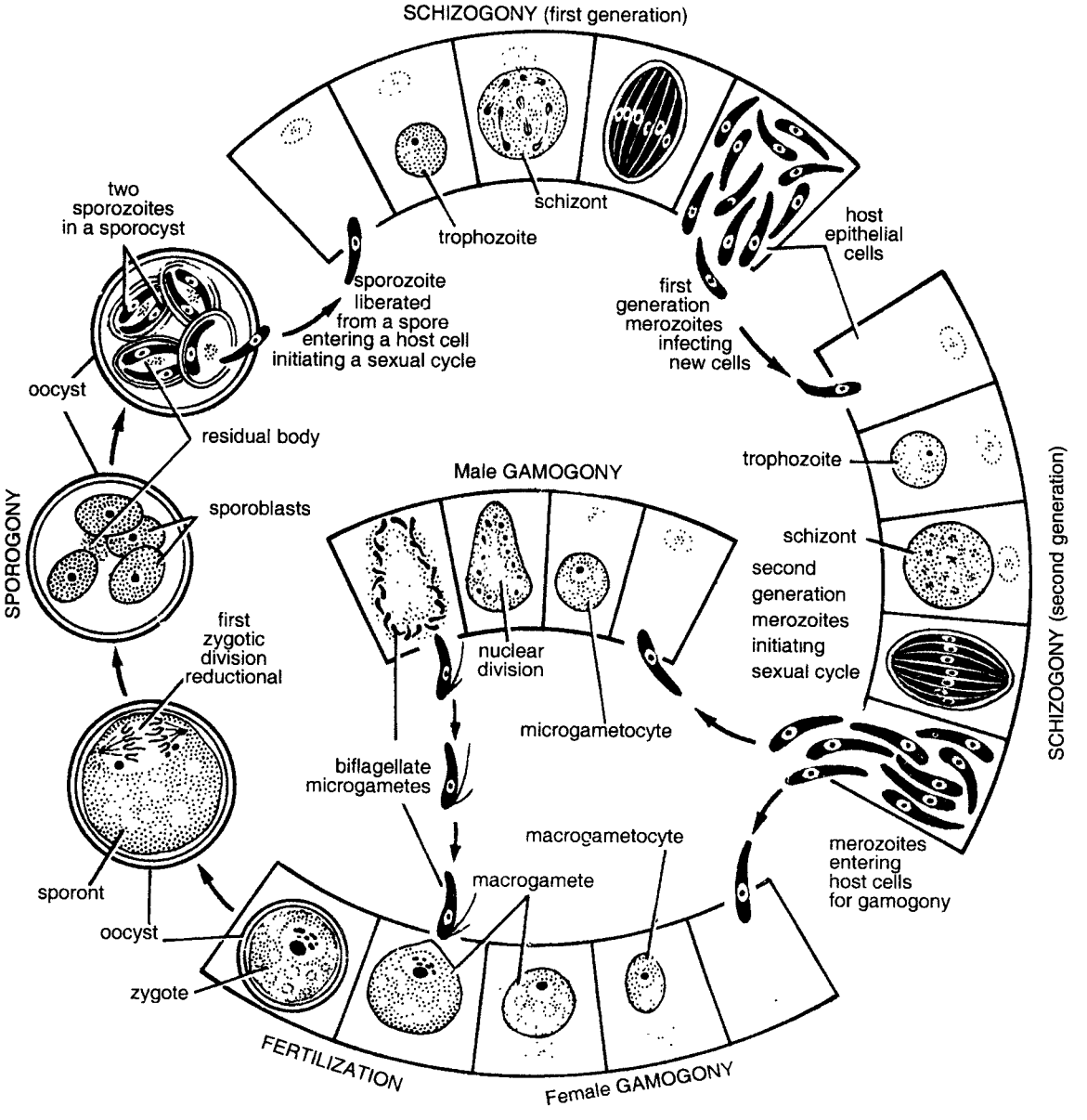


Fig. 28. *Eimeria.* Stages in life-cycle.

Pathogenesis : ***Eimeria*** destroys the mucous membrane of the intestine and also the liver cells and causes disease called as coccidosis.

Special features : ***E. stiedae*** causes **liver coccidiosis** of rabbits and is responsible for severe epidemic causing many deaths. Coccidiasis also causes diarrhoea.

Identification : Since the parasite has rounded trophozoite and all above features, hence it is ***Eimeria***.

29. *Plasmodium*

Classification :

Phylum..... Protozoa	→	Unicellular.
Sub-phylum..... Plasmodroma	→	Cilia absent, locomotion by pseudopodia.
Class..... Sporozoa	→	Internal parasites, contractile vacuoles wanting.
Sub-class..... Telosporidia	→	Naked or encysted spores, schizogony and sporogony.
Order..... Haemosporidia	→	Blood parasites, spores naked, schizogony and sporogony alternate.
Genus..... *Plasmodium*		

Habit and habitat : ***Plasmodium*** is an intracellular liver and blood parasite infecting man, monkeys and rodents. It causes very familiar disease called **malaria** with famous symptom of **chill** and **high fever** referred as **malarial fever**. Genus ***Plasmodium*** has 5 species infecting man **:** (i) ***P. vivax*** causing **tertian** or benign malarial fever, (ii) ***P. malariae*** causing quartem malaria, (iii) ***P. falciparum*** causing malignant tertian fever, (iv) ***P. ovale*** causing mild tertian fever, and (v) ***P. cyanomolgi*** monkey malarial parasite recently transferable to man. These days changing environmental conditions have resulted into falciparaziation of malaria. More and more people are getting ***P. falciparum*** infection. Some of male American Negroes having deficiency of glucose-6-phosphate dehydrogenase are not susceptible to ***P. falciparum*** infection. Similarly some persons having sicide-shaped anemia disease are resistant to ***P. falciparum*** infection (Fig. 29).

Distribution : World-wide.

Comments :

(1) **Commonly** called as **malarial parasite**.

(2) Life-cycle is **digenetic** involving man as **intermediate host** and **mosquito** as definitive host. Life cycle includes 3 phases.

(3) (i) **Exoerythrocytic** (EE) **phase** in liver of man, (ii) **Erythrocytic schizogony** in erythrocytes, (iii) **Sexual phase** starting with development of gametocytes in man (**microgametocytes** and **macrogametocytes**) and gametogenesis (**microgamete**, **macrogamete**) fertilization and **sporogony** in mosquito.

(4) Mode of infection is **skin penetration**. Infective sporozoites are injected into skin during mosquito bite. **Sporozoites** reach liver; they undergo **EE schizogony**. Nucleus of sporozoite divides repeatedly and gives rise to **Merozoites**.

(5) Merozoites leave liver and reach blood for **erythrocytic schizogony**. Merozoites are responsible for causing **parasitemia**, **chill** and **high fever**. They undergo through successive stages such as **trophozoite**, **signet ring stage**, **amoeboid stage**, **rosette stage** and then again **merozoites**.

(6) After successive breeds of merozoites, certain merozoites differentiate into **microgametocyte** and **macrogametocytes** which do not develop further in man's blood and require invertebrate mosquito host. Whenever mosquito bites man, it not only **injects** several sporozoites but also **sucks** several gametocytes.

(7) Gametocytes reach stomach of mosquito in the epithelial cells where they undergo gametogenesis.

(8) Microgametocytes or male gametocyte gives rise to 6 spindle shaped **exflagellated microgametes**. Macrogametocyte or female gametocyte gives rise to female macrogamete.

(9) Microgamete enters macrogamete, nuclei fuse and **zygote** or ookinete is formed.

(10) Ookinete undergoes sporogony, nucleus divides repeatedly forming large number of sporozoites.

Pathogenesis : Main clinical features of malaria are as follows **:** (a) **Hot stage Fever :** This is referred as malarial **paroxym**. It lasts for 6 to 10 hours and has 3 stages— (i) **Chill** and **cold** lasting about 20 minutes to 1 hour, (ii) Hot stage causing fever **pyrexia** or **hyper pyrexia** from 1 to 4 hours and (iii) the **sweating stage** lasting 6 to 10 hours, (b) Anaemia; (c) **Hyperplasia** of reticulo-endothelial system; (d) **Immunosupression**; (e) Spleen is enlarged.

Prophylaxis (prevention) and treatment : The mosquito nets be used to prevent bite of infected mosquitoes. The breeding places of mosquitoes be kept clean by insecticides, etc. The treatment with drugs-these days quinine, mepaerine, chloroquine, camoquin, pamaquine, paludrine and daraprin are used.

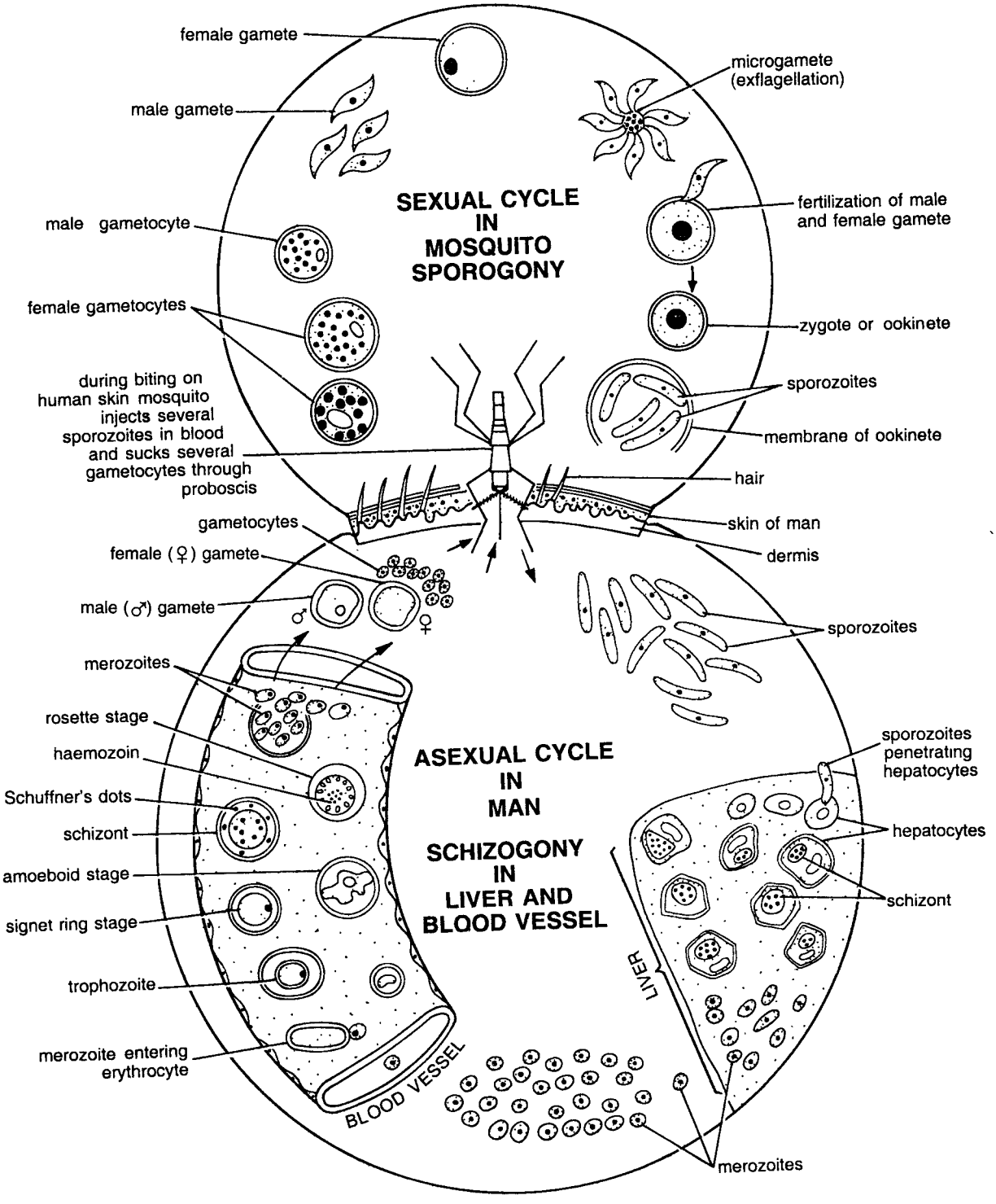


Fig. 29. Life-cycle. *Plasmodium vivax.*

30. *Opalina*

Classification :

Phylum.....Protozoa	→	Unicellular.
Sub-phylum..... Plasmodroma	→	Cilia absent, locomotion by pseudopodia.
Class..... Opalinata	→	Cilia-like organelles in oblique rows.
Genus..... ***Opalina***		

Habit and habitat : Opalinids are **entocommensals** in intestine and rectum of tadpoles and adult anuran amphibians (frogs and toads) and occasionally other cold blooded vertebrates.

Distribution : It has **cosmopolitan** distribution.

Comments :

(1) **Commonly** referred as **rectal ciliate.**

(2) Body is simple oval, strongly flattened and measuring 400 to 500 microns in length. It differs from typical ciliates almost in every respect except **cilia** which completely cover the body.

(3) **Mouth** and **contractile vacuole** absent.

(4) Cytoplasm is differentiated into outer **ectoplasm** and inner **endoplasm.** Ectoplasm is further differentiated into outer thin **pellicle** and inner layer having longitudinal contractile **myonemes.**

(5) Endoplasm contains several **cell organelles** specially several **small nuclei** hence called as **multinucleated form.**

(6) ***Opalina*** is **multinucleated.**

(7) Reproduction is by **binary fission** and by **gamete** formation.

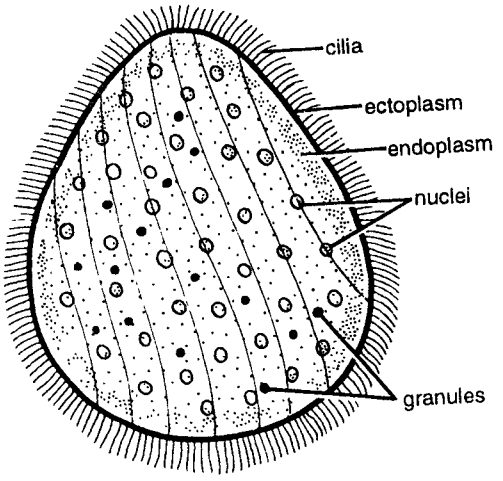


Fig. 30. *Opalina.*

(8) At the time of egg laying of their hosts, the ***Opalina*** divide into small forms, the **encysted** form pass out in the faeces and when ingested by **tadpoles**, excyst and then divide into anisogamous gametes. The **zygote** either encysts again and passes out to infect other tadpoles or at once develops into the adult.

(9) The species are ***O. ranarum*** and ***O. obtrigonoidea.***

Identification : Since the animal has oval flattened body, **uniform small cilia** and all above features, hence it is ***Opalina.***

31. *Paramecium*

Classification :

Phylum.....Protozoa	→	Unicellular.
Sub-phylum..... Ciliophora	→	Ciliary movement in all stages.
Class..... Ciliata	→	Cilia present throughout life.
Sub-class..... Euciliata	→	Cytopharynx, contractile vacuole, mega and micronucleus present.
Order..... Holotricha	→	Equal cilia.
Sub-order.....Trichostomata	→	Mouth leads in cytopharynx.
Family..... Paramecidae	→	Oral groove present.
Genus..... ***Paramecium***		

Habit and habitat : ***Paramecium*** is best known ciliate, found in fresh-water ponds, rivers, lakes, ditches, streams and pools, etc. (Fig. 31).

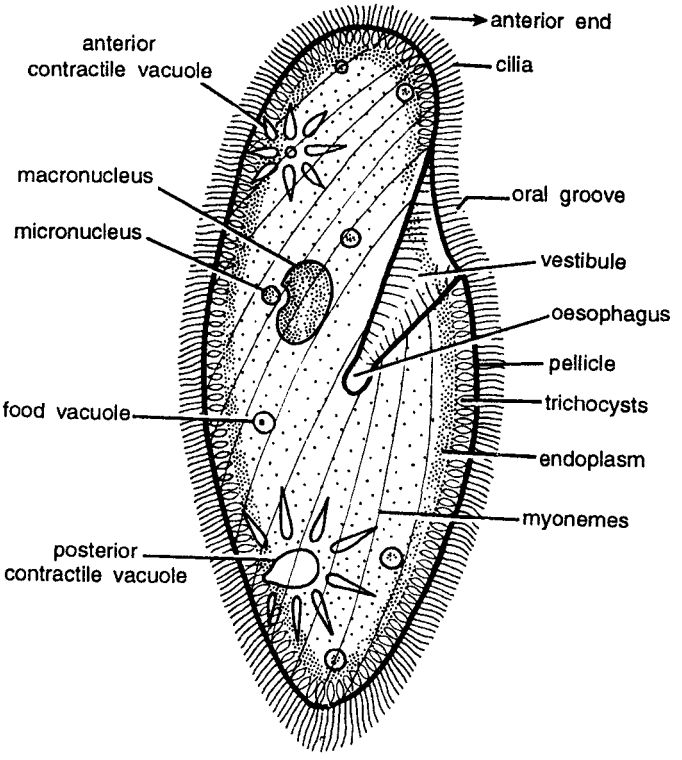


Fig. 31. *Paramecium.*

Distribution : It has cosmopolitan distribution.

Comments :

(1) **Commonly** called as **slipper animalcule**, being microscopic, elongated slipper-shaped, cigar-shaped or spindle shaped.

(2) Most familiar and extensively studied protozoans.

(3) Anterior end is bluntly rounded, while posterior end is pointed.

(4) ***P. caudatum*** measures 80 to 350 microns, while ***P. aurelia*** 170 to 290 microns.

(5) **Pellicle** covers the body. It is clear, firm and elastic cuticular membrane. Pellicle has series of polygonal or hexagonal depressions for **trichocysts.**

(6) **Cilia** covers the entire animal. They are hair-like projections of uniform length, except at posterior end where they are longer and at cytopharynx where they form undulating membrane.

(7) Infraciliary system consists of **basal bodies** and **kinetodesmata.**

(8) Cytoplasm contains **ecto-** and **endoplasm.** Ectoplasm has **myonemes** and **rod-shaped trichocysts.** Endoplasm contains **food vacuoles, granules, meganucleus, micronucleus, anterior contractile, posterior contractile vacuole, fat** and **glycogen.**

(9) Trichocysts are rod-shaped bodies consisting of lower trichocyst shaft, basal body and projecting **cilium.** Cilium project through the hexagonal areas. Trichocysts are discharged to anchor with substratum.

(10) Reproduction is **by binary fission, conjugation, endomixis, hemixis** and **automixis.**

(11) Locomotion is **ciliary.** Nutrition is **holozoic** and it shows response to light and temperature, etc.

Special features : ***Paramecium*** has great experimental value in cytogenetical studies. T.M. Sonneborn (1938) reported that ***P. aurelia*** occurs in two strains. One with **Kappa particles** kills the other sensitive strain without Kappa particles. ***P. aurilia*** is taken as example to explain cytoplasmic inheritance.

Identification : Since the animal contains slipper-shaped body and 2 contractile vacuoles which are star-shaped and has all above features, hence it is ***Paramecium***.

32. *Paramecium* in Binary Fission

Comments :

(1) Asexual reproduction by binary fission takes place under favourable temperature and other conditions.
(2) **Micro** and **macro-nuclei** elongate and divide by mitosis and amitosis respectively (Fig. 32).
(3) Division is by transverse constriction.
(4) Dividing line passes at right angles to longitudinal axis.
(5) Constriction deepens; dividing the cell into halves. Each half has a daughter nucleus and a contractile vacuole.
(6) Buccal groove is also divided into two, and in both individuals the missing parts of buccal groove develop.
(7) By the time separation takes place, each half develops essential structures and thus two individuals are formed.

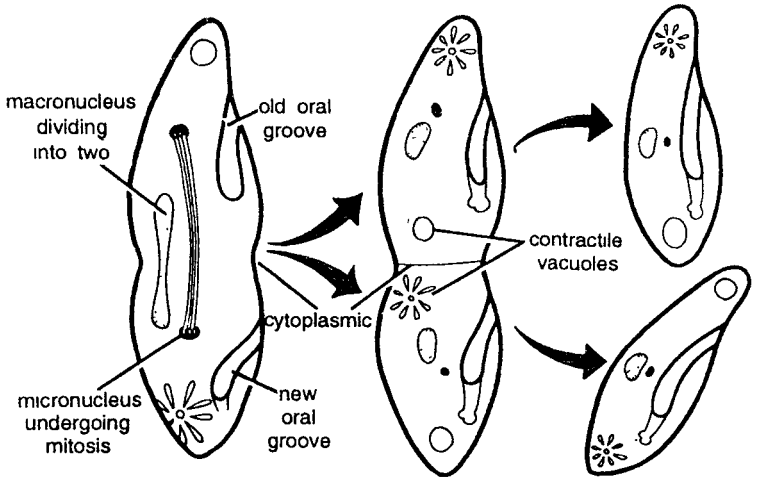


Fig. 32. *Paramecium.* Binary fission.

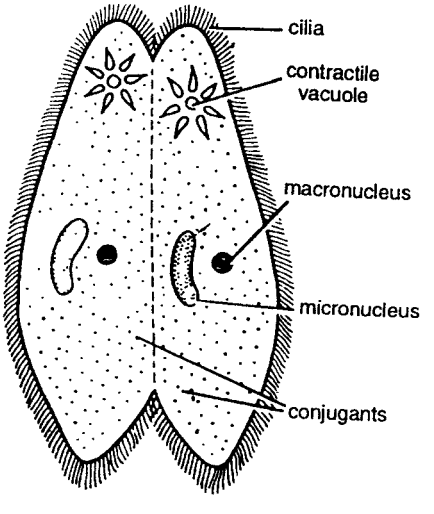


Fig. 33. *Paramecium.* Conjugation.

33. *Paramecium* in Conjugation

Comments :

(1) **Conjugation** constitutes the sexual part of the reproduction (Fig. 33).
(2) Two individuals come in contact for mating and unite by their own grooves.
(3) Pellicle between two forms is disintegrated; but they swim together and are called as conjugants or gametocytes.
(4) In each conjugant **macronucleus** disappears and the **micronucleus** divides twice forming 4 haploid daughter micronuclei.
(5) Three daughter micronuclei out of four disintegrate in each conjugant, while remaining one divides into two unequal daughter **pronucleus**. The smaller one is called as active potential male migratory pronucleus, while the larger one is called as stationary female pronucleus.

(6) Migratory male **pronucleus** of one conjugant moves through the protoplasmic bridge into other conjugant and fuses with **stationary female** nucleus to form zygote and vice versa.
(7) Zygote nucleus is **diploid** and is called as **synkaryon** or **amphinucleus**. This kind of complete union of two nuclei of different individuals is known as **amphimixis**.
(8) After this, nuclear division continues and after a series of changes, four adult paramecia are formed.
(9) Process of conjugation is conditioned as it occurs in deficiency of nutrition, at a certain temperature and forms smaller individuals.
(10) Conjugation occurs in different strains. **Conjugation** has important significance, as it imparts **rejuvenation** and nuclear **reorganisation**, and also facilitates in transference of hereditary materials. It is also helps in the formation of better, resistant paramecia.

34. *Balantidium*

Classification :

Phylum..... Protozoa	→	Unicellular.
Sub-phylum..... Ciliophora	→	Ciliary movement in all stages.
Class..... Ciliata	→	Cilia present throughout life.
Sub-class..... Euciliata	→	Cytopharynx, contractile vacuole, mega- and micronucleus present.
Order..... Spirotricha	→	Adoral membranelles extending around peristome in clockwise direction.
Sub-order..... Heterotricha	→	Short cilia over whole body.
Genus..... *Balantidium*		

Habit and habitat : ***Balantidium*** is commonly found in the intestines of pigs, sheep, camels, opossums, ostriches, cockroaches and man. It is abundantly found in the rectal content of the frog.

Distribution : Cosmopolitan.

Comments :

(1) It is **motile** and spherical in shape, measuring 60 to 70 microns in length and 40 to 60 microns in breadth.
(2) Entire body of the parasite is covered by longitudinal slightly **spiral** rows of **cilia**.
(3) At the anterior end is a large peristomal depression or vestibule or **cytopharynx** leading to mouth or cytostome.
(4) **Cytosome** contains long cilia.
(5) Cytoplasm is differentiated into **ectoplasm** and **endoplasm**.
(6) Endoplasm includes spherical small **micronucleus** attached to elongated sausage-shaped **macronucleus**, **contractile vacuole**, **food vacuole** and a posterior permanent **cytopyge or anus**.
(7) Nutrition is **holozoic**.
(8) Reproduction is by **binary fission** and **conjugation**.

Economic status : The pathogenic species is ***B. coli,*** found in the colon of men, monkeys and pigs. It causes **ulcers** and **dysentery**. The natural host for ***B. coli*** is the pig in which it is transmitted in the encysted state. Human beings who handle pigs become infected by the cysts. The cysts react with intestinal epithelium where they cause pathological changes. ***B. coli*** of pigs serve as biological control for nematode larvae.

Identification : Since the parasite has slit like vestibule and all above feature hence it is ***Balantidium***.

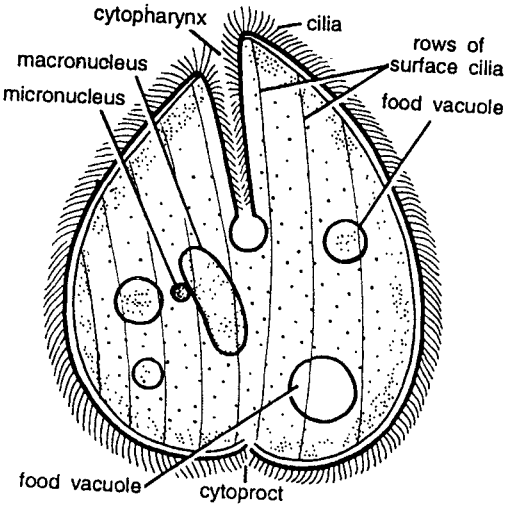


Fig. 34. *Balantidium.*

35. *Nyctotherus*

Classification : Same as that of ***Balantidium***.

Genus.....*Nyctotherus*

Habit and habitat : ***Nyctotherus*** is **endocommensal** in the alimentary canal of cockroaches, crickets, myriapods, fishes, amphibians and mammals. It is commonly found associated with other rectal ciliates ***Balantidiun*** and ***Opalina***. This commensal is occasionally found in man.

Distribution : Cosmopolitan.

Comments :

(1) Body is bean-shaped dorsoventrally flattened and measuring 60 to 120 microns in length.

(2) **Ectoplasm** and **endoplasm** are clearly distinguished, the former containing **pellicle** and **contractile vacuoles**, while the later having **food particles, fat, glycogen granules, macronucleus** and **micronucleus**.

(3) Cytostome leads into a coiled **cytopharynx**. Cytopharynx contains **long cilia**.

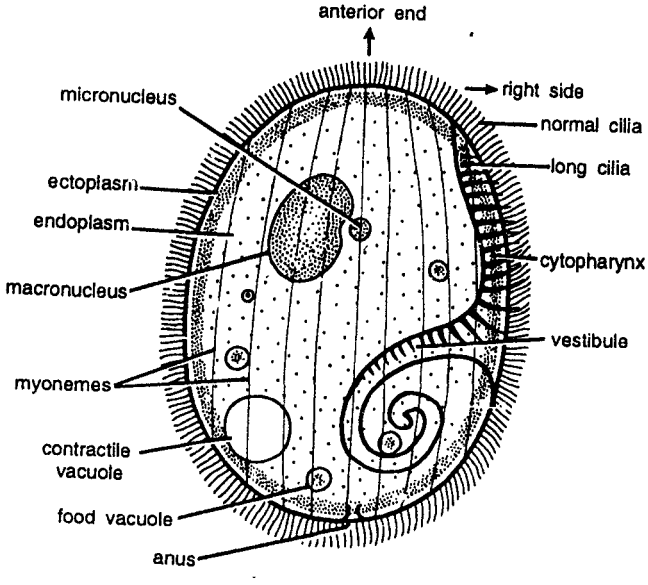


Fig. 35. *Nyctotherus.*

(4) Permanent **cytopyge** is present posteriorly.

(5) Reproduction is by **binary fission** and **conjugation**.

(6) ***Nyctotherus cordiformis*** multiplies by binary fission in the rectum of frog tadpoles. When the tadpole is about to metamorphose, smaller preconjugant forms arise which pair and exchange nuclear material. The large exoconjugant found in the rectum of newly metamorphosed frog undergo binary fission which become encysted. The cyst hatch when eaten by tadpoles.

Identification : Since the protozoan contains coiled cytopharynx and all above features, hence it is ***Nyctotherus***.

36. *Stentor coerules*

Classification : Same as that of ***Balantidium***.

Genus.....*Stentor*

Species.....*coerules*

Habit and habitat : ***Stentor*** is commonly found in freshwater, rich in vegetation. It is a large ciliate having a sky-blue pigment called as **stentorin** (Fig. 36).

Distribution : Cosmopolitan.

Comments :

(1) It measures 1 to 4 mm in length and is oval or pyriform in shape.

(2) Body is differentiated into **ectoplasm** and **endoplasm**.

(3) Body is covered by **cilia**, arranged in colourless, striped areas, alternating with blue granular areas.

(4) Anteriorly, the body is produced into **ramose pseudopodia**, which act as hold-fast organ.

(5) Anterior end also contains a coiled **cytostome**.

(6) Animal may be oriented by considering the part of the frontal field nearest the **cytostome**.

(7) **Endoplasm** contains **macronucleus** and **micronucleus, food vacuoles** and **contractile vacuoles.**

(8) During fission and conjugation the macronucleus may assume a vermiform or rounded appearance.

Identification : Since the animal has coiled cytosome and all above features, hence it is ***Stentor***.

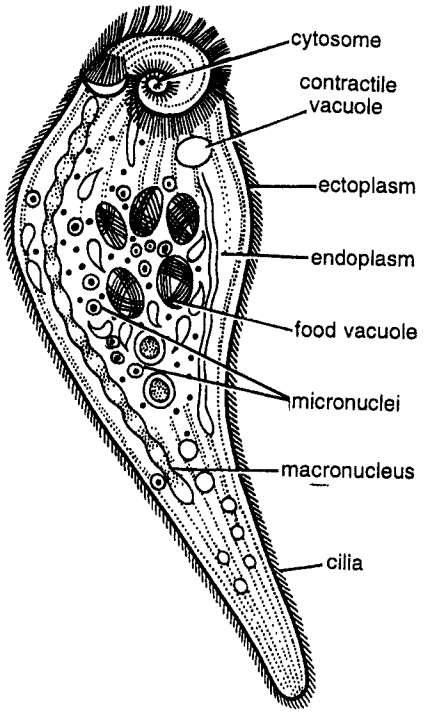


Fig. 36. *Stentor coerules.*

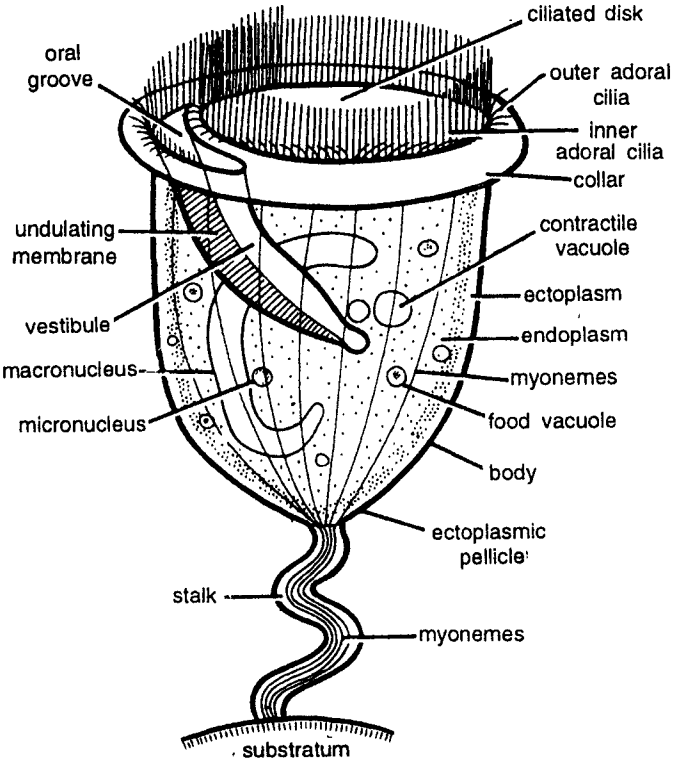


Fig. 37. *Vorticella.*

37. *Vorticella*

Classification :

Phylum..... Protozoa	→	Unicellular.
Sub-phylum..... Ciliophora	→	Ciliary movement in all stages.
Class..... ..... Ciliata	→	Cilia present throughout life.
Sub-class..... Euciliata	→	Cytopharynx, contractile vacuole, mega and micronucleus present.
Order..... Peritricha	→	Sedentary; aboral cilia in spiral, clockwise fashion.
Genus..... *Vorticella*		

Habit and habitat : ***Vorticella*** is solitary, stalked and abundant ciliate, found in rivers, ponds, attached to weeds, stones, aquatic worms, fishes and amphibians by means of its stalk.

Distribution : It has cosmopolitan distribution (Fig. 37).

Comments :

(1) ***Vorticella*** is **commonly** called as **bell-animalcule**.

(2) Body is bell-shaped with a contractile stalk attached to **substratum**.

(3) It measures 150 microns in length, excluding **stalk**, which measures 50 to 4,150 microns in length.

(4) Free end of the body is typically flattened bell or vase shaped called as disc, which is slightly convex, having vestibular opening on the side.

(5) Cytoplasm is differentiated into **ectoplasm** and **endoplasm**.

(6) **Peristome** contains 2 rows of spirally coiled cilia, called as **outer adoral cilia** and **inner adoral cilia** forming **ciliated disk**. Peristome leads into oral **groove** which is continued into **vestibule**. **Vestibule** has **undulatory membrane**. Ciliated disc rests on **collar**.

(7) **Ectoplasm** is devoid of trichocysts and contains **pellicle** and **contractile myonemes.**
(8) Endoplasm is exclusively in body proper, and possesses **food particles,** long and **curved macronucleus** and **small micronucleus** and **cytopyge.**
(9) Locomotion is rapid by stalk and cilia. Nutrition is **holozoic.** ***Vorticella*** responds to external stimuli.
(10) Reproduction is by **binary fission** and occasionally by conjugation. The species known are ***V. campanula*** **and** ***V. canvallaria.***

Identification : Since the protozoan has bell-shaped body with 2 rows of spirally coiled cilia, hence it is ***Vorticella.***

38. *Ephelota*

Classification :

Phylum..... Protozoa → Unicellular.
Class..... Suctoria → Adults without cilia.
Genus..... *Ephelota*

Habit and habitat : ***Ephelota*** is a microscopic marine form.
Distribution : Cosmopolitan.
Comments :

(1) Body is spherical and **pedicellate** not seated in a cup.
(2) Cytoplasm contains **ectoplasm** and **endoplasm.**
(3) Distal end contains two kinds of **tentacles :** (i) **long tentacles** which are meant for piercing, and (ii) **short tentacles** which are meant for sucking.
(4) The **endoplasm** contains **meganucleus, micronucleus,** other granules and **contractile vacuole.**
(5) The bud detaches from parent body and develops into adult.
(6) Reproduction is by **exogenous budding.** The distal end is produced into several buds containing extensions of nucleus.

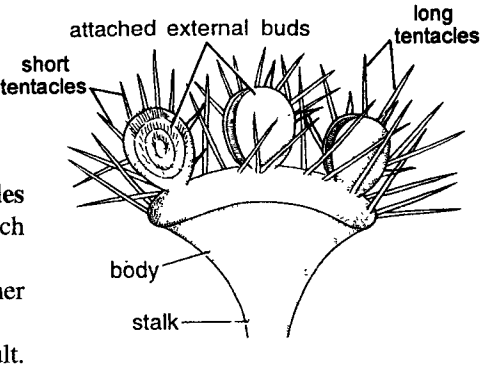


Fig. 38. *Ephelota gigantia* forming exogenous buds.

Identification : Since the animal has above features, hence it is ***Ephelota.***

PHYLUM PORIFERA

Cellular Grade of Construction

After protozoans Porifera (sponges) evolved having cellular grade of organization and diploblastic with ectoderm and endoderm layers. In cellular grade different cells perform different functions. Ectoderm and endoderm are bound to mesenchyme.

39. *Sycon* : L.S.

Comments : *Observe the following histological details.*

(1) Body wall layers are of **cellular organization** and **diploblastic** consisting of loosely organized layers (Fig. 39).
(2) Outer one is **ectoderm,** inner **endoderm** and both bounding to intermediate **mesenchyme.**

(3) Ectoderm or dermal epithelium is made up of large, flattened, sacciform polygonal, contractile ectoderm cells, closely cemented together, and perforated by dermal pores or **ostia**. It also lines the incurrent canals.
(4) **Mesenchyme** forms bulk of the sponge body and is made up of gelatinous matrix in which different kinds of **spicules** (monaxon, triaxon) and various cells like **collenocytes, chromocytes, scleroblasts, archaeocytes**, germ cells and gland cells are present.
(5) Endoderm forms lining of **flagellated chambers** and consists of **collar cells** or **choanocytes.**
(6) **Prosopyles** communicate with incurrent canals and **flagellated chambers.**
(7) Flagellated chambers open in the central **spongocoel by apopyles.**
(8) **Spongocoel** opens to outside by **osculum.**
(9) **Syconoid canal system** well developed for feeding and carrying out various physiological activities.
(10) Water circulates through **ostia → incurrent canal prosopyles → radial canal → apopyles spongocoel → osculum → exterior** (out).

Identification : Since the section contains finger like radial canals without dermal cortex and all above features, hence it is L.S. ***Sycon***.

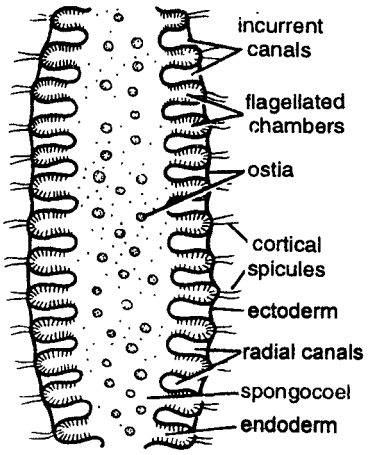


Fig. 39. *Sycon.* L.S.

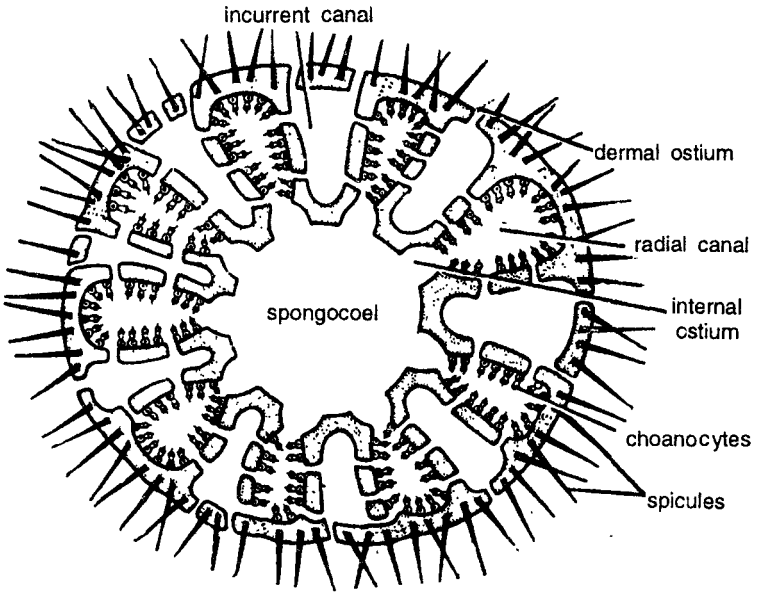


Fig. 40. *Sycon.* T.S.

40. *Sycon* : T.S.

Comments : *The transverse section of* ***Sycon*** *will reveal the same histological details as L.S.* ***Sycon.***

(1) It is circular in outline, diploblastic and the body wall layers are outer **ectoderm**, middle **mesenchyme** and inner **endoderm** (Fig. 40).
(2) **Ectoderm** or dermal epithelium is perforated by **dermal pores** or **ostia** and lined by **pinacocyte cells.**
(3) Mesenchyme is a gelatinous thick layer and contains **monaxon spicules, collenocystes, amoebocytes, archaeocytes, and scleroblast cells, etc.**
(4) **Endoderm** forms the lining of the **radial canals** and is made of **flagellated** or **choanocyte cells.**
(5) **Radial canals** alternate with **incurrent canals**, which are communicated by **prosopyles**. The radial canal opens into the **spongocoel** by internal ostium or **apopyles.**

(6) In a T.S. of ***Sycon*** the out-pushing or finger-like projections of **flagellated chambers** are quite distinct in circular way. Each choanocyte cell contains a basal body, having a nucleus and a single flagellum.
(7) **Canal system syconoid** type. The course of water current is **ostia → incurrent canal → prosopyle → radial canal → apopyle → spongocoel → osculum → exterior.**

Identification : Since the section has finger-like flagellated chambers alternating with incurrent canals and all above features, hence it is T.S. ***Sycon.***

41. *Grantia* : L.S.

Comments : *L.S. through* ***Grantia*** *shows the following histological details.*
(1) Section show **cellular grade organization** and **diploblastic pattern.**
(2) Body wall layers are made up of **outer ectoderm** intermediate **mesenchyme** and inner **endoderm** cells.
(3) **Ectoderm** or dermal epithelium is made up of spindle-shaped **pinacocyte cells** perforated by dermal pores or external **ostia.**
(4) ***Grantia*** differs from ***Sycon*** only in the development of dermal cortex, which occupies the incurrent canal spaces.
(5) Dermal membrane spreads on entire surface forming **cortical zone**, which is provided with cortical spicules.
(6) With the development of **dermal cortex**, **incurrent canals**, are channelised and become irregular and branched forming definite incurrent canals, which communicate with radial canals by **prosopyles.**
(7) **Mesenchyme** is a gelatinous matrix, containing **amoebocytes, archaeocytes, germ cells, gland cells, scleroblast cells, collenocyte cells** and **spicules.**

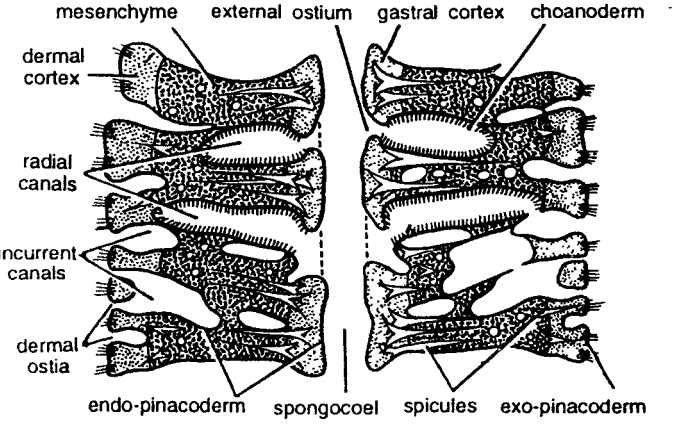


Fig. 41. *Grantia.* L.S.

(8) **Endoderm** forms lining of radial canals having choanocyte cells. The radial canals also become **branched** at their outer ends and open into the spongocoel by internal ostia or apopyles.
(9) **Canal system syconoid :** Water current passes through external **ostia** → definite **incurrent** water tubes → **prosopyles → radial canal → apopyle → spongocoel → osculum → exterior (out).**

Identification : Since the section has dermal cortex, irregular radial canals and definite incurrent canals and all above features, hence it is L.S. ***Grantia.***

42. *Grantia* : T.S.

Comments :
(1) Body wall layers are of **cellular grade organization** and **diploblastic** (Fig. 42).
(2) Outer layer in **ectoderm** and **endoderm** bound to intermediate mesenchyme.
(3) **Ectoderm** is made up of **pinacoderm cells** perforated by **ostia.**
(4) Ostia open into **incurrent canal** which communicated with **radial canal** by **prosopyles.**
(5) Radial canal contains **choanocytes** or **flagellated cells.** Radial canal opens into spongocoel by apopyle.
(6) **Dermal cortex** well developed leading into irregularly shaped incurrent canals.

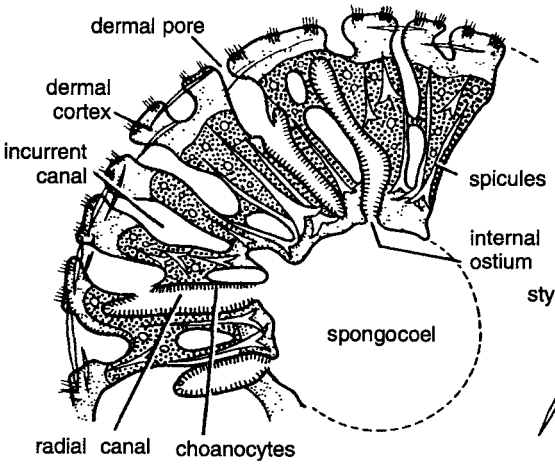


Fig. 42. *Grantia.* T.S.

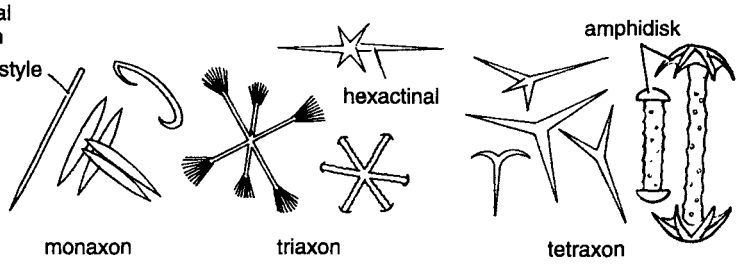


Fig. 43. Spicules.

Identificaion : Since the dermal cortex and definite incurrent canals are seen in circular manner, hence it is T.S. ***Grantia***.

43. Spicules of Sponges

Comments :

(1) Sponge body wall is supported by various minute, crystalline and calcareous bodies called as **spicules**, which are secreted by special mesenchymal cells called as **scleroblasts** (Fig. 43).

(2) Spicules provide taxonomic character and are classified according to the axes and rays, spoken of as axon, **actine** or **actinal** respectively.

(3) Spicules are of two types : (i) **Megascleres** or supporting skeleton, (ii) **Microscleres** small and non-supporting. Kinds of Megascleres are as follows :
   (i) **Monaxon** consists of a single axis, straight or curved. They may be styles, rhabds and tylots.
   (ii) **Tetraxon** consists of four rays. It also includes triradiate or triactinal spicules.
   (iii) **Triaxon** consists of three axes.
   (iv) **Polyaxon** having several equal rays. **Amphidisk spicules** are found in fresh-water sponges. In this type, the rhabdom contains disks at both ends. The arrangement of different types of spicules could be seen in ***Sycon***.

(4) Microscleres are found throughout the mesenchyme and include spires and asters.

(5) Spicules support and protect the body. They are helpful in identification, classification and metabolism.

Identification : The clear transparent monaxon or triaxon spicules indicate **spicules of sponges**.

44. Gemmules

Comments :

(1) **Gemmules** are **asexual reproductive** bodies forming a part of regular life-cycle (Fig. 44).

(2) **Gemmules** or **endogenous** buds are diagnostic of Porifera and especially of fresh-water and a few marine sponges.

(3) **Gemmulation** or endogenous budding is a peculiar mode of reproduction under unfavourable conditions such as excessive cold or draught.

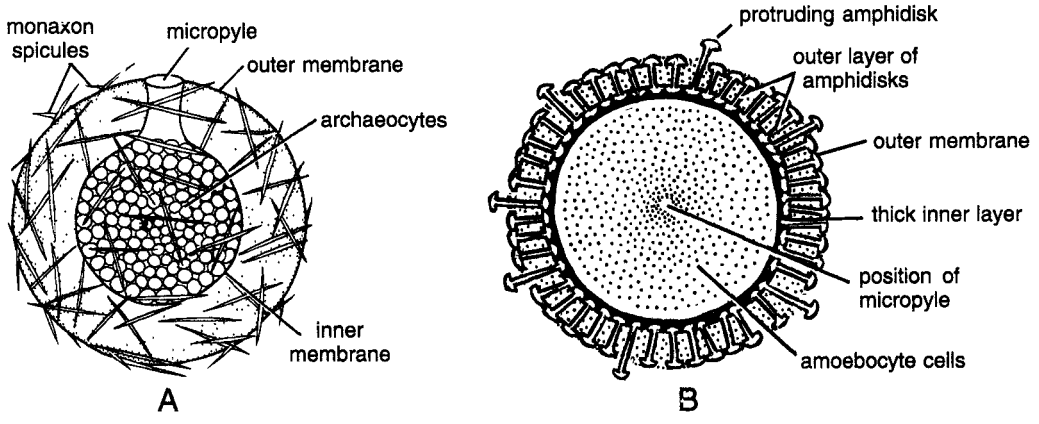


Fig. 44. **A.** Gemmule of *Ephydatia.* **B.** Gemmule of *Spongilla.*

(4) Gemmules contain **outer** and **inner membrane.**
(5) Gemmule is rounded structure formed by aggregation of **archaeocytes** into groups accompanied by **trophocytes** which are impregnated with food particles of glycoprotein or lipoproteins.
(6) There are other amoebocyte cells, forming columnar layers around the rounded masses of archaeocytes.
(7) **Scleroblasts** secrete the **amphidisk spicules,** which form a row in columnar layer between outer and inner membranes. At this stage, the food-laden gemmules having columnar cells, trophocytes and amphidisk spicules are detached.
(8) Large number of gemmules are formed which fall to bottom. Gemmules are resistant to external factors such as freezing and drying. Gemmules of fresh-water sponges can be kept for 2 years.
(9) They hatch at a temperature of 13°—21°C in about 3 days. After hatching, a gemmule gives rise to a young sponge.
(10) In ***Ephydatia***, gemmules are **monospiculous,** while in ***Spongilla*** they are amphidisks.
(11) A full-grown gemmule is usually pierced by opening on one side, called as **micropyle.**

Identification : Since the material has micropyle in mature and amphidisk spicules in immature gemmules and has all above features, hence it is **Gemmule** whole mount.

45. Amphiblastula

Comments :

(1) **Amphiblastula larva** is found in Porifera. During asexual reproduction sperms are shed in water which fertilize ova to give zygote.
(2) Zygote undergoes cleavage and develops into **stomoblastula.**
(3) Its characteristic of the class Calcarea consisting of trophic membrane formed of maternal choanocytes.
(4) Anterior or upper half of larva contains flagellated **micromerus** and the lower half contains non-flagellated **macromeres** and hence it is called as **Amphiblastula** larva.
(5) A full-developed **amphiblastula** comes in radial canal and then passes to exterior through osculum and then leads a free-swimming life.
(6) After a brief free life, gastrulation takes place. Macromeres grow more rapidly than **micromeres** and the micromeres become invaginated.
(7) Invaginated open end is blastopore. The flagellated cells become choanocytes. Mesogloea and amoebocytes are derived from both layers of the cells.

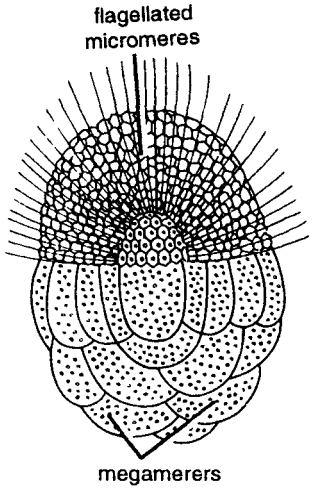


Fig. 45. Amphiblastula.

(8) Larva becomes sedentary by fixing its blastoporal end. It elongates and grows into the new young sponge. First it is an olynthus or asconoid stage and later on metamorphoses into permanent syconoid stage.

Identification : Since the larva has upper half flagellated, lower non-flagellated and all above features, hence it is **Amphiblastula**.

PHYLUM COELENTERATA

Tissue Grade Construction

Coelenterates evolved after Porifera. These are tissue grade animals. Different cells combined to form a tissue. Different tissues perform different functions. They are diploblastic cuelenteron having ectoderm, intervening mesoglea and endoderm. They are acoelomate. Gastrovascular cavity is coelenteron.

46. *Hydra* : Entire

Classification :

Phylum.....Coelenterata	→	Tissue grade of construction, diploblastic and acoelomate.
Class.....Hydrozoa	→	Hydroids containing medusa with velum.
Order.....Hydroidea	→	Polypoid generation well developed.
Sub-order.....Athecata	→	Hydrotheca absent.
Genus.....*Hydra*		
Species.....*viridis*		

Habit and habitat : ***Hydra*** is a solitary, fresh-water and cosmopolitan hydrozoan, found attached to or hanging downwards with some object in lakes, ponds, streams, seasonal ditches and in cool, clean and permanent stagnant water (Fig. 46).

Distribution : It has **cosmopolitan** distribution.

Comments :

(1) It is a **polypoid**, tubular and cylindrical coelenterate and when fully extended measures 1 cm in length.

(2) Contracted ***Hydra*** becomes globular.

(3) Posterior end acts as **hold-fast** organ. It is called as **pedal disc** or **basal disc** and contains gland cells, which secrete adhesive secretion.

(4) Oral end of the body is produced into a conical projection called as **hypostome** which contains mouth encircled by 6 to 10 **contractile tentacles**.

(5) **Mouth** leads into **gastrovascular** cavity.

(6) Body wall contains **nematocysts** which are offensive and defensive organs.

(7) Sides of ***Hydra*** bear **testis**, **ovaries** and **buds**. ***Hydra viridis*** contains symbiotic green algae called **Zoochlorellae**.

(8) Reproduction **sexual**.

(9) ***Hydra*** is extensively used in **experimental** studies such as in **regeneration**.

(10) Other species of ***Hydra*** are ***H. littoralis***, ***H. utahensis*** and female of ***H. littoralis***.

Identification : Since the animal has raised **hypostome** and all above features hence it is ***Hydra viridis***.

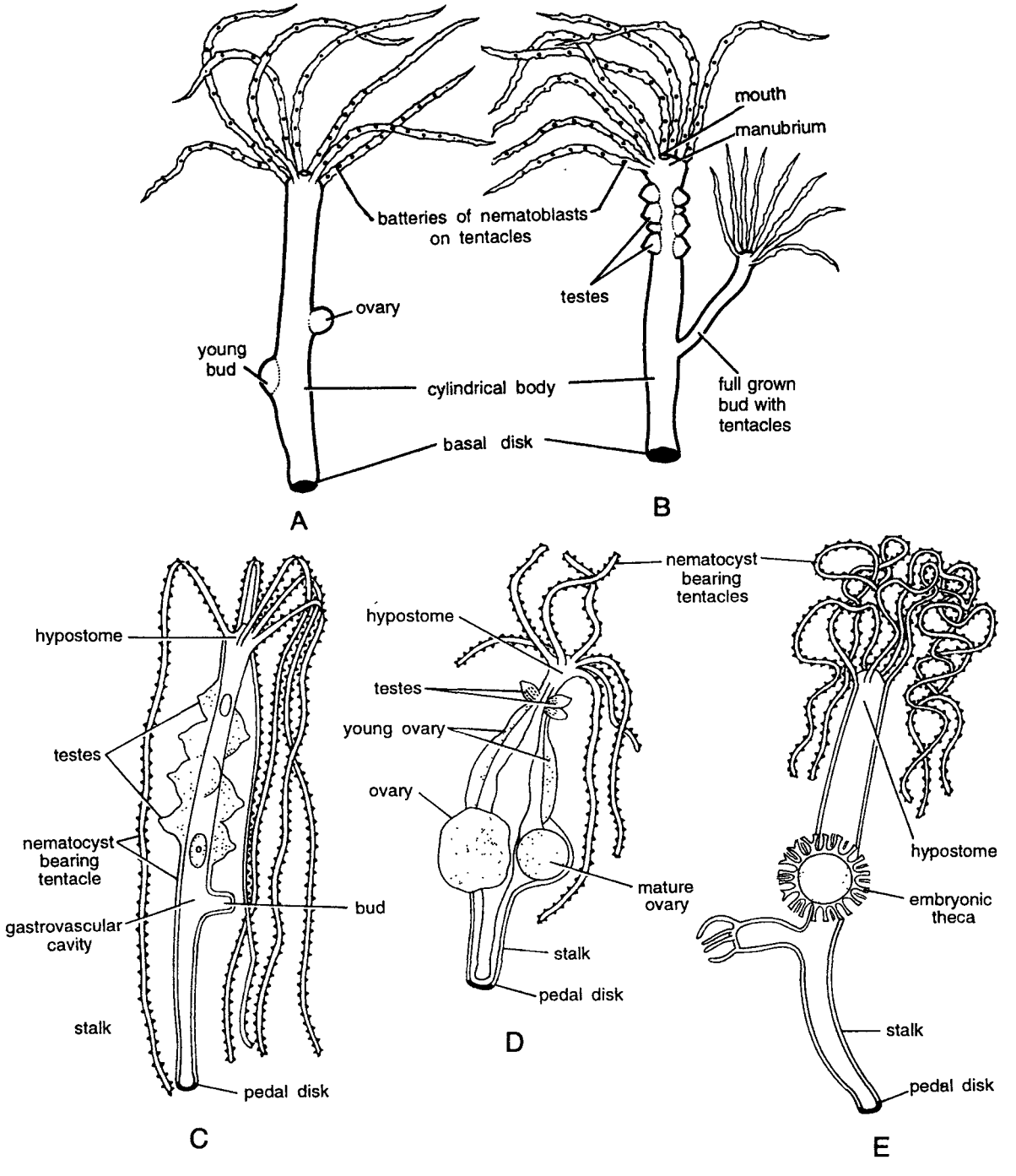


Fig. 46. *Hydra.* Entire. **A.** *Hydra viridis* Female, **B.** *Hydra viridis* Male. **C.** *Hydra littoralis* Male. **D.** *Hydra utahensis,* **E.** *Hydra littoralis* Female.

47. *Hydra* : L.S.

Comments : *Longitudinal section of* ***Hydra****, passing through tentacles, hypostome, body and base, shows interesting histological details* (Fig. 47).

(1) Section shows **tissue grade** of **organization** and **diploblastic layeration.**

(2) Body wall or green layers are composed of outer **ectoderm** and inner **endoderm** with an intervening **mesogloea.**

(3) In L.S. the **enteron** is seen in tentacles and older buds also.

(4) In high magnification, ectodermal cells of different kinds are seen, such as **epithelio-muscular cells, interstitial cells, nematoblasts sensory cells, nerve cells, gland cells** and **germ cells.**

(5) Beneath ectoderm is **mesogloea,** which is a thin, delicate, transparent and non-cellular layer of gelatinous matrix, called as mesolamella.

(6) Mesogloea differs in its nature in different coelenterates.

(7) Endoderm or gastrodermis forms internal lining of enteron. Like ectoderm, endodermal cells are also of various kinds as epithelio-muscular secretory, sensory, nerve and interstitial cells.

(8) Different types of cells have **division of labour** performing various functions.

(9) Buds and gonads are found on sides.

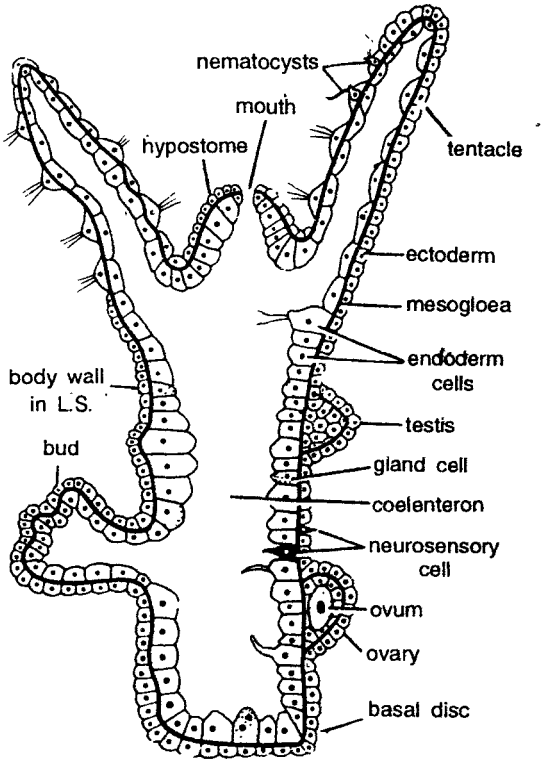


Fig. 47. *Hydra.* L.S.

Identification : Since the section has Y-shaped body, raised hypostome, buds and gonads on side hence it is L.S. ***Hydra.***

48. *Hydra* : T.S. Passing Through Body (Plain)

Comments :

(1) **Diploblastic acoelomate** and **tissue grade** (Fig. 48).

(2) The usual layers such as **ectoderm mesogloea** and **endoderm** are seen.

(3) In ectoderm and endoderm various kinds of cells such as **neurosensory cells, gland cells, nematocyst,** could be seen.

(4) The **enteron** is present in centre.

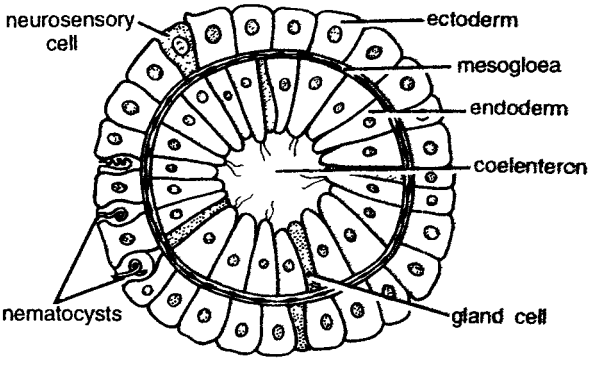


Fig. 48. *Hydra.* T.S. Plain.

49. *Hydra* : T.S. Passing Through Testis

Comments : The section through **testis** shows **diploblastic layeration** and **tissue grade organization** with following details :

(1) Testis section is observed as conical elevation in the epidermis near the oral end of the body.
(2) Number of **testis varies** in different species.
(3) Mature testis possesses a tiny papilla at its free end and by the rupture of papilla numerous spermatozoa liberate into water.
(4) **Ectoderm** bordering the testis contains small columnar cells.
(5) Internally testis contains a number of elongated cysts formed from the interstitial cells.
(6) Each interstitial cell at the base of the cyst is a primordial germ cell or primary spermatogonium.
(7) **Spermatogonium** divides mitotically to form **secondary spermatogonia** (spermatocytes), which grow into spermatids.
(8) **Spermatids** differentiate into **spermatozoa**.
(9) In a T.S. of testis, spermatogonia, spermatocytes, spermatids and spermatozoa are differentiated.
(10) Sperm contains head, body and tail.

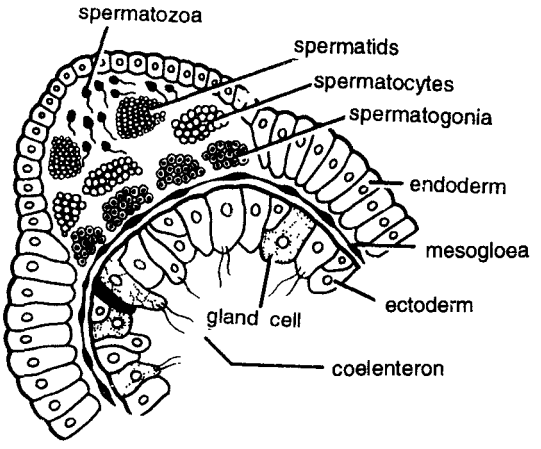


Fig. 49. *Hydra.* T.S. through Testis.

Identification : Since the section has conical elevation revealing spermatids spermatocytes and sperms, hence it is T.S. ***Hydra*** through testis.

50. *Hydra* : T.S. Passing Through Ovary

Comments : The section is built on **tissue grade organization** with **diploblastic layeration** and showing the following histological details (Fig. 50).

(1) **Ovary** is found in the middle part of the body.
(2) It originates as a swelling in the ectoderm and assumes a spherical shape. A single ovary produces a single ovum.
(3) Body wall layers are **ectoderm, mesoglea** and **endoderm**.
(4) Interstitial cells multiply to give rise to germ mother cells or **oogonia** which become centrally located, and are called as **oocytes**.
(5) It becomes enlarged and amoeboid having big **nucleus**. It undergoes two maturation divisions and develops into a complete ovum yolk, granules and nucleus.

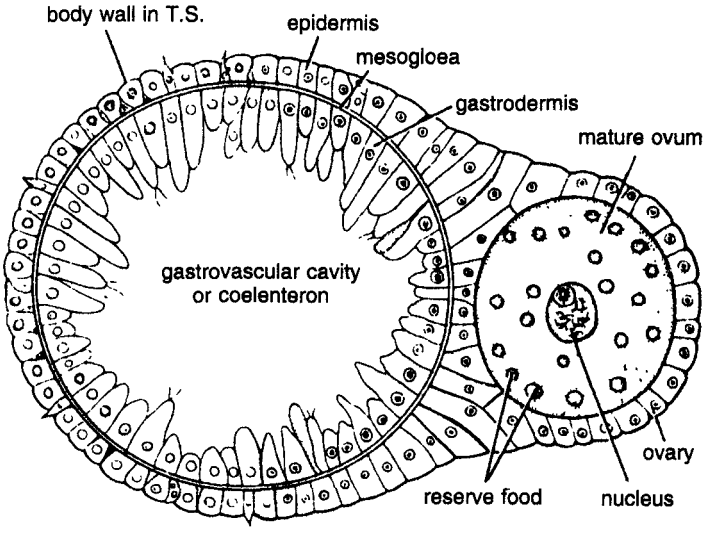


Fig. 50. *Hydra.* T.S. through Ovary.

(6) Oocyte becomes enlarged and amoeboid. It undergoes maturation divisions and develops into complete **ovum** having yolk granules, nucleus with chromatin and reserve food.
(7) In a T.S. of mature **ovary**, **ectoderm layer**, ovum with nucleus, yolk granules and disintegrating interstitial cells could be observed.

Identification : Since the section has ovum and all above features, hence it is ***Hydra*** **T.S. ovary.**

51. *Hydra* : T.S. Passing Through Bud

Comments : The section shows **tissue grade** built up and **diploblastic layeration** with the following details (Fig. 51).
(1) In a T.S. of bud the **epidermis**, **mesogloea** and **endoderm** are seen.
(2) Bud may be formed at any place on the body.
(3) Bud elongates and later develops all the structures of ***Hydra*** and then separates from the parent body.
(4) Other structures seen are **gland cells**, **interstitial cells**, **cnidoblast**, **gastrovascular cavity** and **Coelenteron.**

Identification : Since the section has ectoderm, mesoglea endoderm and all above features, hence it is ***Hydra*** **T.S. bud.**

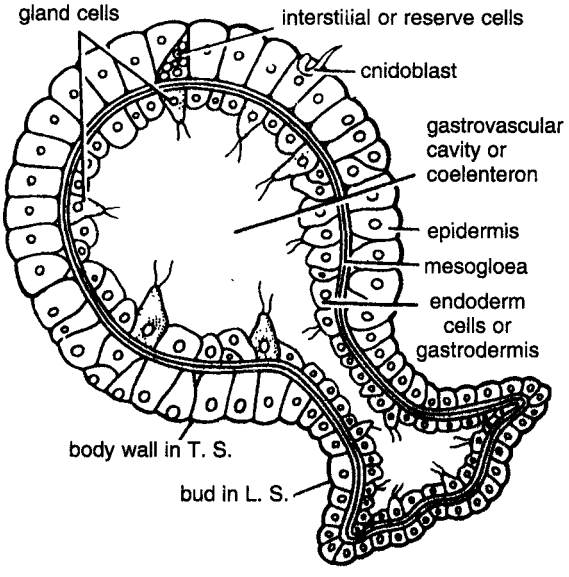


Fig. 51. *Hydra.* T.S. Bud.

52. *Bougainvillea*

Classification :

Phylum.....Coelenterata	→	Tissue grade of construction. Acoelomate. Diploblastic.
Class.....Hydrozoa	→	Hydroids containing medusa with velum.
Order.....Hydroidea	→	Polypoid generation well-developed.
Sub-order.....Athecata	→	Hydrotheca absent.
Genus.....*Bougainvillea*		

Habit and habitat : ***Bougainvillea*** is marine, cosmopolitan, colonial, animal attached to rocks, shells and seaweeds.

Distribution : It is found in Europe, Gulf of St. Lawrence to Southward and California.

Comments :

(1) It is an **arborescent** branching colony with annulated perisarc.

(2) Creeping **hydrorhiza** gives off vertical branches containing several polyps and **medusae.**

(3) **Medusae** may be brick-red or yellowish coloured.

(4) Stem is composed of outer perisarc and inner coenosarc comprising of **ectoderm, enteron** and **endoderm.**

(5) Polyps or **hydranths** have **hypostomes.** Each hydranth possesses a single whorl of filiform tentacles and is of **gymnoblastic** type because perisarc does not form hydrotheca.

(6) **Medusa** contains **exumbrellar, sub-umbrellar** surfaces, **manubrium** and **tentacles. Medusae** are bell-shaped and originate from coenosarc of a hydrocaulus.

(7) Blastostyles are absent.

(8) Reproduction is by **asexual** and **sexual** methods by polyps and medusae respectively.

(9) When fully developed, medusa breaks from its stalk and swims away. It has thick gelatinous wall, wide velum, 4 radial canals and gonads develop on the manubrium.

(10) **Lithocysts** are absent.

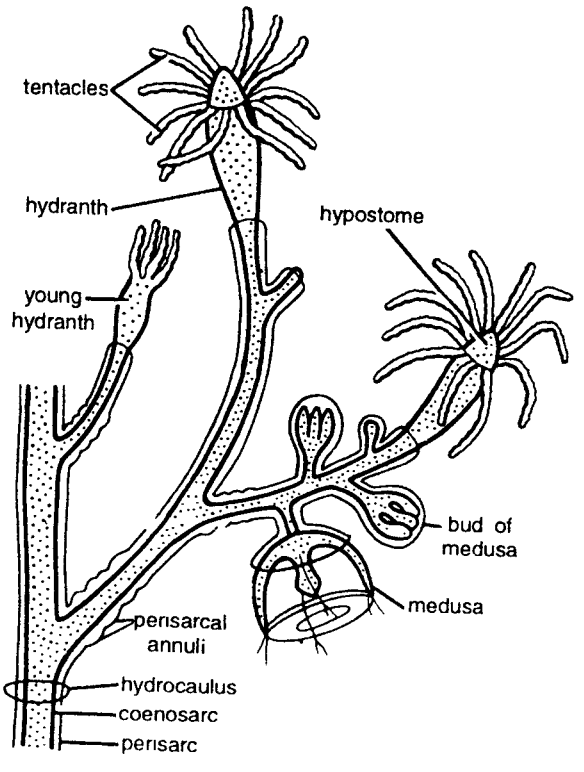


Fig. 52. *Bougainvillea.*

Identification : Since the colony has annulations in perisarc and all above features, hence it is ***Bougainvillea.***

53. *Tubullaria*

Classification :

Phylum..... Coelenterata	→	Tissue grade, diploblastic and acoelomate.
Class..... Hydrozoa	→	Hydroids containing medusa with velum.
Order..... Hydroidea	→	Polypoid generation well developed.
Suborder..... Athecata	→	Hydrotheca absent.
Family..... Tubularidae	→	Two circles of tentacles; gonophores grape-like.
Genus..... *Tubullaria*		

Habit and habitat : ***Tubullaria*** is marine, found on sandy bottoms, in shallow or brackish water in clusters of 5 to 10 individuals forming an irregularly branched colony. Composed of feeding **hydranths,** gonophores, stems and **stolons.** It feeds on microorganisms (Fig. 53).

Distribution : It is found in Europe, California and Cape Cod northwards.

Comments :

(1) **Polyps** or hydranths are brightly coloured with flower-like appearance attached to **stalk.**

(2) Each hydranth distally possesses a conical region bearing two whorls of **solid, filiform tentacles** called as **oral tentacles** and **aboral tentacles.**

(3) At the base of the hydranth the stalk forms a swelling where the perisarc comes to an end without forming a protective hydrotheca.
(4) Stem contains **perisarc** and **coenosarc** and is transparent.
(5) **Gonophores** are attached in clusters to the **hypostome**. **Medusa** consists of **exumbrellar** and **subumbrellar** surfaces, for **knob-like tentacles.**
(6) They are deep, bell-shaped with manubrial gonads.
(7) Colony is **dioecious**. Reproduction takes place by **sexual** and **asexual** methods.
(8) Life cycle includes **planula, actinula** larvae.
(9) ***Tubullaria*** shows structure of ancestral coelenterate.

Identification : Since the animal has flower-like hydranth with 2 whorls of tentacles, grape like gonophores and all above features hence it is ***Tubullaria***.

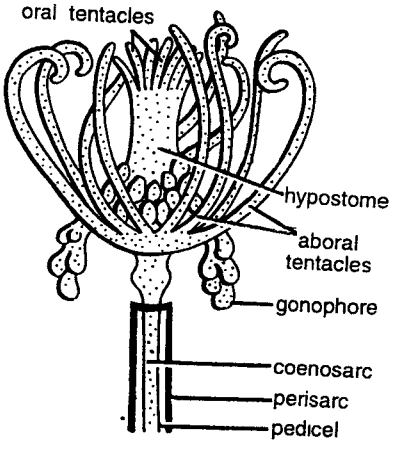


Fig. 53. *Tubullaria.* Hydranth.

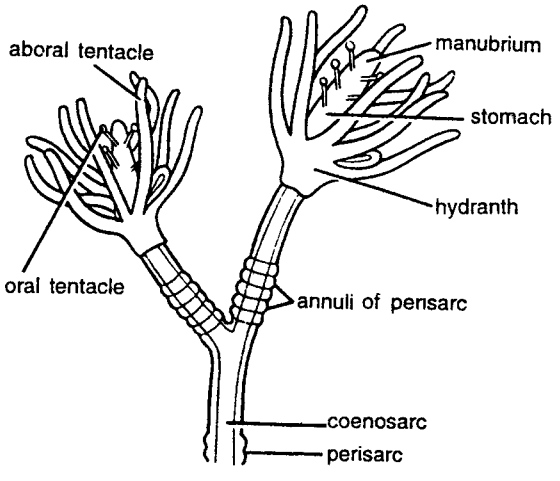


Fig. 54. *Pennaria.*

54. *Pennaria*

Classification :

Phylum..... Coelenterata	→	Tissue grade, diploblastic and acoelomate.
Class..... Hydrozoa	→	Hydroids containing medusa with velum.
Order..... Hydroidea	→	Polypoid generation well developed.
Sub-order.....Athecata	→	Hydrotheca absent.
Family..... Pennariidae	→	Distal tentacles capitate, proximal tentacles filiform.
Genus..... *Pennaria*		

Habit and habitat : ***Pennaria*** is a marine colonial form, found in shallow waters on piles, rocks and seaweeds (Fig. 54).

Distribution : It is found in the Gulf of Mexico, Bay of Fundy, New England coast, Massachusetts Bay to Gulf of St. Lawrence and British Columbia to San Diego.

Comments :

(1) Colony consists of **polyps** (**trophosome**) and medusa (**gonosome**).
(2) Colony consists of bushy growth with regular pinnate branches, measuring a height of 15 cm. ***Pennaria*** is characterised by having a free medusa stage.
(3) **Hydranth** is naked and bears 2 kinds of tentacles. The polyps are of large size and bright pink in colour.

(4) **Oral** or **capitate tentacles** which are short, are scattered near the hypostome and bear **nematocysts**.
(5) **Aboral filiform** tentacles present near the base of the hydranth. At the origin of each branch **perisarc** is annulated having **annuli**.
(6) Medusae develop on the side of the hydranth and are of degenerate type.
(7) At the distal part reproductive **zooids** or gonophores are present.
(8) Colony of ***Pennaria*** is **monopodial**, having a growth zone terminal just below terminal hydranths.

Identification : Since the animal has capitate filiform tentacles, pinnately branched colony and all above features, hence it is ***Pennaria***.

55. *Sertularia*

Classification : Same as that of ***Obelia***.
Genus.....*Sertularia*

Habit and habitat : Marine and colonial form found attached with sea weeds.

Distribution : Cosmopolitan.

Comments :
(1) Colony contains hydrorhiza from which emerge branching stems or hydrotheca divided into **nodes** and **internodes**.
(2) Each **internode** contains a pair of **hydrotheca**, with completely enclosed **polyps** and hydranths having **polyps** with **tentacles**.
(3) **Perisarc** and **coenosarc** present.
(4) Female **gonotheca** or **gonangia** are simple, **oval** and **sessile** containing developing **planulae in blastostyles**.
(5) **Male gonangia** simple and slender.

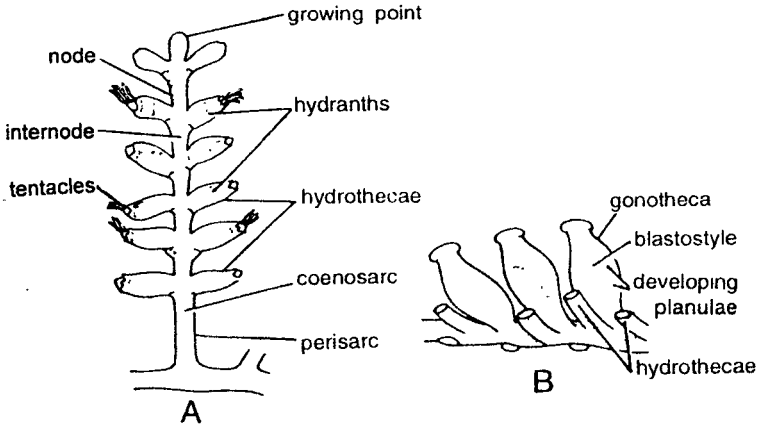


Fig. 55. *Sertularia.* **A.** Male gonangia., **B.** Female gonangia.

Identification : Since each internode has a pair of hydrotheca and colony contains all above features hence it is ***Sertularia***.

56. *Plumularia*

Classification : Same as that of ***Obelia***.
Genus.....*Plumularia*

Habit and habitat : Marine, sessile and colonial form (Fig. 56).

Comments :
(1) Colony consists of creeping **hydrorhiza** and plume like **stems**.
(2) From each stem arise alternate pinnate branches called **hydrocladia**.
(3) Sessile hydrothecae continuously grow on one side of hydrocladia.
(4) Being small, hydrothecae do not enclose polyps completely.
(5) Besides **gastrozooids** there are several small **dactylozooids**, **tentacles** and **pnematophores** which are devoid of **mouth**. It has amoeboid processes through which it engulfs diatoms and protozoans.

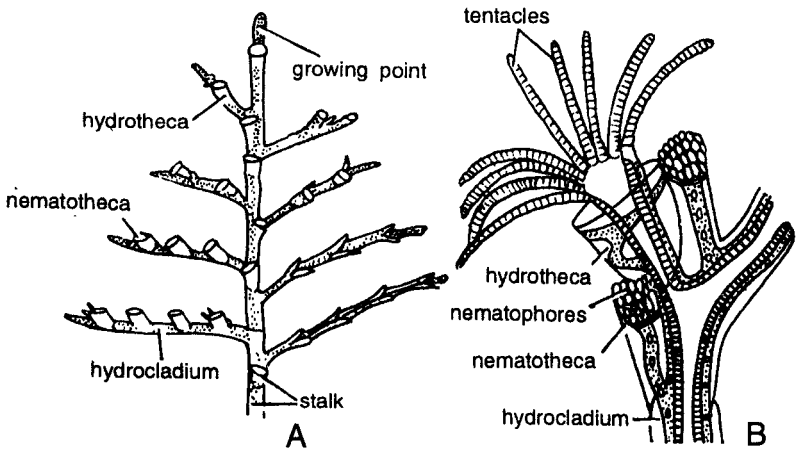


Fig. 56. *Plumularia.* **A.** A portion of colony. **B.** A polyp (magnified).

(6) Each polyp contains **hydrocladium, nematotheca, nematophores, hydrotheca** and **tentacles.**
(7) Tip of the stem represents growing point.

Identification : Since the colony has **hydrocladium** and all above features, hence it is ***Plumularia.***

57. *Eudendrium*

Classification :

Phylum.....Coelenterata	→	Tissue grade, diploblastic and acoelomate.
Class.....Hydrozoa	→	Hydroids containing medusa with velum.
Order.....Hydroidea	→	Polypoid generation well developed. Hydrotheca absent.
Sub-order.....Athecata	→	Male and female gonophores.
Family.....Eudendridae		
Genus.....*Eudendrium*		

Habit and habitat : ***Eudendrium*** is a marine and colonial hydroid form with reticulated hydrorhiza.

Distribution : It is found in Atlantic and Pacific oceans (Fig. 57).

Comments :

(1) **Colony** measures about 10 to 95 cm in height. The **perisarc** is hard and bears **transverse annulations.**
(2) **Hydranths** have a trumpet-shaped hypostome with a single **whorl of filiform tentacles.**
(3) **Hydranths** are pinkish in colour with globular manubrium.
(4) Unlike ***Pennaria,*** free medusoid stage is absent and an intermediate stage between ***Obelia*** and ***Bougainvillea*** is found.
(5) **Medusae** are budded off from the stem bearing hydranths.
(6) Male and female sporosacs are separately budded off. **Male sporosacs** are found in a whorl just beneath and the **female sporosacs** just above the tentacles and sometimes on hydrocaulus. The former are reddish while the latter orange in colour.

Identification : Since the animal has annulated perisarc and trumpet-shaped hypostome and all above features, hence it is ***Eudendrium.***

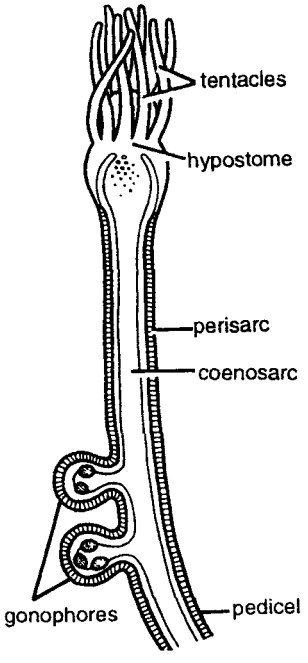


Fig. 57. *Eudendrium.*

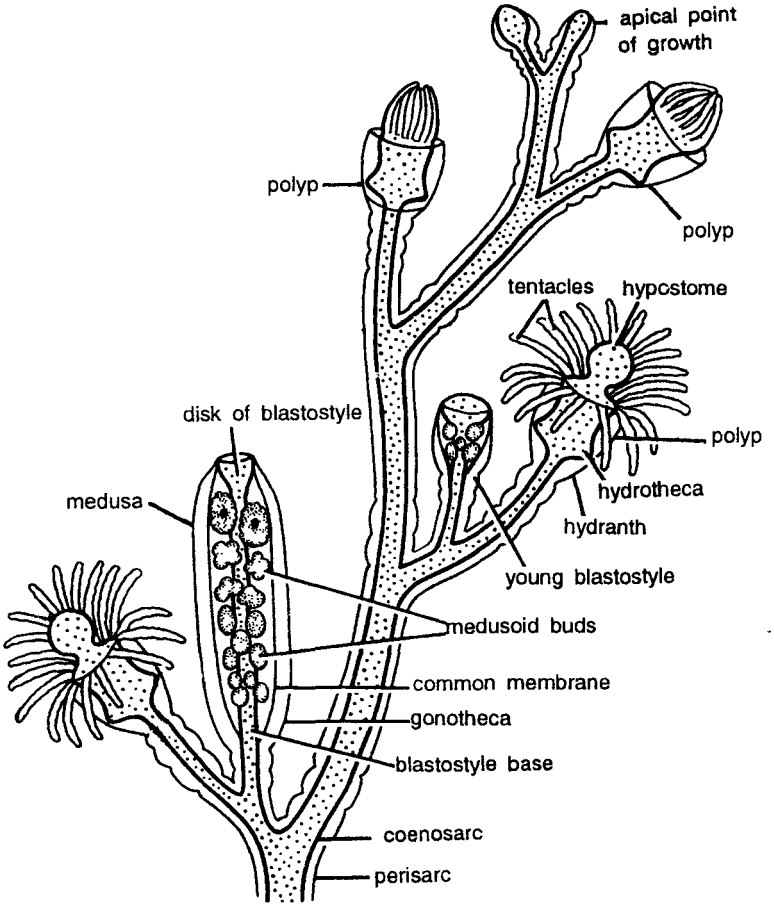


Fig. 58. *Obelia.* Colony.

58. *Obelia*

Classification :

Phylum..... Coelenterata	→	Tissue grade, diploblastic and acoelomate.
Class..... Hydrozoa	→	Hydroids; medusa with velum.
Order..... Hydroidea	→	Polypoid generation well developed.
Sub-order..... Calyptoblastea	→	Hydranths have hydrotheca and gonophores with gonotheca.
Genus..... *Obelia*		

Habit and habitat : ***Obelia*** is colonial, marine, sedentary hydrozoan **zoophyte, attached to seaweeds,** shells and rocks (Fig. 58).

Distribution : Its range is from the Arctic region to the Gulf of Mexico and the Pacific coast, and from Southern California to Oregon. It is found in shallow water and also upto approximately 250 feet deep.

Comments :

(1) It is a **dimorphic** colony in the form of small seaweed filaments, measuring several cm in height. The filaments may be horizontal and vertical. The colony consists of several parts.

(2) **Hydrorhiza :** It is basal or horizontal portion called as stolon or rhizostome, which is meant for attachment to substratum. Hydrorhiza gives vertical branches called **hydrocaulus.**

(3) **Hydrocaulus** gives alternate branches that terminate into individual **zooids** called as **polyps** and **medusae.**

(4) **Coenosarc :** Stems and zooids are made of a living hollow, cellular tube called as **coenosarc.** It is made up or ectoderm, endoderm and mesogloea.

(5) Stems and zooids are made up of two components : (i) Outer protective tough, transparent non-cellular covering called as **perisarc** and (ii) **mesogloea** and (iii) inner living hollow cellular tube called **coenosarc.**

(6) Zooids consist of **polyp** and **medusa.**

(7) **Medusa** grows at the base of polyp-bearing branches and is enclosed in **blastostyles.** Medusa is composed of upper **exumbrellar** and **lower sub-umbrellar** surfaces, **manubrium** and **gonads.** Free medusae occur in the life cycle. It is a reproductive zooid.

(8) **Polyp** is a bell-shaped cup made up of lower cup-shaped **hydrotheca** and upper **hypostome.** Hypostome is a feeding zooid having circlet of 24 **nematocyst bearing tentacles.**

(9) Growth of the colony is sympodial, i.e., each new hydranth arises as bud from the stem, just proximal to the next youngest polyp.

(10) It reproduces **asexually** and **sexually.**

Identification : The colony has alternate branches of polyps, blastostyles and all above features, hence it is ***Obelia.***

59. *Obelia* : Medusa

Comments :

(1) **Medusa** is a modified **zooid** for **sexual reproduction.**

(2) It is a solitary free-swimming zooid, originating from blastostyles.

(3) Medusa is umbrella-like and has convex **exumbrellar** and concave **sub-umbrellar** surfaces with well defined **radial symmetry.**

(4) Umbrellar edge contains radially symmetrical **tentacles.**

(5) Base of fully grown tentacle is thickened to **tentacular bulb**, which contains a number of **stinging cells.**

(6) In the four radial positions each tentacular bulb contains two otocysts, which are hollow and balancing organs containing calcareous otoliths.

(7) **Manubrium** hangs from the centre of sub-umbrella, having mouth.

(8) Mouth communicates with 4 radial canals which join with circular canal lining umbrellar margin which all around contains **velum.**

(9) Beneath the radial canals are gonads lying in sub-umbrellar ectoderm.

Identification : Since the mount has circular tentaculated body, 4-radial rounded gonads and all above features, hence it is ***Obelia*** medusa a very favourite slide-spot.

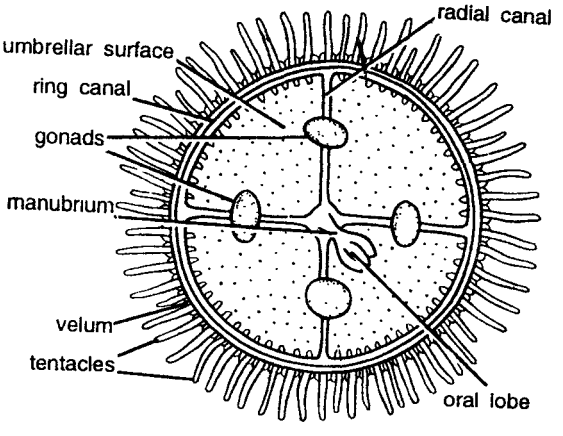


Fig. 59. *Obelia.* Medusa.

60. *Campanularia*

Classification : Same as that of ***Obelia***.

Genus.....*Campanularia*

Habit and habitat : ***Campanularia*** is a simple or branched colony.

Distribution : It is found in U.S.A., Asia and Europe.

Comments :

(1) Colony consists of **network** like **hydrorhiza** and vertical branches bearing **polyps** or **hydranth**.

(2) Branches originate separately from **hydrorhiza annulated at lower** and **upper regions**.

(3) **Polyp** is termninal, consisting of hydranth and trumpet shaped **hypostome**.

(4) Hydranths have small manubries surrounded by 10-12 tentacles.

(5) **Gonangia** are found on separate short stalk. Gonophores are found on **blastostyles**. Blastostyles are covered by **gonotheca**. **Blastostyles** and **gonotheca** are called as **gonangium**.

(6) **Gonangia** are large oval truncated structures having **medusae**.

(7) Blastostyles give rise to **planula** larvae directly. No free medusa stage.

Identification : Since the animal contains separate polyps, gonangia and all above features, hence it is ***Campanularia***.

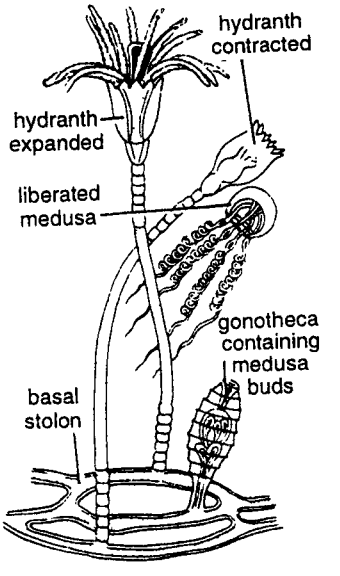


Fig. 60. *Campanularia.*

61. *Aurelia* : Planula Larva

Comments :

(1) Fertilized egg after **cleavage**, **morula** and **gastrula** stages gives rise to a ciliated larva called as **planula larva**.

(2) Embryo becomes elongated.

(3) **Planula** larva contains **ciliated ectoderm**, **mesoglea**, **endoderm** and **coelenteron**.

(4) Fully formed planula are seen on the oral arms of female jelly fish.

(5) It gives rise to next larval stage called as **Scyphistoma larva**.

(6) Planula larva is made up of **ectoderm**, **mesoglea** and **endoderm**. Ectoderm has **ciliated cells**, **gland cells** and **sensory cells**. Ectoderm cells of anterior region are taller than posterior region. Endoderm has non-ciliated cells and gland cells.

Identification : Since the larva contains ciliated ectoderm and all above features, hence it is **Planula larva**.

Special features : Planula larva has great phylogenetic significance as it is used to explain the origin of **bilateria**. **Planulid Acoeloid Theory of Origin of Bilateria** is widely accepted.

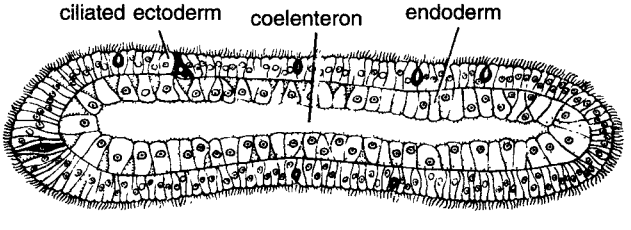


Fig. 61. Planula larva.

62. *Aurelia* : Scyphistoma Larva

Comments :

(1) **Planula** larva attaches to rock by aboral end; blastopore closes; cilia are lost; the body becomes elongated and planula is metamorphosed into **scyphistoma** or **hydratuba** (Fig. 62).

(2) **Scyphistoma** larva is composed of expanded **oral end, ephyrae, basal** stalk and **adhesive pedal disc**. By pedal disc larvae remain attached with the substratum. Oral end contains mouth **manubrium** and **tentacles**.

(3) The number of tentacles varies from 16 to 32. The first tentacles are **perradial**, followed by **interradial** and **adradial** ones.

(4) The scyphistoma of temperate zones remain without change in full in winter. It feeds and produces other scyphistomae.

(5) In early spring process of strobilation sets in, i.e., young medusae (Ephyrae) are produced by transverse fission.

(6) In some species **strobilation** is monodisk producing one Ephyra while in other species it is polydisk strobilation.

(7) Each strobila or segment forms next larval stage called as **Ephyra**.

Identification : Since the larva has **Ephyrae**, hence it is **Scyphistoma larva**.

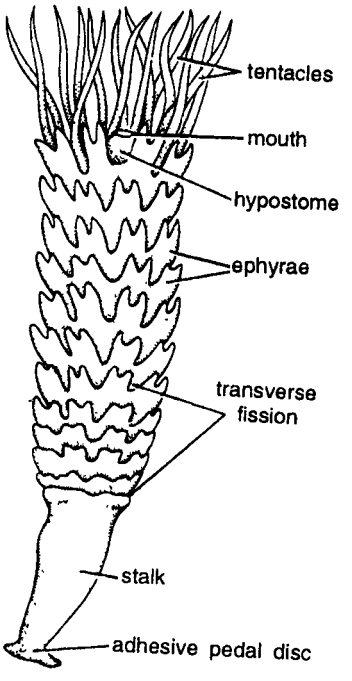


Fig. 62. Scyphistoma larva.

63. *Aurelia* : Ephyra Larva

Comments :

(1) Scyphistoma larva gives rise to **Ephyra** larva (Fig. 63).

(2) Oral surface of Scyphistoma develops into **sub-umbrellar** surface of **Ephyra**.

(3) **Umbrellar** surface contains 8 **bifid arms**, four per-radial and four inter-radial.

(4) Bifid arms are called as **marginal lappets.**

(5) At the base of bifid **arms rhopalia** develops which are sensory structures.

(6) The ephyra when finished is constricted off by a muscular contraction and swims as tiny medusa which later develops into adult ***Aurelia***.

(7) **Inter-radial canals** are well developed while **perradial and adradial canals** are in rudimentary stage.

Identification : Since the animal has tentacles and tetramerous symmetry and all above features, hence it is **Ephyra larva**.

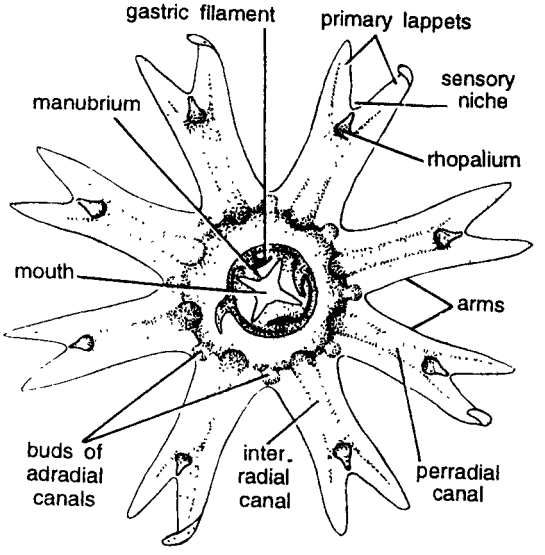


Fig. 63. Ephyra larva.

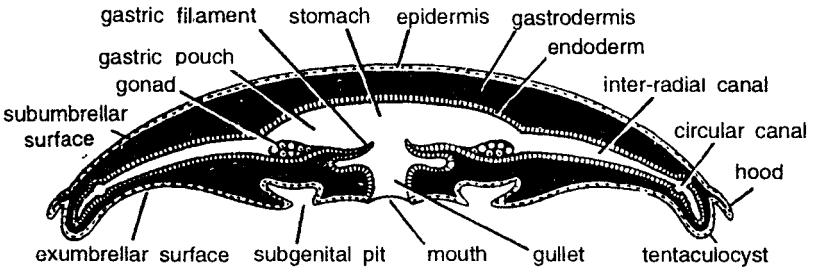


Fig. 64. *Aurelia.* Vertical section.

64. *Aurelia* : Vertical Section

Comments :

(1) Vertical section of ***Aurelia*** reveals its histological structure (Fig. 64).
(2) Body wall contains **epidermis** and **gastrodermis** with an intervening **mesoglea**.
(3) Epidermis contains, epithelial cells, sensory cells, nerve cells, gland cells and cnidoblasts.
(4) Epidermis covers umbrellar surface, velarium, tentacles, sub-genital pits, sub-umbrellar surface, oral arms and manubrium.
(5) Gastrodermis is made up of **columnar endothelial cells** in which gland cells, nerve cells and muscles are absent.
(6) Mesoglea forms a thick layer having elastic fibers and moving amoeboid cells. In ***Aurelia,*** mesoglea is like connective tissue.
(7) In section, **nematocysts** are seen in oral arms and tentacles.

Identification : Since the section has nematocyst in oral arms and tentacles and all above features, hence it is V. S. ***Aurelia***.

PHYLUM PLATYHELMINTHES

Organ Grade Construction

Platyhelminthes having free-living and parasitic evolved after tissue grade coelenterates having organ-grade construction. They are acoelomate bilateria and triploblastic having ectoderm, mesoderm and endoderm. Mesoderm gave to various organs such as digestive system, reproductive system and nervous system etc., hance they organs grade construction. Various tissues combined together to give rise to a organ.

65. *Dugesia* : Planaria

Classification :

Phylum..... Platyhelminthes	→	Flatworms, acoelomate bilateria with organ grade of construction.
Class..... Turbellaria	→	Epidermis containing rhabdoids present.
Order..... Tricladida	→	Planarians, intestine with three branches.
Sub-order..... Paludicola	→	Fresh-water planarians.
Family..... Planariidae		
Genus..... *Dugesia* or Planaria		

Habit and habitat : ***Dugesia*** is found commonly in fresh-water ponds, shallow rivers, streams, lakes and ditches. It is common in stagnant water rich in water vegetation. It is gregarious and found gliding under surface of the stones and leaves.

Distribution : It is found in India, Myanmar, U.K., U.S.A. and U.S.S.R.

Comments :

(1) **Commonly** called as **Planaria** or ***Euplanaria***.
(2) Animal is dorsoventrally, flattened, elongated, leaf-like, slimy, semi transparent, brownish or blackish and measuring 1-1.5 cm in length.
(3) Body is differentiated into **dark dorsal** and **light coloured ventral** surface. Ventral surface has adhesive zones.
(4) Anterior end is differentiated as **head** containing a pair of dark eyes or ocelli and a pair of side projections called as **auricles**.
(5) Entire body is partly ciliated.
(6) Mouth or **proboscis** pore lies a little behind the middle of the body.
(7) **Anus is absent. Genital pore** is found a little behind the mouth.
(8) Alimentary canal is quite conspicuous, having **mouth**, **pharyngeal cavity**, **proboscis** and **intestine**, which is divided into **one anterior** and **two posterior intestinal branches**. Proboscis lies in proboscis sheath and opens to outside by **proboscis pore**.
(9) Excretory organs are **protonephridia**. Excretory pores are found on sides of the body.
(10) **Hermaphroditic :** Reproduction is by **regeneration** and **sexual**. Species of ***Dugesia*** are ***D. tigrina*** and ***D. dorotocephala***.

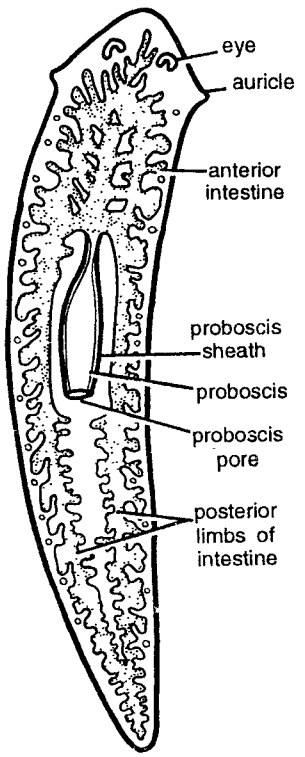


Fig. 65. *Dugesia* or Planaria.

Special features : These planarians are largely employed for **experimental** work in **regeneration** and **grafting**. These experiments are of medical significance for plastic surgery.

Identification : Since the animal has auricles, eyes, proboscis and all above features, hence it is ***Dugesia***.

66. *Dugesia* : Planaria : T.S. Passing Through Pharynx

Comments :

(1) T.S. passing through pharynx of ***Dugesia*** or **Planaria** showing its **triploblastic** and **acoelomate** nature (Fig. 66).
(2) Body wall layers are **epidermis**, **muscle layer** and **mesenchyma** or **parenchyma**.
(3) **Epidermis** is **syncytial**, **ciliated**, single-layered of columnar cells with rounded nucleii. Epidermal cells contain **rod-shaped rhabdites**.
(4) Below epidermis is muscle layer separated by basement membrane. Muscle layer consists of **outer circular**, middle **diagonal** and **inner longitudinal** fibers.
(5) Mesenchyme is found just below muscle layer. It contains mucous glands, rhabdite forming glands and other organs.
(6) In section cut parts of intestinal caecae, **vitellaria** and **protonephridia** are seen.
(7) **Pharynx** in T.S. shows, **pharyngeal sheath**, **pharyngeal chamber**, **epithelial layer** circular and **longitudinal muscle layer** and glandular layer.
(8) In section cut parts of intestinal caecae, **vitellaria**, **protonephridia**, **flame-cells**, **oviduct**, **sperm duct**, **nerve cord** and **adhesive zones** are observed.

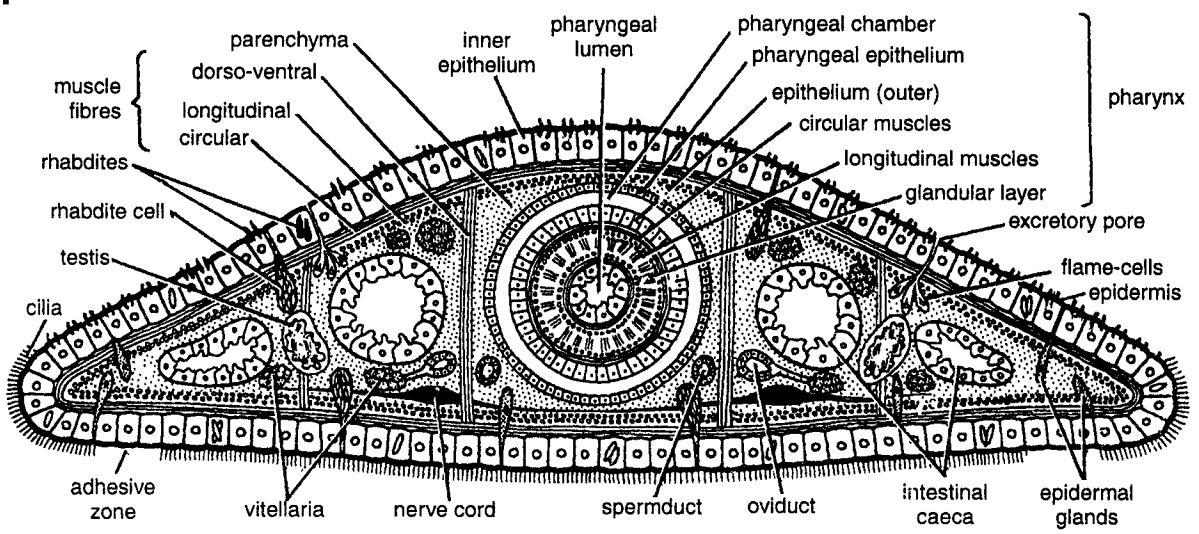


Fig. 66. *Dugesia* or Planaria. T.S. passing through Pharynx.

Special features : Planarian section shows syncytial epidermis containing offensive and black coloured defensive organs or rhabdites in low and high magnifications.

Identification : Since the section contains **rhabdites** and all above features, hence it is T.S. proboscis of ***Dugesia*** or **Planaria**.

67. *Gunda segmentina*

Classification :

Phylum.....Platyhelminthes	→	Flatworms, acoelomate bilateria with organ grade of construction.
Class.....Turbellaria	→	Epidermis containing rhabdoids.
Order.....Tricladida	→	Planarians, intestine with three branches.
Sub-order.....Maricola	→	Marine planarians.
Genus.....*Gunda*		
Species.....*segmentina*		

Habit and habitat : ***Gunda segmentina*** is a marine triclad.

Comments :

(1) Animal shows **cephalization** and dorsoventrally flattened body.

(2) **Auricles** with a pair of **ocelli** are distinct in the **head**.

(3) **Intestine** has three branches, **one anterior** and **two posterior**. All the three branches protrudes into **simple caecum** on each side.

(4) **Mouth** is found beyond equatorial line of the body. It communicates with the proboscis pore and proboscis.

(5) **Gonads** are found between the intestinal caeca, forming neat longitudinal row on each side.

Special features : ***Gunda segmentina*** is a very important **triclad Turbellaria** as it helps in explaining the **gonocoel theory** of the origin of **coelom**.

Identification : Since the animal has alternate intestinal branches, gonads and all above features, hence it is ***Gunda segmentina***.

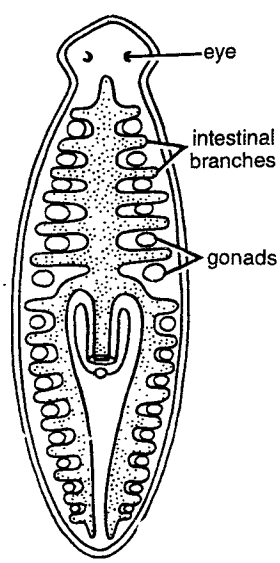


Fig. 67. *Gunda segmentina.*

68. *Polystoma*

Classification :

Phylum..... Platyhelminthes	→	Organ grade, acoelomate, bilateral flatworms.
Class..... Trematoda	→	Flukes, ecto or endoparasites.
Order..... Monogenea	→	No intermediate host, oral sucker weak or absent.
Sub-order..... Polyopisthocotylea	→	Opisthaptor with many suckers.
Family..... Polystomatidae	→	Opisthaptor contains six armed suckers.
Genus..... ***Polystoma***		

Habit and habitat : ***Polystoma*** or ***Polystomum*** is a monoecious parasite found in the urinary bladder of frogs, toads and turtles (Fig. 68).

Comments :

(1) **Body** is dorsoventrally flattened and leaf-like.

(2) Posterior end contains an expanded, adhesive case or **opisthaptor**, which contains 3 **pairs of suckers**, 2 to 4 large **chitinous hooks** and many minute hooklets.

(3) Alimentary canal, in a stained slide, is a conspicuous structure consisting of **mouth**, **pharynx** and **forked intestine**, which unites again posteriorly to have single insertion in sucker region.

(4) In the main body intestinal limbs are joined by 2 or 3 **transverse caeca**.

(5) It is **hermaphoditic**. Female system consists of an **ovary**, **genito-intestinal canal**, 2 **vaginae**, **vitellaria** and its duct. **Germarium** and **vitellaria** are separate. Male system comprises **testis**, **sperm duct** and **penis**.

(6) **Life cycle** without intermediate host and direct.

(7) During winter season gonads remain non-functional and the breeding season starts in spring. The worms copulate and produce 4 to 122 **eggs**. Eggs hatch into **miracidium** which attach with the gills of tadpole of frog and during metamorphosis of the latter, they reach into the urinary bladder and develop into adult.

Special features : ***Polystoma*** shows following special features :

(1) Correlation between hatching of ***P. integerrimum*** eggs and the development and metamorphosis of the frog is one of the amazing natural synchronization. Larva attaches to external gills of tadpole. Then during metamorphosis of the latter larva migrate through branchial chamber into alimentary canal and then settle in the usinary bladder.

(2) In some cases, when larva of ***P. integerrimum*** attaches to gills of younger tadpole, an unnatural acceleration in larval development takes place. It becomes neotenous producing viable eggs with incomplete somatic development (Williams, 1960).

(3) The life cycle of ***Polystoma*** helps understanding the **evolution** of **parasitism**.

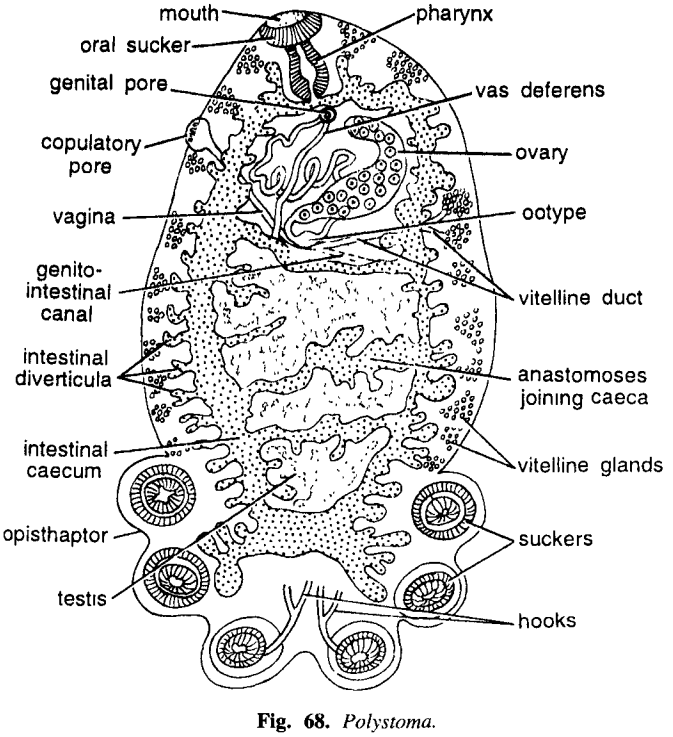


Fig. 68. *Polystoma.*

Identification : Since the parasite has circular opisthaptor with 6 suckers and all above features, hence it is ***Polystoma***.

69. *Diplozoon*

Classification :

Phylum.....Platyhelminthes	→	Organ grade, acoelomate, bilateral flatworms.
Class.....Trematoda	→	Flukes, ecto or endoparasites.
Order.....Monogenea	→	Oral sucker weak. No intermediate host.
Sub-order.....Polyopisthocotyle	→	Opisthaptor with many suckers.
Genus.....*Diplozoon*		

Habit and habitat : ***Diplozoon*** is an ectoparasite, found on gills of fresh water fishes.

Distribution : It is found in India, Myanmar and Srilanka.

Comments :

(1) It is very interesting ectoparasite as two individuals are **united permanently in the form of X.**
(2) **Union** is both **morphologically** and **physiologically.**
(3) Posteriorly, before suckers, genital organs and alimentary canal **cross** with each other.
(4) In each individual, digestive system consists of **mouth**, surrounded by **oral sucker**, **pharynx** and **intestine.**
(5) Male and female reproductive system well developed. **Vitelline glands, testis** and **ovary** are found in each individual.
(6) **Sperm duct, uterus,** and **vagina** of one individual cross with those of other. **Uterus** opens to outside by gonopore.
(7) **Vitelline glands** are well developed.
(8) **Opisthaptor** contains 8 **suckers,** arranged in double rows of four in each individual.
(9) Eggs differentiate into **diporpo larvae,** which hatch and attach with the gills.
(10) Two young **diporpo larvae** attach with each other and form adult ***Diplozoon***.

Special features : The two diporpo associate themselves intimately. The ventral sucker of one embraces the conical protuberance of the other and vice versa and the two remain in permanent copula.

Identification : Since the ectoparasites have fused, X –shaped body of two individuals and all above features, hence it is ***Diplozoon***.

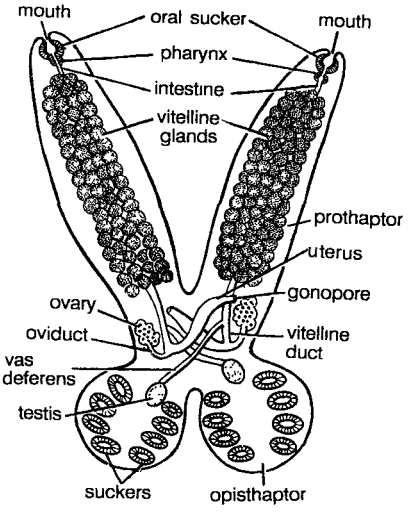


Fig. 69. *Diplozoon.*

70. *Fasciola hepatica* : Entire : Sheep Liver Fluke

Classification :

Phylum.....Platyhelminthes	→	Organ grade, acoelomate, bilateral flatworms.
Class.....Trematoda	→	Flukes ecto or endoparasites.
Order.....Digenea	→	Two suckers; one or more intermediate hosts.
Family.....Fasciolidae	→	Liver flukes; internal organs branched.
Genus.....*Fasciola*		
Species.....*hepatica*		

Habit and habitat : ***Fasciola hepatica*** is a **cosmopolitan, pathogenic, polyxenous** parasite found in the bile duct and biliary passages in the liver of sheep and other herbivorous mammals. Another fluke

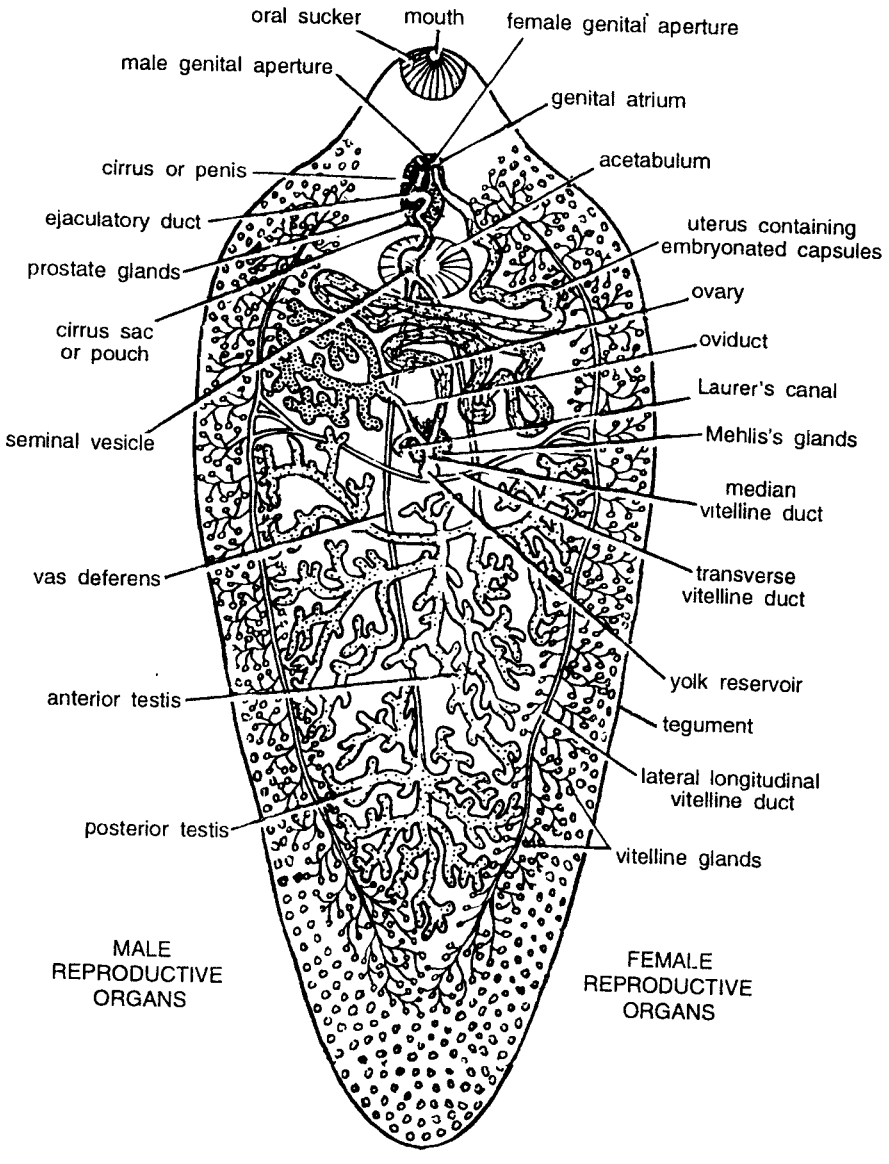


Fig. 70. *Fasciola hepatica.*

Fasciola gigantica is also commonly found in these animals. ***F. hepatica*** is **zoonotic** infecting man in Cuba, France, Algeria. Ecologically, sheep and cattle raising areas are primary zones where human infections are prevalent.

Distribution : It is **endemic** parasite, reported from India, China, Cuba, Argentina, U.S.S.R. and U.S.A.

Comments :

(1) **Commonly** called as **sheep liver fluke.**

(2) Body is **leaf** like, dark brown and dorso-ventrally flattened. The anterior end is produced into a conical projection.

(3) Pigmentation of the parasite is dark brown.
(4) **Oral** and **ventral suckers** are present. The latter forms adhesive organ with the tissues of the host.
(5) A single excretory pore is found at the posterior extremity. Alimentary canal consists of mouth, oral sucker, oesophagus and bifid highly diverticulated blind intestine.
(6) **Hermaphroditic : Male reproductive system** consists of 2 **tandem dendritic testes, vasa deferentia, seminal vesicle, ejaculatory duct, cirrus** and **prostate glands. Seminal vesicles, prostate, ejaculatory duct** and **cirrus** are enclosed in a **cirrus pouch.** In female **system germarium** and vitellaria are separate structures. Various parts of **female-system** are single **ovary, oviduct, ootype, uterus, vitelline glands** and **their ducts.** Vitelline glands are present on the sides.
(7) Life cycle digenetic. **Sheep acts as definitive host** and **snail *(Limnea truncatula)* as intermediate host.**
(8) Life cycle stages include free-living **miracidium** which penetrate molluscs and change into sporocyst and then into **Redia.** Redia gives rise to **cercaria.** Cercaria emerge from Redia and snail, lead a free-life and encyst on water plants to change into **metacercaria.** When sheep grazes on metacercaria containing leaves of water vegetation, it becomes infected.

Pathogenesis : Fascioliasis causes eosinophilia, anaemia, calcification of the bile duct, **haemorrhage** in **liver cells** and **liver rot.** In cattles often fascioliasis and hydatidiasis infections are found concurrently. The infection can be checked by destroying the snail population and contaminated water vegetation. Anthelmintics used are Emetin, Hydrochloride, Filicin and Hexachlorethane, etc.

Identification : Since the parasite has tandem testes, branched internal organs and all above features, hence it is ***Fasciola hepatica.***

71. *Fasciola hepatica* : T.S. Passing Through Testes

Comments : The T.S. through testes shows the following histological details (Fig. 71).
(1) Section passes through the posterior three-fourth region.
(2) Body wall is composed of **tegument musculature** and **mesenchyme.** Various cut body parts are embedded in the mesenchyme.
(3) **Tegument** is characterized by the presence of scales.
(4) Body cavity or coelom is completely absent.
(5) Just beneath tegument is muscle layer.
(6) Muscle layers are **outer, circular, middle longitudinal** and **inner diagonal** fibres. Longitudinal muscle fibres dominate and are found in entire section.
(7) **Mesenchyme** consists of irregularly-shaped and fluid-filled mesenchyme cells.

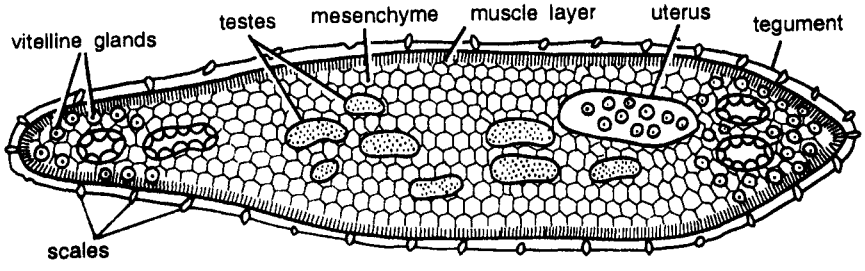


Fig. 71. *Fasciola hepatica.* T.S. passing through Testes.

(8) **Testes** : The dendrites are irregularly cut in section, showing blue colour with haematoxylin and containing **spermatozoa** in various stages of development.
(9) **Intestinal branches** : Intermingled with sections of testes, intestinal sections are also clearly seen.
(10) **Intestine** is composed of some body layers containing long, flagellated epithelial columnar cells.
(11) On lateral fields brownish vitellaria, in the form of rounded follicles, are abundantly found.

Identification : Since the section shows scales in tegument, cut dendritic branches of testis in middle, vitelline glands on sides hence it is T.S. through testes.

72. *Fasciola hepatica* : T.S. Passing Through Uterus

Comments : The section passes through the anterior region and shows the following histological details.
(1) Body wall is composed of **tegument** on all sides, **muscle** layers (**outer circular**, **longitudinal**, **inner diagonal fibres**) and **mesenchyme**, which consists of loosely filled spaces (Fig. 72).
(2) Tegument is characterised by the presence of **scales**.
(3) **Tegument** is more or less homogeneous and non-cellular having affinity for basic stains. It is divided into outer and inner zones. (For details see T.S. through testes).
(4) **Uterus** coils are seen at various places in the section. It is a wide tube containing **fertilized eggs**.
(5) **Eggs** are clearly seen with shell and nucleus.
(6) On right side, **ovarian sections** are also seen.
(7) Few intestinal sections, having long **flagellated** epithelium, are also found.
(8) In a section passing through the uterus, most of the mesenchyme if filled with uterine coils filled with eggs.

Identification : Since the section contains scales integument, various cut portions of uterus and vitelline glands on sides, hence it is T.S. through **uterus of *Fasciola***.

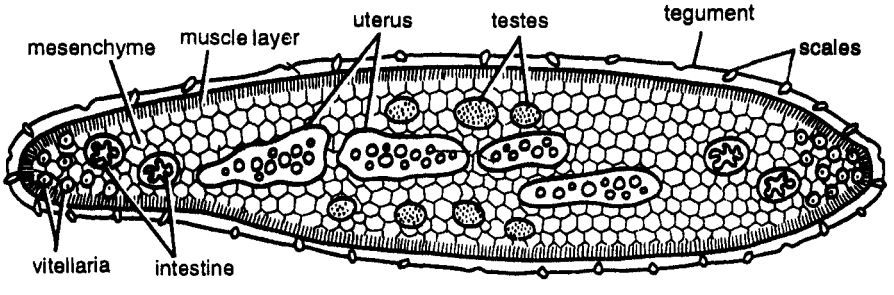


Fig. 72. *Fasciola hepatica.* T.S. passing through Uterus.

73. *Fasciola hepatica* : T.S. Passing Through Testes and Uterus

Comments : The section shows the following details.
(1) Body wall is composed of **tegument**, **musculature** and **mesenchyme**. The muscle layers consist of **outer circular**, **middle longitudinal** and **inner oblique** fibres. Mesenchyme is composed of spongy, fluid-filled cells in which other organs are embedded (Fig. 73).
(2) **Tegument** is homogeneous, non-cellular living protoplasmic layer having affinity for basic stains.

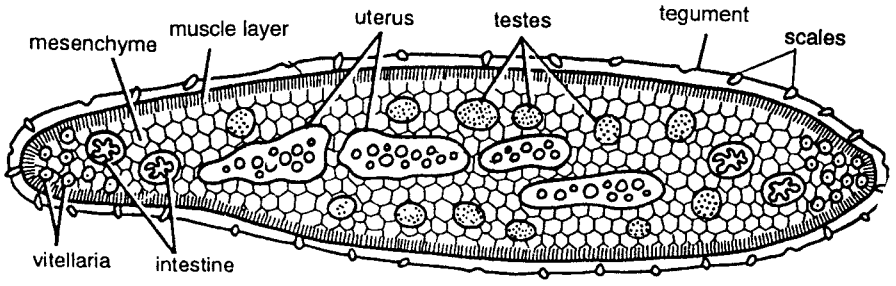


Fig. 73. *F. hepatica.* T.S. passing through Testes and Uterus.

(3) **Tegument consists** of **outer** and **inner zones.**
(4) **Uterus :** Cut portions of uterus contain ova.
(5) **Testes :** Dendrites of testes are cut, giving a granular appearance. The lateral sides of the section are filled with rounded and brownish **vitelline glands.**
(6) **Intestinal caeca** appear distinct and could be identified by observing flagellated inner columnar cells. Uterus and intestine contain repetitions of body wall layers.

Identification : Since the side contains cut dendritic testes and wide lumen uterus filled with eggs, hence it is **T.S.** ***Fasciola*** **through testes** and **uterus.**

74. *Fasciola hepatica* : T.S. Passing Through Cirrus Sac

Comments : Section passes through the **cephalic cone** with the following histological details (Fig. 74).
(1) Body wall is composed of **tegument** with scales, circular, longitudinal and oblique **muscle** fibres and **mesenchyme** cells. Detailed structure same in T.S. ***F. hepatica*** through testes.
(2) Tegument is characterised by having **scales.**
(3) A large sac-like structure, called as **cirrus sac,** encloses seminal vesicle, **prostate glands, ejaculatory duct** and **cirrus.**
(4) **Seminal vesicle** is a large vesicle in cirrus sac full of spermatozoa.
(5) **Cirrus** contains same body-wall layers with highly developed muscles. The lumen of the cirrus represents precirral canal. The cuticle of cirrus is spiny.
(6) In a T.S. through cirrus sac, portions of **uterus, ovary, intestine.**
(7) **Cirrus sac** occupies central position in the section.

Identification : Since the section has distinct cirrus sac with cirrus hence it is a **T.S.** ***Fasciola*** **through cirrus sac.**

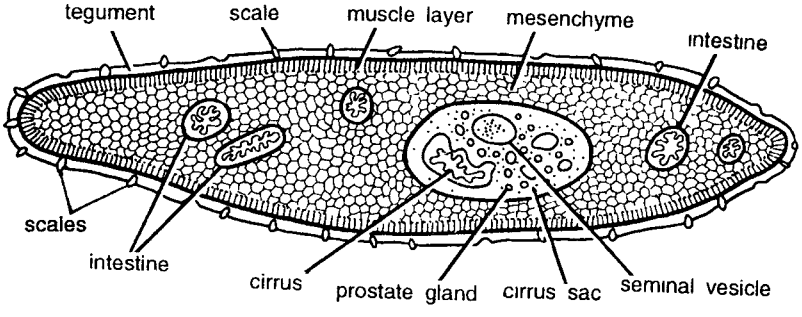


Fig. 74. *F. hepatica.* T.S. passing through Cirrus sac.

75. *Fasciola hepatica* : M.L.S. of Anterior Region

Comments : In median longitudinal section practically all the structures can be observed and it shows the following histological details.

(1) At the anterior extremity is **mouth**, surrounded by **oral sucker** having radially arranged muscles (Fig. 75).
(2) **Tegument** is characterised by the presence of **scales.**
(3) Buccal cavity leads into muscular **pharynx** and **oesophagus.**
(4) **Cirrus sac containing cirrus, prostate glands** and **seminal vesicle** are found below the parts of alimentary canal at the level of the ventral sucker.
(5) On lateral side below cirrus sac is a large **acetabulum** or **ventral sucker.** The cavity of the sucker the radially **arranged muscles** are very distinct.
(6) **Uterus, excretory duct, ootype, Mehli's glands** and **vitelline glands** are observed.
(7) Body wall is composed of living non-cellular and syncytial **tegument muscle layers and mesenchyme. Longitudinal muscle layers** are continuous. Tegument contains **scales.**

Identification : Since the section has both oral and ventral suckers anteriorly, hence it is M.L.S. ***Fasciola*** through anterior region.

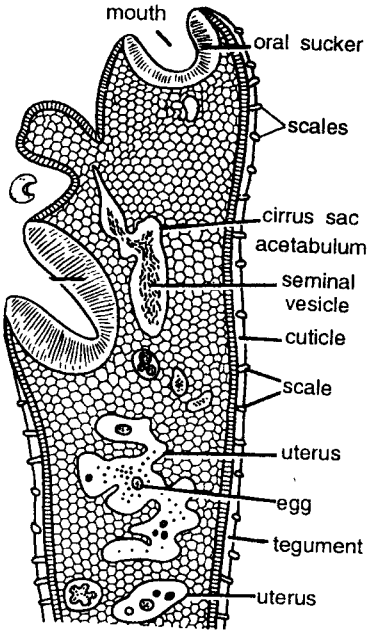


Fig. 75. *F. hepatica.* M.L.S. of Anterior region.

76. *Paramphistomum*

Classification :

Phylum..... Platyhelminthes	→	Organ grade, acoelomate, bilateral flatworms.
Class..... Trematoda	→	Flukes, ecto or endoparasites.
Order..... Digenea	→	Two suckers, endoparasites, one or more intermediate hosts.
Family..... Paramphistomidae	→	Fleshy body with large acetabulum.
Genus..... *Paramphistomum*		

Habit and habitat : ***Paramphistomum*** is an endoparasite in the rumen of sheep, deer, cattle, etc.

Distribution : It is found in India, Srilanka, Myanmar, Asia, Europe and U.S.A.

Comments :

(1) **Commonly** called as **Amphistome** parasite because **acetabulum** is large and found near posterior end of the body (Fig. 76).
(2) **Colour** of the body is **red.** Generally the infection of ***Paramphistomum*** in the rumen is so severe that the black coloured villi are overshadowed by red coloured ***Paramphistomum.***
(3) **Oral sucker** is absent.
(4) It is called as **amphistome** parasite, because **acetabulum** is large and found near posterior end of the body.

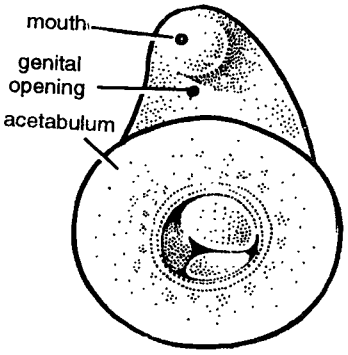


Fig. 76. *Paramphistomum.*

(5) Intestine is forked and unbranched. Lymphatic system is primitive embedded in the parenchyma. Enclosed within the lymphatic canals are primitive blood vessels.
(6) There are two **testes** with **tandem** arrangement, sperm ducts, seminal vesicle and cirrus.
(7) **Female system** has **ovary**, **ootype**, **vitellaria** and folded **uterus**. Eggs are large.
(8) **Genital atrium** is just beneath the fork of the intestine.

77. *Gastrothylax*

Classification : Same as that of ***Paramphistomum***.
Genus..... ***Gastrothylax***
Habit and habitat : ***Gastrothylax*** is an endoparasite, found in the rumen of buffalo.
Distribution : It is found in India, Srilanka and Myanmar.
Comments :
(1) **Body** is elongated and covered by **tegument** (Fig. 77).
(2) It has a **deep ventral pouch** extending upto ventral sucker, which is supposed to be elongated genital chamber.
(3) In having ventral pouch it differs from all other **Digenea**.
(4) Alimentary canal contains **mouth**, **pharynx**, **oesophagus** and simple **non-diverticulated intestine**.
(5) Male reproductive system consists of 2 **rounded testes** near the base of the pouch. The female system has a **single ovary**, **uterus**, **ootype**, **vagina** and **seminal receptacle**.
(6) **Excretory bladder opens** to exterior by a single excretory pore.
(7) Posterior end has a large adhesive sucker or **acetabulum**.
(8) It is called as **amphistome** parasite.
Identification : Since the parasite contains ventral pouch and all above features, hence it is ***Gastrothylax***.

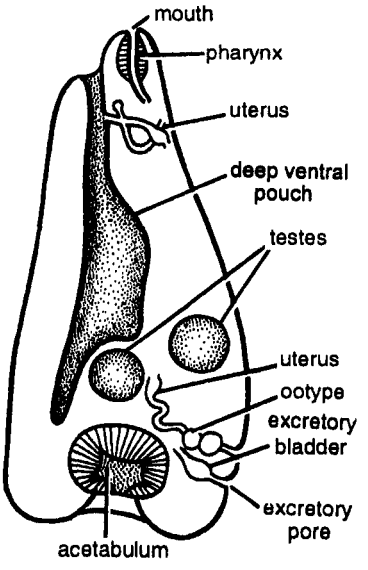


Fig. 77. *Gastrothylax.*

78. *Schistosoma haematobium* : Blood Fluke

Classification :

Phylum..... **Platyhelminthes**	→	Organ grade, acoelomate and bilateral fluke.
Class..... **Trematoda**	→	Flukes, ecto or endoparasites.
Order..... **Digenea**	→	Two suckers, endoparasites.
Family..... **Schistosomatidae**	→	Unisexual.
Genus..... ***Schistosoma***		
Species..... ***haematobium***		

Habit and habitat : ***Schistosoma*** is found in abdominal cavity of man in the mesenteric blood vessels and in extra hepatic portion of the portal system. They attach themselves to the **intima** of veins.
Distribution : They are **endemic** in Sudan, India, China, Japan, France, Portugal and the West Indies.
Comments :
(1) They are **commonly** called as **blood flukes** (Fig. 78).
(2) Blood flukes are peculiar amongst whole trematodes because of the egg-laying habit. Sexes are separate and is tubulated body.

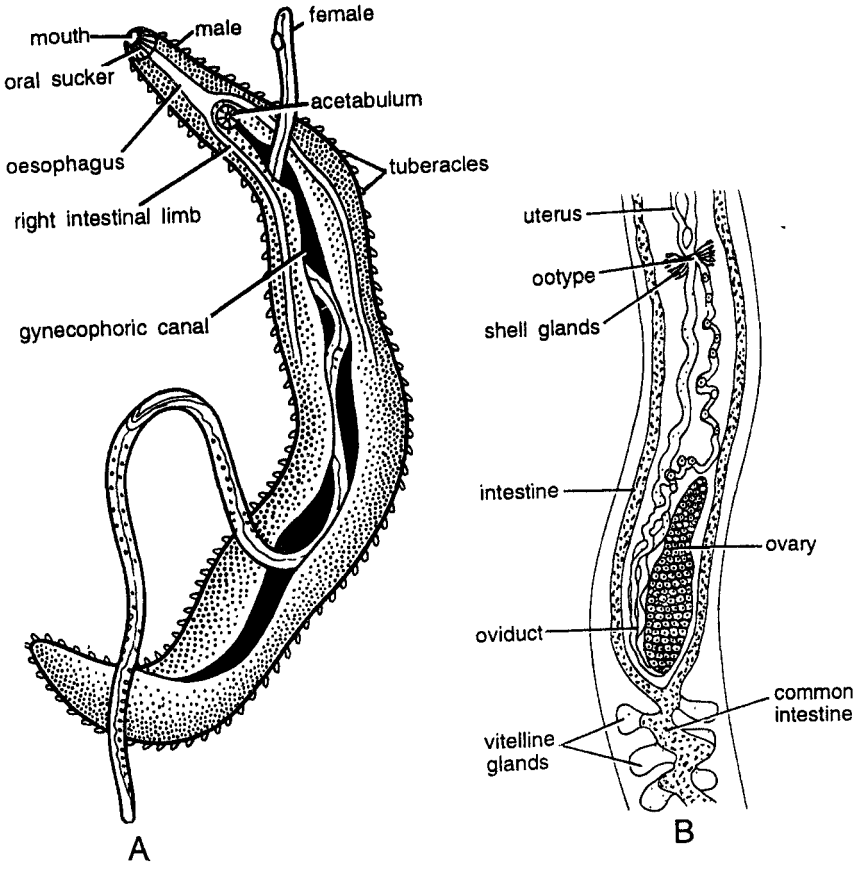


Fig. 78. *Schistosoma haematobium.* **A.** Entire, **B.** Female reproductive system.

(3) Most important characteristic feature of the parasite is that the **female is carried permanently by the male** in its **gynecophoric canal formed** by the folding of its **tegument.**
(4) Males are smaller and stouter (10 to 15 mm) than females (15 to 20 mm).
(5) **Oral** suker and ventral suker (acetabulum) are present in the male and are well developed. In female acetabulum is poorly developed.
(6) Tegument is finelly **tuberculated.**
(7) Alimentary canal consists of **mouth, oral sucker, oesophagus** and **bifid** intestine. The intestinal limbs unite posteriorly and run in zigzag manner upto the posterior end of the body.
(8) Male reproductive system consists of 4 to 5 **testes, sperm duct** and **cirrus.**
(9) Female system has **ovary, oviduct, uterus, ootype** and **vitellaria.**
(10) Vitelline glands are found between the intestinal spirals.
(11) Development includes a **molluscan** as **intermediate host.** Mode of infection is **skin penetration** during walking in water, washing and swimming. The human beings can't avoid cercarial infection due to their swimming and bathing habits and also walking in water.

Pathogenesis : Schistosomiasis causes **headache, temperature, eosinophilia, anaemia, dysentery, vesical thrombosis** and **serious damages to urinogenital system.** Other species are ***S. mansoni, S. japonicum, S. intercalation, S. bovis, S. spindale*** and ***S. meognitum.***

Identification : Since the female is found in the gynecophoric canal of the male and all above features, hence it is ***S. haematobium.***

79. *Opisthorchis* or *Clonorchis sinensis*

Classification :

Phylum..... Platyhelminthes	→	Organ grade, acoelomate, bilaterally symmetrical worms.
Class..... Trematoda	→	Flukes, ecto and endoparasites.
Order..... Digenea	→	Two suckers endoparasites, one or more intermediate hosts.
Genus..... *Opisthorchis*		
Species..... *sinensis*		

Habit and habitat : A digenetic parasite found in liver bile duct and sometimes in pancreatic duct and duodenum of man. It also parasitizes pigs and dogs.

Distribution : Prevalent in India and China.

Comments :

(1) **Commonly** called as **liver fluke of man** (Fig. 79).
(2) Body spatula type. It is found in thousands in the bile duct of man.
(3) **Digestive** system consists of **mouth**, **pharynx** and bifid **intestine**.
(4) **Hermaphroditic : Male** reproductive system consists of **testes**, **sperm duct**, **seminal vesicle**, **ejaculatory duct** and **genital aperture**.
(5) **Female** system consists of **ovary**, **oviduct**, **ootype**, **vitelline gland**, **Mehlis's gland**, **uterus** and **genital aperture**.
(6) Vitelline glands are united by transverse vitelline duct which open into ootype.
(7) Brain is observed anteriorly.
(8) **Life cycle indirect :** First intermediate host is ***Bythinia*** snail where **miracidium**, **sporocyst**, **redia** and **cercaria** larvae develop. Cercaria comes out and encysts on fishes as **metacercaria**. Whenever man eats such unadequately cooked fishes, he becomes infected.

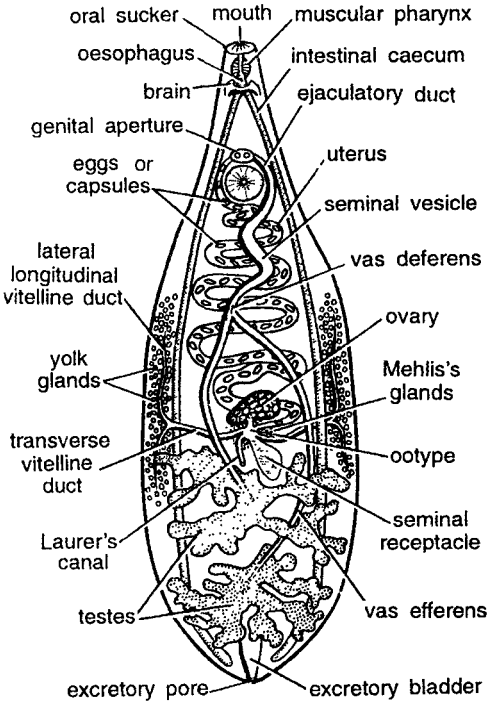


Fig. 79. *Opisthorchis.*

Identification : Since fluke has spatula shape and all above features, hence it is ***Ophisthorchis***.

80. *Fasciola hepatica* : Eggs

Comments :

(1) Eggs of ***Fasciola hepatica*** mounted over the slide are seen in different stages of development.
(2) A single fluke produces 3,000 to 35,000 eggs daily (Fig. 80).
(3) **A fertilized egg** is oval, measuring 130 to 150 microns in length and 63 to 93 microns in breadth.
(4) Each egg contains an operculum.
(5) **Segmentation** of eggs starts while in uterus.
(6) First division divides the zygote into two unequal cells. **Smaller** one is called as **propagatory** cell while **larger** one is **somatic cell**. Besides, there are yolk cells.

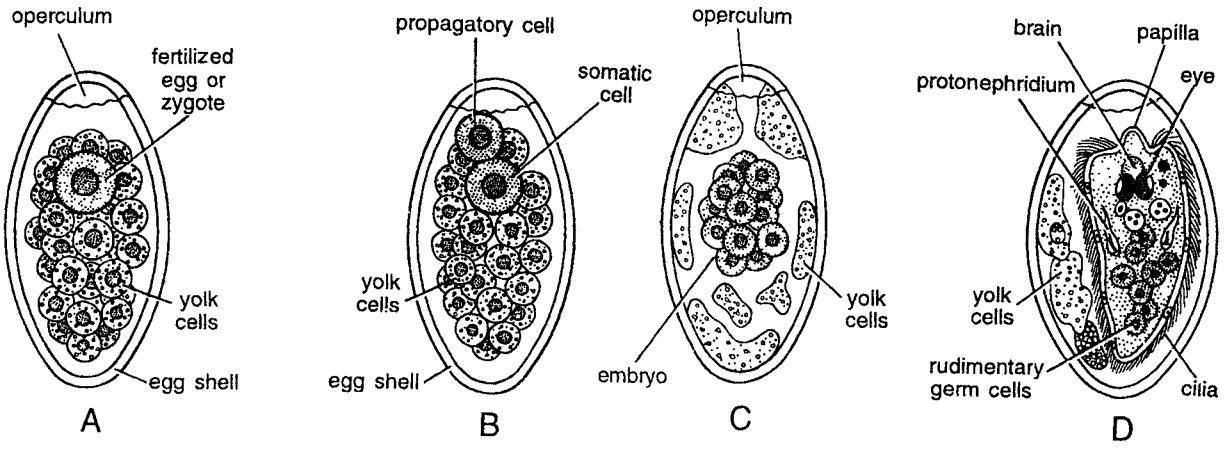


Fig. 80. *Fasciola hepatica.* Eggs at different stages. **A.** Fertilized egg, **B.** 2-celled stage, **C.** Many celled stage, **D.** Embryonated stage.

(7) **Many celled stage** contains several propagatory and somatic cells.
(8) Fully embryonated egg contains **Miracidium larva** and few yolk cells.

Identification : Since the egg contains operculum and in oval shape, hence it is egg of ***F. hepatica***.

81. *Fasciola hepatica* : Miracidium Larva

Comments :

(1) **Miracidium** is the first free-swimming larva in the life cycle of ***F. hepatica***. Zygote develops into miracidium after 6 to 9 days at 25-30°C.

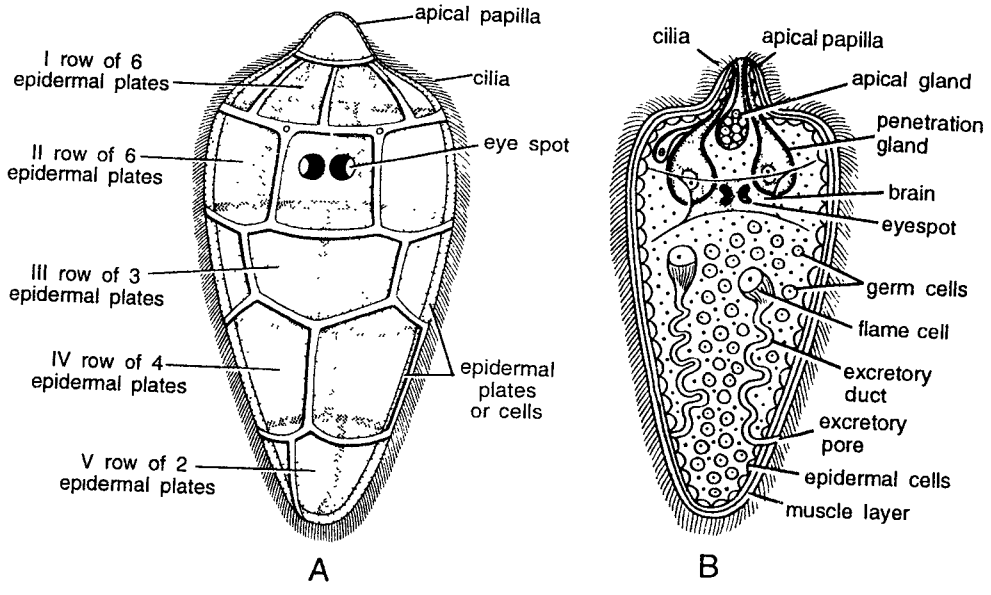


Fig. 81. *Fasciola hepatica.* Miracidium larva. **A.** Epidermal plates, **B.** Internal structure.

(2) **Miracidium** larva hatches or comes out from the egg by breaking the shell and leads a free life.
(3) **Body** is microscopic, conical, dorso-ventrally flattened and covered with **ciliated epidermal plates.** Epidermal plates are of **taxonomic** importance. There are 21 plates arranged in 5 rows. Epidermal plates or cells consist of 6, 6, 3, 4 and 2 in I, II, III, IV and V rows respectively.
(4) Anterior end is produced into a conical papilla which acts as boring organ.
(5) **Body wall** consists of muscle layers, glandular epithelium and delicate fluid-filled mesenchyme cells, in which internal organs are embedded.
(6) Internally, a multinucleated **apical gland**, 2 to 7 **penetration glands, eyespots, brain, germ balls** and **flame cells** are present.
(7) Apical gland is non-functional and is supposed to be primitive gut, while the penetration or cephalic glands, secrete secretion, which can dissolve a bit of tissues. They help in penetration of miracidium into the snail's body.
(8) **Cilia, apical papilla** and **penetration glands** are purely larval adaptations.
(9) Miracidium larva swims actively in water in search of a suitable molluscan intermediate host, which may be ***Limnea truncatula***, ***Bulinin*** or ***Planorbis***. If it gets a suitable host it changes into next or second-stage larva (sporocyst).
(10) Failing to get a suitable snail, the larva dies after 24 hours.

Identification : Since the larva has ciliated epidermal plates, apical gland-penetration gland and all above features, hence it is **Miracidium larva of *F. hepatica*.**

82. *Fasciola hepatica* : Sporocyst Larva

Comments :

(1) Miracidium larva on getting a suitable snail penetrates into the body of the snail and metamorphoses into **intramollusca phase**, called as **sporocyst** larva.
(2) It shows extreme degree of **parasitism**, being **devoid** of **alimentary canal** and **locomotory organs**.
(3) It also destroys the tissues of the snail.
(4) It penetrates through pulmonary chamber and during this process, cilia, with epidermal plates brain, eye spots, apical and penetration glands are degenerated.
(5) Body becomes rounded having **germ balls** and four **flame cells.**
(6) **Sporocyst** becomes germinal, **sac-like structure**, measuring about 1 mm in diameter.
(7) Body wall layers are **tegument, epithelial cells, muscle layers** and **mesenchyme.**

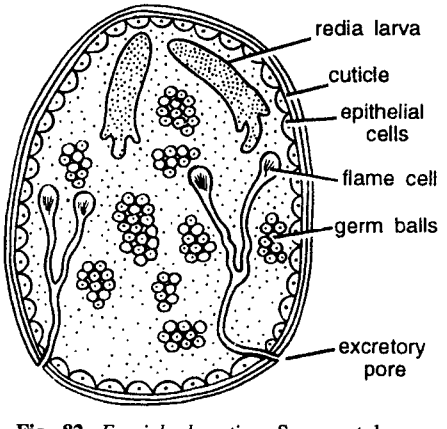


Fig. 82. *Fasciola hepatica.* Sporocyst larva.

(8) Germ balls in sporocyst multiply and form next or third larval stage, called as redia larva.
(9) Sporocyst is **non-feeding** stage.
(10) Excretory pores are still 2 in number.

Identification : Since the slide has rounded sac-like structure with redia inside and all above features, hence it is **sporocyst larva** of ***F. hepatica*.**

83. *Fasciola hepatica* : Redia Larva

Comments :

(1) **Redia larva** is a third **intra-molluscan parasitic larva**, found in the digestive glands (Fig. 83).
(2) The unique feature of the larva is that, it develops from the **germ balls** present in sporocyst. **Germ balls** multiply and give rise to redia.
(3) Body is elongated, cylindrical and complex in structure.
(4) It measures 1.3 to 1.6 mm in length.
(5) Anteriorly, there is a muscular ring-like swelling, called as ***collar***. Just beneath the collar is birth pore.
(6) Posteriorly, larva contains two processes near foot called as **lappets**, which anchor in the tissue of the snail.
(7) Body wall is composed of **tegument**, **epithelial layer** and **delicate mesenchyme.**
(8) **Alimentary canal** consists of **mouth**, **pharynx** and **elongated gut. Pharynx contains pharyngeal glands.**
(9) **Flame cells** increase in number and a number of twigs are formed. There are still 2 **excretory pores.**
(10) Germ balls are present, occupying major portion of the body. They differentiate into next larval stage, called as **cercaria larva**. In ***F. hepatica***, redia larva with rich nourishment gives rise to **secondary generation** of rediae by germ balls. Daughter redia and cercariae come out from mother redia through birth pore.

Identification : Since the larva has lappets, elongated body collar and all above features, hence it is **Redia larva** of ***F. hepatica***.

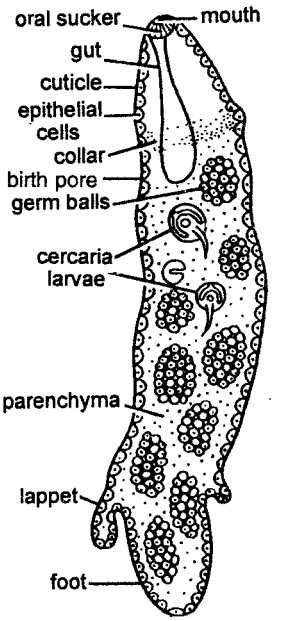


Fig. 83. *Fasciola hepatica.* Redia larva.

84. *Fasciola hepatica* : Cercaria Larva

Comments :

(1) **Cercaria** larva is a free-swimming larva. It comes out from redia through birth pore as well as from snail by the pressure of the perivisceral space and between 9-26°C temperature (Fig. 84).
(2) It has higher grade of organization and considerably resembles the young fluke.
(3) **Body** is oval in shape with a long simple tail, measuring 0.25 to 0.35 mm in length.
(4) Body and tail are covered with **tegumental spines**. Tail and spines are purely larval structures meant for locomotion.
(5) Body wall is composed of **tegument**, **circular**, **longitudinal** and **diagonal muscle fibres** and **mesenchyme.**
(6) Beneath the muscle layer and numerous unicellular **cystogenous glands**, which will form cyst of future larva.
(7) Digestive system consists of **mouth**, **oral sucker**, **pharynx**, **oesophagus** and **forked intestine** on trematode pattern. **Acetabulum** is present just below the fork of the intestine.

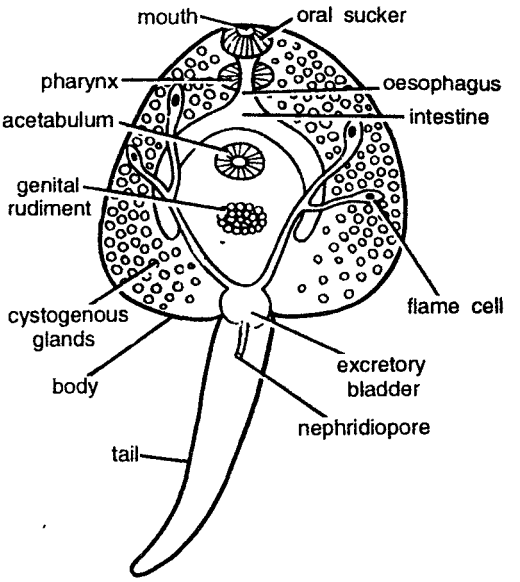


Fig. 84. *Fasciola hepatica.* Cercaria larva.

(8) **Flame cells** still increase in number. The nephridial tubes unite to form excretory vesicle. Which opens on the tail by **nephridiopore**.
(9) **Germ balls** represent genital rudiments.
(10) Cercaria larva, after brief free-life, undergoes encystment on water plants, the tail and cuticular spines are shed, cystogenous glands form cyst and disappear and the encysted cercaria is called as **metacercaria**.

Identification : Since the larva has body, tail bifid intestine, oral, ventral sucker hence and all above features hence it is **cercaria larva** of ***F. hepatica***.

85. *Taenia solium* : Scolex

Classification :

Phylum..... **Platyhelminthes**	→	Organ grade, acoelomate and bilateral flatworms.
Class..... **Cestoda**	→	Segmented tapeworms without digestive tube.
Sub-class..... **Eucestoda**	→	Merozoic tapeworms, larva with six hooks.
Order..... **Cyclopylidae**	→	Scolex with four suckers and rostellum provided with hooks.
Genus..... ***Taenia***		
Species..... ***solium***		

Comments :

(1) Anterior cephalic end of the body terminates into knob-like structure, called as **scolex**.
(2) It is **quadrate**, about 1 mm in diameter with four **protuberant suckers**, which act as sticking organs.
(3) In addition to suckers, scolex contains **rostellum**, which is pigmented and provided with a double **row of hooks**.
(4) Number of hooks varies from 28 to 32.
(5) Longitudinal excretory canal and transverse excretory canals are present.
(6) Smaller hooks alternate with larger hooks, measuring 110 to 140 and 160 to 180 microns respectively.
(7) Internally, scolex contains spongy **mesenchyme** with **nephridial network** and ring.
(8) Scolex lies buried on the intestinal mucosa of host's intestine. It **destroys the tissues of the host's intestine**.

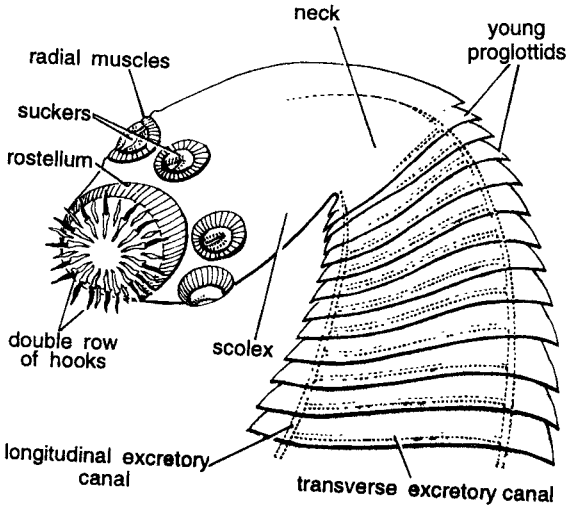


Fig. 85. *Taenia solium.* Scolex.

Identification : Since the rostellum has 28 to 32 hooks and all above features, hence it **scolex of *Taenia solium***.

86. *Taenia solium* : Mature Segment

Comments :

(1) **Mature segment** of ***Taenia solium*** is square like, **hermaphroditic** with a single set of reproductive organs, and having **osmoregulatory and nervous systems** (Fig. 86).
(2) Genital organs constitute main structures.
(3) Male genital system consists of **follicular testes, vasa efferentia, vasa deferens** and **cirrus**.

(4) Female system consists of **ovarian lobes** connected by **isthmus, oviduct, ootype, compact vitellaria** and **Mehli's glands. Vagina** carries the sperms. It starts from **genital atrium** and opens into **ootype.** It swells to form **seminal receptacle** before opening into **ootype.**
(5) **Uterus** arises from ootype and extends upwards.
(6) Male and female genital tubes open into **genital atrium** with common **gonopore.** Genital atrium found on **genital papilla** alternates irregularly in the following segments.
(7) Excretory duct and nerve cord run side by side on each side successively from one segment to the other.

Identification : Since segment has bilobed ovary and all above features, hence it is, **mature segment** of ***Taenia solium.***

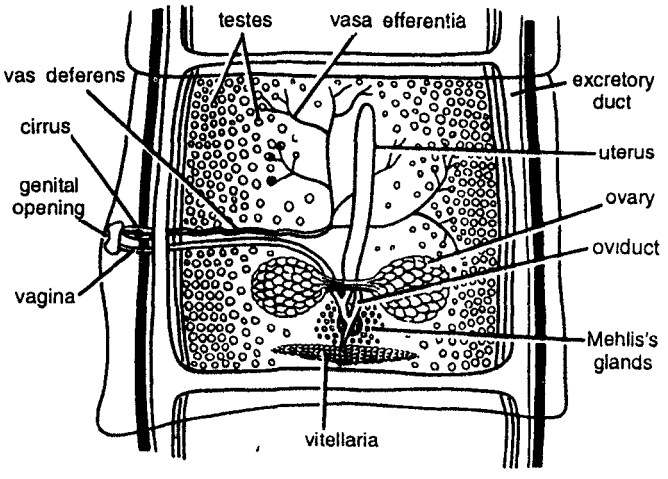


Fig. 86. *Taenia solium.* Mature segment.

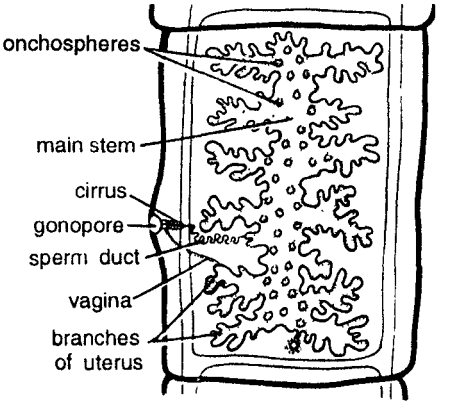


Fig. 87. *Taenia solium.* Gravid segment.

87. *Taenia solium* : Gravid Segment

Comments :

(1) **Gravid segments** are situated posteriorly. They are longer than their bredth (Fig. 87).
(2) **Uterus** becomes branched containing about 11 to 13 branches, measuring 10 to 12 mm in length and 4 to 6 mm in breadth.
(3) Uterus is full of **onchospheres.**
(4) Other organs **atrophy.**
(5) In ***Taenia solium***, gravid segments are detached from main chain and this phenomenon is known as **apolysis.**
(6) Uterus is blind without any opening and hence, the whole segment is detached.
(7) It is passed to the exterior along the stool of the host and eggs reach outside by this method.
(8) Sometimes, the gravid segments burst in the intestine and liberate several **onchospheres.**
(9) They show wriggling movement.

Identification : Since the slide has branched uterus filled with eggs, hence it is **Gravid segment** of ***T. solium.***

88. *Taenia solium* : T.S. Passing Through Mature Segment

Comments : *The section passing through uterus or middle region shows several structures and shows the following histological details.*

(1) Body wall layers are composed of **tegument muscle layers sub-cuticle and mesenchyme.**

(2) Previous cuticle is now called as **tegument** in cestode. It is composed of outer fringe like **comidial layer**, middle **homogeneous** and inner **basement membrane.**

(3) Outer layer according to electron microscopic studies have revealed that it consists of **microvilli** or **microstiches** like these of **microvilli** of unit membranes.

(4) Outer layer is also called **epidermis** and contains several **mitochondria.** In the absence of **alimentary canal**, all the nutritional chemicals, electrolytes and ions are taken through the tegument by active transport.

(5) **Muscle fibres** layer comprises of **outer circular** and **inner longitudinal muscle fibres.**

(6) Longitudinal muscles are well developed and the parasite is able to move its ribbon-like body in all directions throughout the length.

(7) **Mesenchyme** or parenchyma fills the interior and it acts as a **packing tissue**, in which various organs are embedded. Mesenchyme also contains dorsoventral and transverse muscles, which run from one proglottid to other.

(8) Mesenchyma or parenchyma is divided into dense **cortical peripheral region** and clear **medullary central** region by circular muscle fibres.

(9) Major portion of the section contains **eggs.** The rounded pinkish **tests** are also seen.

(10) On the lateral sides of section cut proteins of **nerve cord** and **excretory** ducts are also visible.

Identification : Since the section contains hairy tegument, cortex and medulla, various cut portions of testes, uterus, hence it is **T.S. mature segment** of ***Taenia.***

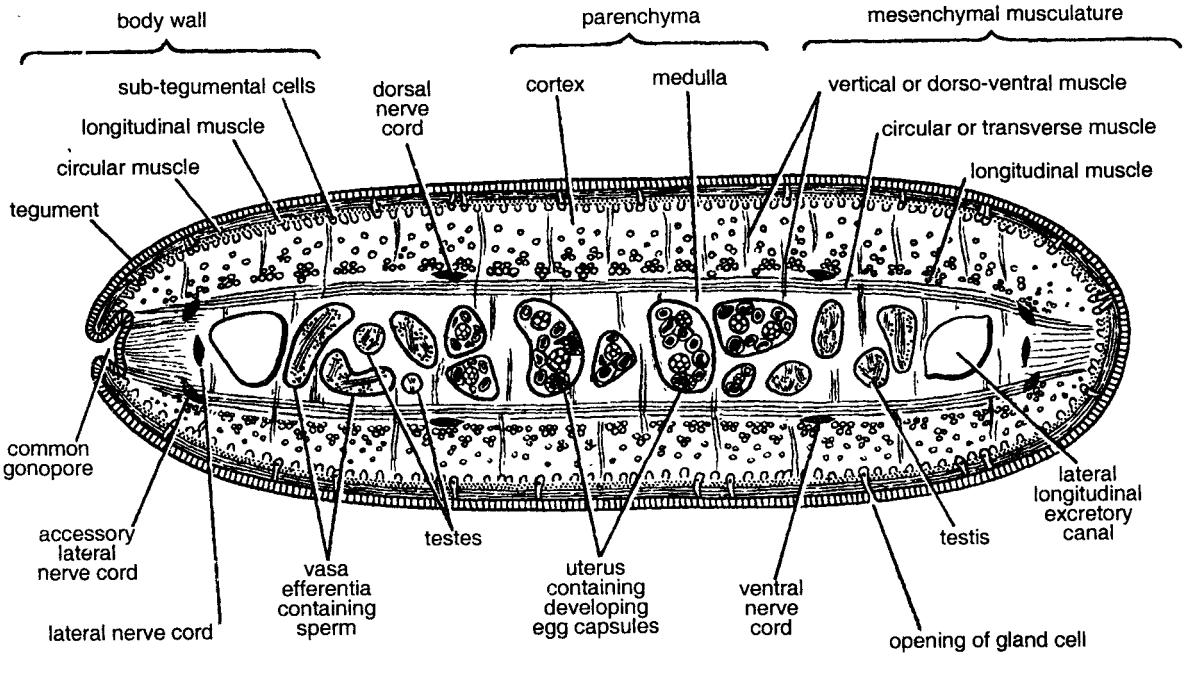


Fig. 88. *Taenia solium.* T. S. through mature segment.

89. *Taenia solium* : Cysticercus Larva

Comments :

(1) Cysticercus larva **commonly** called as **bladder worm** is the **infective stage** found in the intermediate host (Fig. 89).

(2) **Pig** is an intermediate host, where **onchospheres** are developed into encysted cysticercus larvae and these can be very easily spoted as white spots between muscle fibers and the connective tissue.

(3) **Contaminated** part of pig muscle is called as **measly pork**.

(4) Encysted larva consists of a sac or **bladder-like structure**, having **invaginated proscolex** measuring 6 to18 mm in length. **Pro-scolex** contains **suckers** and **hooks**.

(5) Bladder is grossly opalescent, made up of a single layer and filled with a fluid.

(6) **Cysticercus larva of *Taenia solium*** is called as **cysticercus cellulose**.

(7) Cysticercus larvae can be obtained after removing the cyst wall. If the larvae are kept in normal saline solution the scolex is evaginated in 5 to 10 minutes.

(8) Evaginated scolex contains **hooks, rostellum, sucker** and **bladder**. When **cysticerus** are ingested along with **measly pork**, they reach intestine where cyst is dissolved, scolex is **evaginated** and then scolex attaches in the mucosa of the intestine.

(9) Infection of ***Taenia solium*** can be avoided by not eating the measly pork.

Identification : Since the larva contains bladder and proscolex hence it is **bladder worm** of ***Taenia solium***.

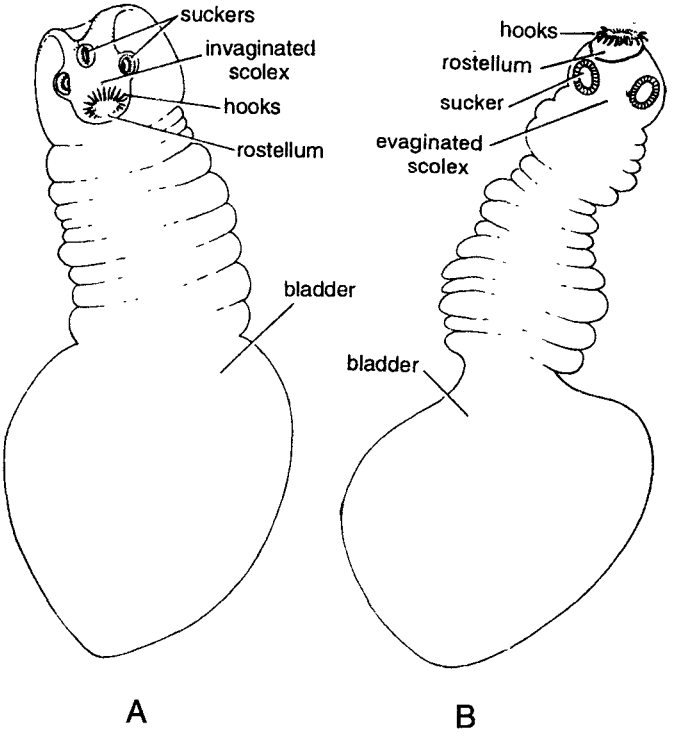


Fig. 89. *Taenia solium.* Cysticercus larva. **A.** Invaginated scolex, **B.** Evaginated scolex.

90. *Echinococcus granulosus*

Classification :

Phylum	**Platyhelminthes**	→	Organ grade, acoelomate and bilateral flatworms.
Class	**Cestoda**	→	Ribbon-shaped tapeworms with alimentation.
Sub-class	**Eucestoda**	→	Segmented tapeworms, larva with six hooks.
Order	**Cyclophyllidea**	→	Four suckers, rostellum retractele.
Family	**Taeniidae**	→	Rostellum contains double rows of hooks.
Genus	***Echinococcus***		
Species	***granulosus***		

Habit and habitat : ***Echinococcus granulosus*** is found in the small intestine of dogs, cats wolves, foxes and other carnivores, which act as definitive hosts. The larvae of this parasite develop into **hydatid** cysts in man and other domesticated herbivorous animals, which act as intermediate host.

Distribution : It has **cosmopolitan** distribution and is especially found in sheep and cattle raising areas. Its infection has been reported from Australia, Japan, India, New Zealand, China and U.S.A.

Comments :

(1) **Commonly** called as '**hydatid worm**'.

(2) ***Echinococcus*** is interesting cyclophyllidian **pathogenic, four-segmented parasite**, measuring 2 to 8 mm in length.

(3) Body is differentiated into (i) **scolex** containing typical **taenoid suckers** and **rostellum** with **hooks**, (ii) **first immature** segment having only rudiments of structures, (iii) **second mature** segment containing fully developed genital organs, and (iv) **third gravid** segment.

(4) Lower part of the scolex acts as neck region, from where new segments are formed.

(5) **Hermaphroditic** and the mature segment contains a **single set** of **genital organs**.

(6) **Male** reproductive system consists of **testes, sperm duct** and **cirrus**.

(7) **Female** system consists of an **ovary, oviduct, vitellaria, uterus, ootype** and **Mehlis's glands**.

(8) **Gravid segment** is elongated containing branched uterus with **onchospheres**.

(9) **Man** acquires infection by **playing** with **dogs**. The onchospheres also reach man along food or drink. Inside man or any other intermediate host, the **onchospheres** develop into a hydatid vesicle or cyst, either unilocular or multilocular. Other hydatids are **alveolar hydatids** and **osseous hydatids**.

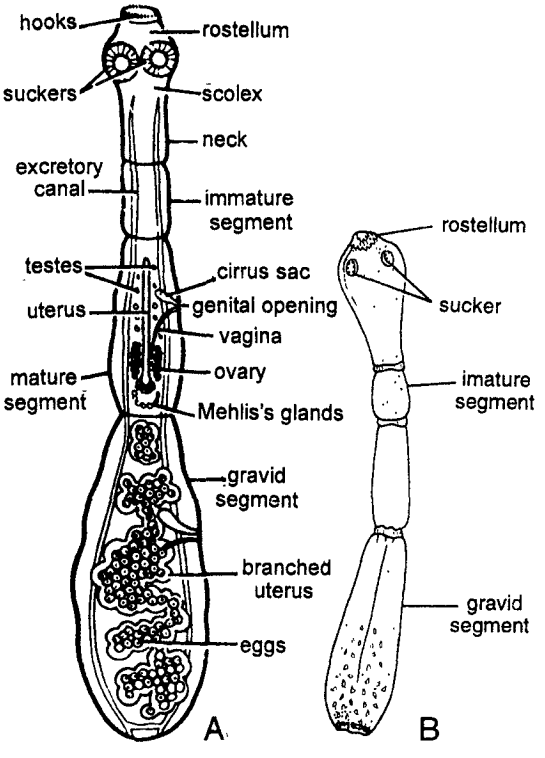


Fig. 90. *Echinococcus granulosus.* **A.** Mounted, **B.** Photograph, Entire.

(10) Hydrated vesicles contain germinal layer which develops internally various **brood capsules**.

Pathogenesis : ***Echinococcus's*** hydatids are harmful to mankind. The cystic fluid produces toxic substances which cause **womiting, diarrhoea abdominal pain, eosinophilia**, and collapse in certain cases.

Identification : Since the parasite contains scolex immature segment and gravid segment, hence it is ***Echinococcus granulosus***.

PHYLUM NEMATHELMINTHES

Pseudocoelomate Animals

Phylum Nemathelminthes contains pseudocoelomate round worms. In these worms the coelom originates from mesoderm but disorganizes and losses all the characters of true coelom. Excretory system and genital organs do not originate from coelomic epithelium, hence called as pseudocoelomate.

91. *Ascaris lumbricoides* : T.S. Male Passing Through Middle of the Body

Comments : The transverse section through the body of male contains selections of alimentary canal, testis, seminal vesicle, vas deferens, etc. and it shows the following histological details, with organ-grade organization.

(1) Due to coiling and recurving of testis and sperm duct, one or more coils are cut in a T.S.

(2) **Body wall** is composed of **cuticle, hypodermis, a muscle layer** and **pseudocoel.**

(3) Cuticle is composed of **cortical layer (outer and inner) median layer, basal layer** and **basement membrane.** Cuticle is thick, tough, transversely striated, semi-permeable and resistant. It is secreted by underlying epidermis.

(4) **Hypodermis** is **syncytial** and bulges in pseudocoel at mid-dorsal, mid ventral and on lateral sides, forming four **longitudinal chords** (diagnostic character), which divide musculature into four quadrants.

(5) Muscle layers consisting exclusively of longitudinal fibres which are composed of muscular and

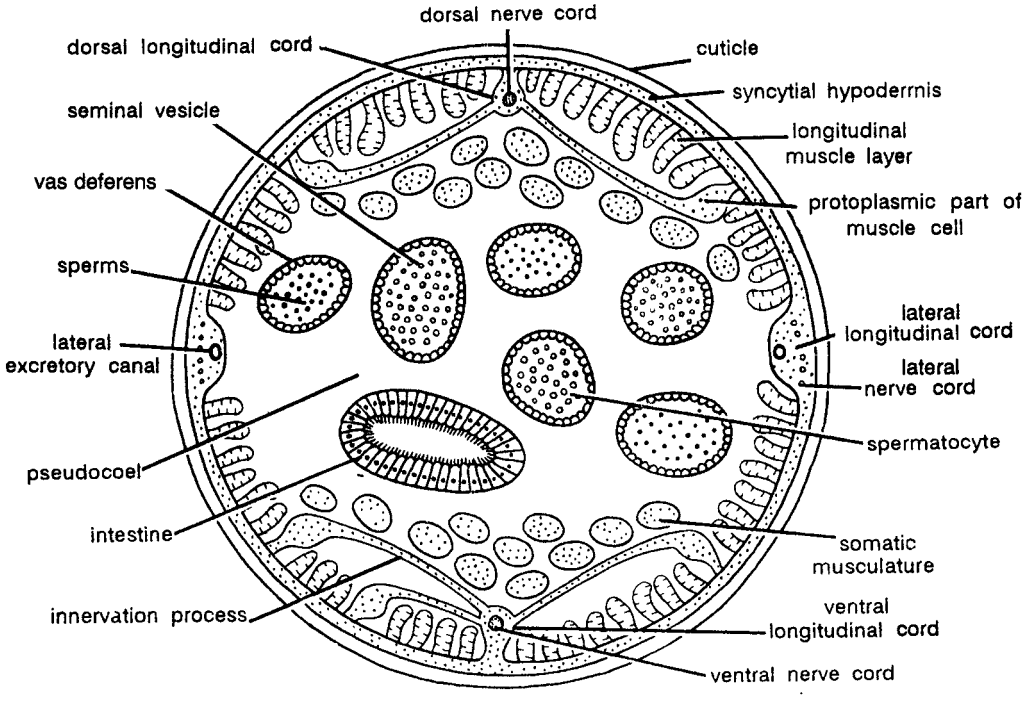


Fig. 91. *Ascaris lumbricoides.* T. S. Male.

nucleated protoplasmic zones projecting on pseudocoel. The muscular zone contains contractile and non-contractile fibres. Muscles are of **polymarian type** (number of rows of muscle fibres).

(6) **Pseudocoel :** False body cavity between digestive tube and body wall. It contains fibrous and giant cells. Pseudocoel develops by the disorganization of the mesenchyme cells and hence it does not contain true characters of coelom, as it has no connection with excretory organ, it is not lined by epithelial layer and sex cells develop independently and hence it is called as **false body cavity** or pseudocoel.

(7) Various rounded cut sections of coiled **testes** are present. Testes sections are without lumen but with a central rachis.

(8) **Sperm** duct and the **seminal vesicle** have wide lumen filled with dot-shaped spermatozoa.

(9) **Intestinal** section is also prominent with long **endodermal** nucleated epithelial **columnar ciliated cells** or brush border.

(10) **Dorsal** and **ventral longitudinal chords contain dorsal** and **ventral nerve chords**, while the **lateral chords contain excretory canals** and nerves. Some giant cells are also visible in the section.

Identification : Since the section contains, besides above structures dot shaped spermatozoa in sperm ducts and solid testis sections, hence it is **T.S. male *Ascaris*.**

92. *Ascaris lumbricoides* : T. S. Female Passing Through Midbody

Comments : The transverse section of female ***Ascaris lumbricoides*** shows sections of ovary, oviduct, uterus, besides digestive tube. Triploblastic and organ-grade (Fig. 92).

(1) **Body wall** is composed of same layers as found in males, such as thick cuticle syncytial hypodermis bulging in pseudocoel forming four longitudinal chords, and muscle fibres. The detailed structure of body wall layers is same as in the case of T.S. of male ***Ascaris***.

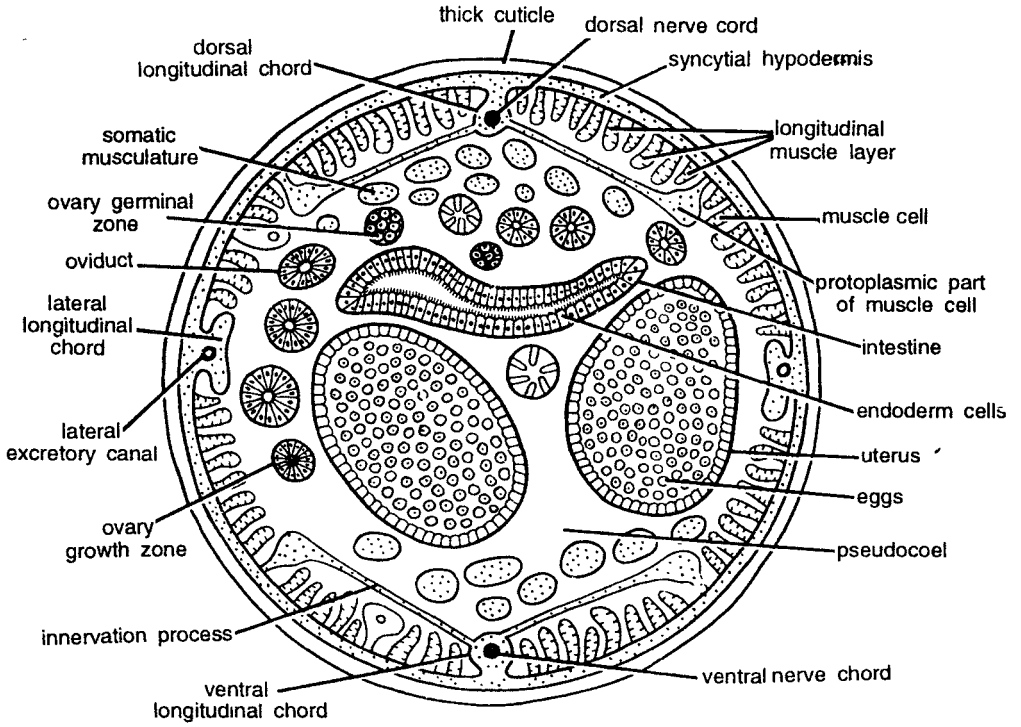


Fig. 92. *Ascaris lumbricoides.* T. S. female.

(2) **Pseudocoel :** False body cavity between alimentary canal and body wall.
(3) **Ovary :** Lumen is absent. Diameter of the section is the smallest, as compared to oviduct and uterus.
(4) **Oviduct :** It is wider than ovarian thread containing lumen and eggs.
(5) **Uterus :** Having **wide lumen full of eggs.**
(6) **Ovary**, oviduct and uterus are elongated, coiled and recurved upon themselves, and hence, more than one section in a T.S.
(7) **Ovary** are very distinct containing single nucleus and cytoplasm.
(8) **Intestine is made** up of **endodermal and columnar epithelial cells.**
(9) **Some giant cells** are also seen in the section.

Identification : Since the section contains besides above structure, ova in uterus, hence it is **T.S. of female *Ascaris*.**

Note : *Students often confuse to differentiate the T.S. of male and female. This is to be kept in mind that whether the T.S. through testes and spermduct or uterus. T.S. through uterus in female will show large nucleated ova while in male's section dot shaped sperms are seen.*

93. *Enterobius vermicularis*

Classification :

Phylum.....Aschelminthes (Nemathelminthes)	→	Pseudocoelomate, unsegmented round worms. Unisexual nematodes.
Order..... Oxyuroidea	→	Pharynx with posterior bulb.
Genus..... *Enterobius*		
Species..... *vermicularis*		

Habit and habitat : ***Enterobius vermicularis*** is strictly human parasite inhabiting caecum appendix and neighbouring parts of intestine from where gravid females migrate to the rectum (Fig. 93).

Distribution : It has world-wide distribution, but it is specially found in Europe, U.S.A., Chile, India, Africa and Canada.

Comments :

(1) **Commonly** called as **pin-worm, seatworm** or **thread worm.**
(2) Male and female are separate.
(3) Adults are small white worms, often seen wriggling actively in stool passed after purge or enema.
(4) **Males** measure 2 to 5 mm in **length** 0.1 to 0.2 mm in breadth, while the famales measure 8 to 13 mm by 0.3 to 0.5 mm.
(5) Anterior end is provided with 3 **small lips** and a pair of cephalic expansion. **Tail end** of male is **ventrally curved** while that of female pointed. **Gubernaculum** in males is absent. Cervical alae present.
(6) **Mouth** leads into oesophagus which has **bulb** at posterior end. Oesophagus leads into **intestine** which opens to outside by **anus** through rectum.
(7) **Male reproductive** system consists of **testis, vas deferens, seminal vesicle, ejaculatory duct** and **cloaca.**

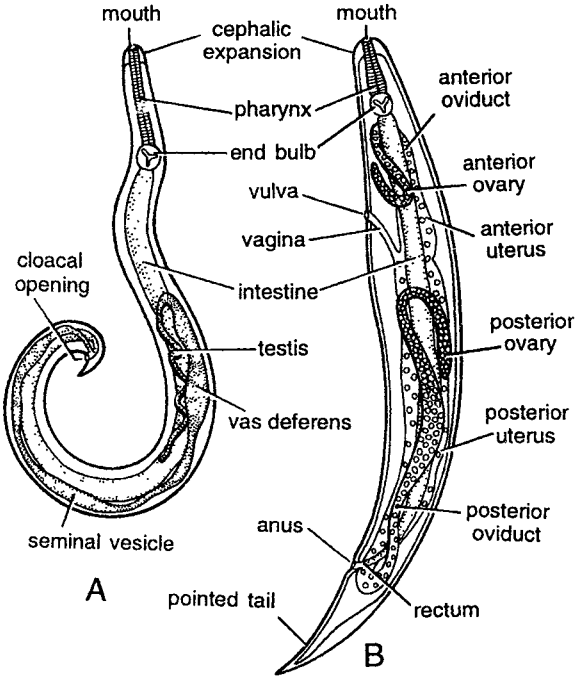


Fig. 93. *Enterobius vermicularis.* **A.** Male, **B.** Female.

(8) **Female reproductive system** consist of **anterior ovary**, **posterior ovary**, anterior **uterus**, posterior **uterus** and **oviducts**. Two uterii unite to form vagina which opens to outside by vulva. **Vulva** is anteriorly situated and ovaries are **didelphic**.

(9) **Life cycle** is simple. The gravid females crawl in the anal region causing itching sensation. The eggs are released. The patient scratches the affected region and eggs come under the nails and again they reach the same host through mouth along food. The infection can also be obtained through the food or drink.

(10) Women and young girls are more susceptible for infection than adult men and male children.

Pathogenesis : The females cause irritation around the anus. The migrating females often enter into female genital tract causing **inflammation**. They may go upto peritoneal cavity through fallopian tubes. The itching caused by migration of the worms in the anal region and **allergic** irritation of the skin may be intense, causing **sleeplessness**, **restlessness**, **nervousness**, **sexual disorder**, **abdominal pain**, **appendicitis**, etc. Anthelmintics and drug treatment include **Hexylrecorcinol**, **Terramycin**, **Diphenan** and **Antepar**.

Instructions : Since the parasite contains cervical alae, bulbous oesophagus and all above features hence it is ***Enterobius***.

94. *Oxyuris*

Classification : Same as those of ***E. vermicularis***.
Genus.....*Oxyuris*

Habit and habitat : ***Oxyuris*** in found in the caecum of common house mouse ***Mus musculus***.

Distribution : Cosmopolitan.

Comments :

(1) **Commonly** called as **pin worms**.

(2) **Males** smaller than females.

(3) **Mouth** is surrounded by one dorsal and two ventrolateral **lips**. Mouth leads into **oesophagus** with a characteristic **bulbous** region. Oesophagus opens into **intestine**. Intestine opens by anus through rectum in females. In males intestine opens to outside through cloaca.

(4) **Males measure** 1.35 to 1.40 mm in total **length** and 0.11 mm is **breadth**.

(5) Males are characterised by having 3 cuticular **mamelons**, **single spicule** and **gubernaculum**. Tail has tail process. Testis occupies measure part of interior.

(6) **Females** measure 2.52 to 4.5 mm in **length** and 0.19 to 0.32 mm in **breadth**.

(7) **Vulva** lies at a distance of 0.46 to 1.08 mm form anterior extremity.

(8) Entire interior of female is filled with large number of eggs in the uterus.

Identification : Since male has 3 mamelons and all above features, hence it is ***Oxyuris* sp.**

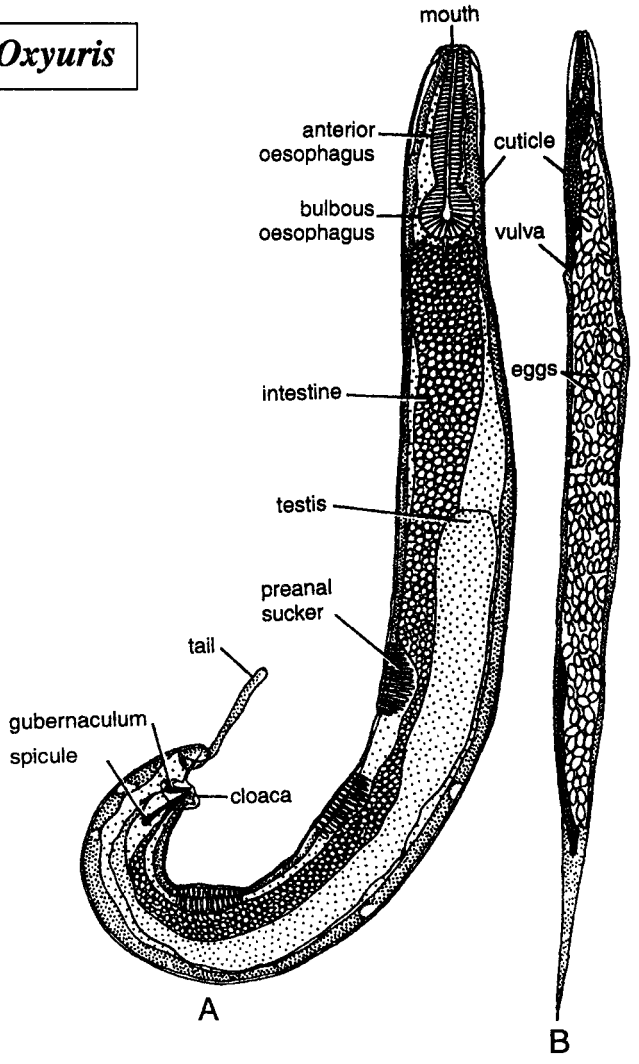


Fig. 94. *Oxyuris.*

95. *Trichinella spiralis*

Classification :

Phylum..... **Aschelminthes (Nemathelminthes)** → Pseudocoelomate, unsegmented roundworms.
Order..... **Trichinelloidea** → Whipworms.
Genus..... ***Trichinella***
Species..... ***spiralis***

Habit and habitat : ***Trichinella spiralis*** is found naturally in the small intestine of dogs, cats, rabbits, wolves, musk rats, badgers, pigs and man. Man acquires infection through food or drink containing ***Trichinella*** eggs.

Distribution : The infection has been reported from Europe, United States, Arctic regions. Africa, Australia and Mexico.

Comments :

(1) **Commonly** called as **whip worm.**
(2) Different from other intestinal worms.
(3) Serious and often fatal results of **trichiniasis** are due to the offsprings of the infecting worms and not due to the adult worms in the intestine.
(4) Adult worms are small and slender. **Males** measure 1.4 to 1.6 mm in length while females 3 to 4 mm. They are usually short lived, generally disappearing within 2 or 3 months after infection.
(5) Anterior end in both sexes in pointed. Posterior end in males is flattened due to copulatory lobe, but in females is pointed.
(6) Mouth leads into **pharynx**, which contains large **granular** cells, called as **stichosome.**
(7) **Vulva** is anterior.
(8) After copulation, males die. Females lay eggs into villi or in peritoneum and mesenteric lymph glands. Eggs hatch and larvae reach in muscles for encystment through blood vessels. It is only striated muscles where the larva of ***Trichinella spiralis*** encysts.

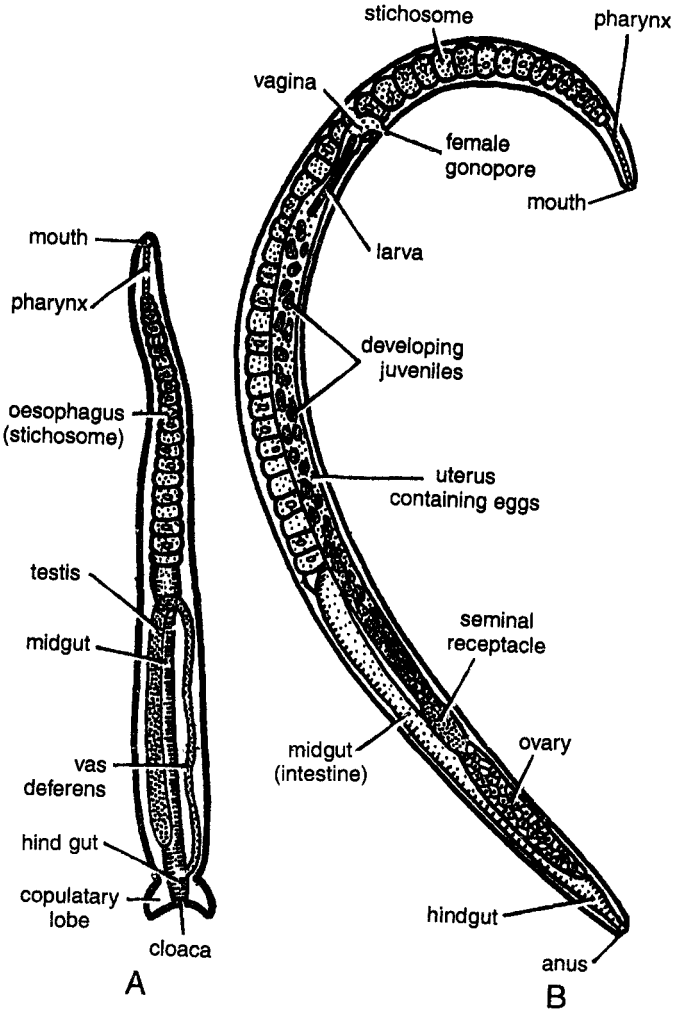


Fig. 95. *Trichinella spiralis.* **A.** Male, **B.** Female.

Pathogenesis : Infection of ***Trichinella*** causes **abdominal pain, haemorrhage, muscular pain, diarrhoea thrombosis, restlessness, kidney failure, pneumonia, degeneration of muscles** and swelling in various parts of the body.

Identification : Since the parasite contains whip-like, hence it is ***Trichinella spiralis.***

96. *Trichinella spiralis* : Encysted Larvae

Comments :

(1) Within the small intestine, the adults armed with stylets are embedded in the mucosa and crypts. Soon after copulation, the males die and females penetrate the crypts of lieberkuhn. Here females give **(oviviparous) larvae** which reach venous blood. The larvae pass through pulmonary capillaries and reach peripheral circulation from where they are carried into the striated muscles. In muscle they remain encysted. The encysted larvae are found in myofibrils first longitudinally oriented but soon become coiled and encapsulated in calcified cysts, one worm per cyst. They develop further in the cells of voluntary muscles. Active muscles, containing a rich blood supply, such as those of diaphragm, ribs, larynx, tongue, eye and limb muscles are favoured.

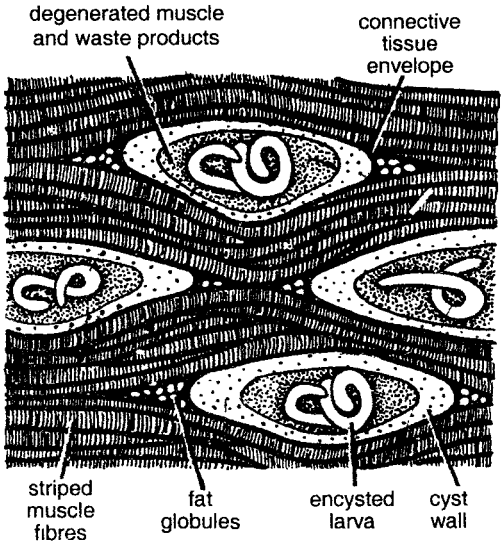


Fig. 96. *Trichinella spiralis.* Encysted larvae.

(2) ***Trichinella*** embryos sometimes pass through placenta in infants and cause **parental infection.**

(3) **Striated muscles** are degenerated in order to accommodate larva. The cyst is composed of nucleated fibrous zone.

(4) Name ***T. spiralis*** is derived from the spiral coils of the larva.

(5) Cyst is formed in about 60-63 days and may contain 1 to 7 larvae. The cysts are lemon shaped, measuring 0.25 to 0.5 mm lying parallel with the muscle fibres.

(6) Migratory larvae cause **eosinophilia, masticatory** and **repiratory troubles, muscular pains, dyspnea** or **asthma.**

(7) Man gets infected by eating raw and inadequately cooked pig muscles containing ***T. spiralis*** cysts.

(8) In human beings, cysts formed undergo calcification. The larvae may also become calcified. After ingestion to suitable hosts, the larvae in the cysts develop to adult stage after 4-ecdyses.

Identification : Since the slide shows coiled larva in cyst and all above features hence it is ***Trichinella spiralis*** encysted stage.

97. *Wuchereria bancrofti*

Classification :

Phylum..... **Aschelminthes (Nemathelminthes)** → Nematodes, round worms.
Order..... **Filarioidea** → Lips, buccal capsule and bursa absent.
Genus..... ***Wuchereria***
Species..... ***bancrofti***

Habit and habitat : ***Wuchereria bancrofti*** adults are found as parasites in coiled stage in the lymphatic and muscular tissues of man (Fig. 97).

Distribution : It is a tropical, sub-tropical and temperate parasite, found in Arabia and India. Gorakhpur region is worst effected.

Comments :

(1) **Commonly** called as **filarial worm** causing **elephantiasis** in man.

(2) **Male** and **female** separate. **Sexual dimorphism** is exhibited by **tail ends** while anterior and remains the same except size.
(3) **Females** are larger than males. Females measure 65 to 100 mm in length and 0.25 mm, in breadth. **Tail end is pointed.**
(4) Anterior end of female shows **mouth** which leads into **oesophagus**. Oesophagus has **muscular** and **glandular** oesophagus which leads into **intestine**, **nerve ring** is anteriorly situated.
(5) Female reproductive system shows **vulva**, **ovejector** and **vagina**.
(6) **Males** measure 40 mm in length and 0.1 mm in breadth.
(7) **Tail end if male is coiled** and characterized by having unequal **spicules** in spiracular sheaths, **gubernaculum** and 12 **pairs of caudal papillae**.

Special features : The prevalence of *W. bancrofti* varies considerably. According WHO there are 200 **million people** suffering from filariasis. In **elephantiasis** the adult worms block the passage of lymph nodes and lymphatic vessels resulting into enormous swelling and development of **fibrous** tissues. Elephantiasis occurs in lower legs, lower lands penis, scrotal sacs, mammary glands in women, external genetalia in females. Legs becomes so swellers and called elephantiasis.

Identification : Since the tail end of male contains 12 pairs of caudal papillae and all above features hence it is *W. bancrofti*.

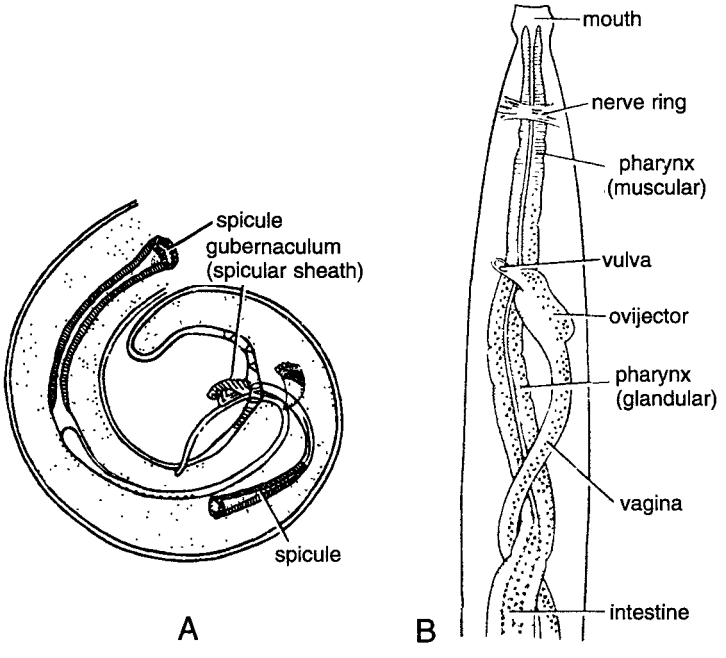


Fig. 97. *Wuchereria bancrofti.* **A.** Posterior end of male, **B.** Anterior end of female.

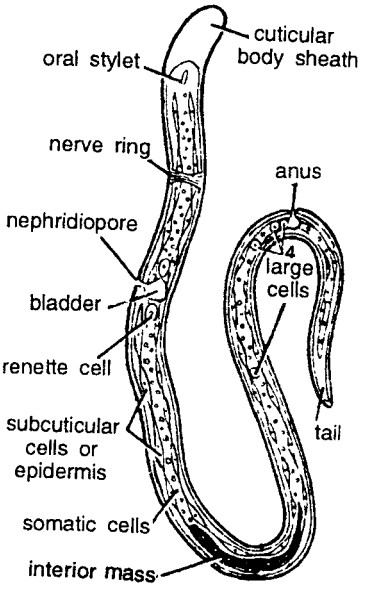


Fig. 98. *Wuchereria bancrofti.* Microfilaria.

98. *Wuchereria bancrofti* : Ensheathed or Encysted Microfilaria

Comments :

(1) They are produced by females of ***Wuchereria bancrofti*** after copulation and fertilization (Fig. 98).
(2) **Microfilaria** larva is the **first stage larva**, surrounded by a **delicate sheath**.
(3) It has several rudimentary **structures**, such as oral **stylet**, **epidermis**, **oesophagus**, **nerve ring**, **excretory bladder**, **sub-cuticular cells**, **somatic cells**, **genital cells** and **anus etc.**
(4) They are transmitted from one person to the other by mosquito (***Culex fatigans***).

(5) Inside the mosquito, larvae undergo **ecdysis** and develop up to **third infective stage**. The mosquito acts as carrier of the disease.

(6) Inside man, **microfilariae** show **day and night periodicity**. During **daytime**, they go into visceral lines and during **night**, they come in peripheral circulation.

Identification : Since the larva contains encasing cuticle, nerve ring and all the above structures, hence it is **Microfilaria** (First stage larva).

99. *Ancylostoma duodenale* : Hookworm

Classification :

Phylum.....**Nemathelminthes** → Nematodes, round worms.
Order..... **Strongyloidea** → Bursate nematodes.
Genus..... ***Ancylostoma***
Species.....***duodenale***

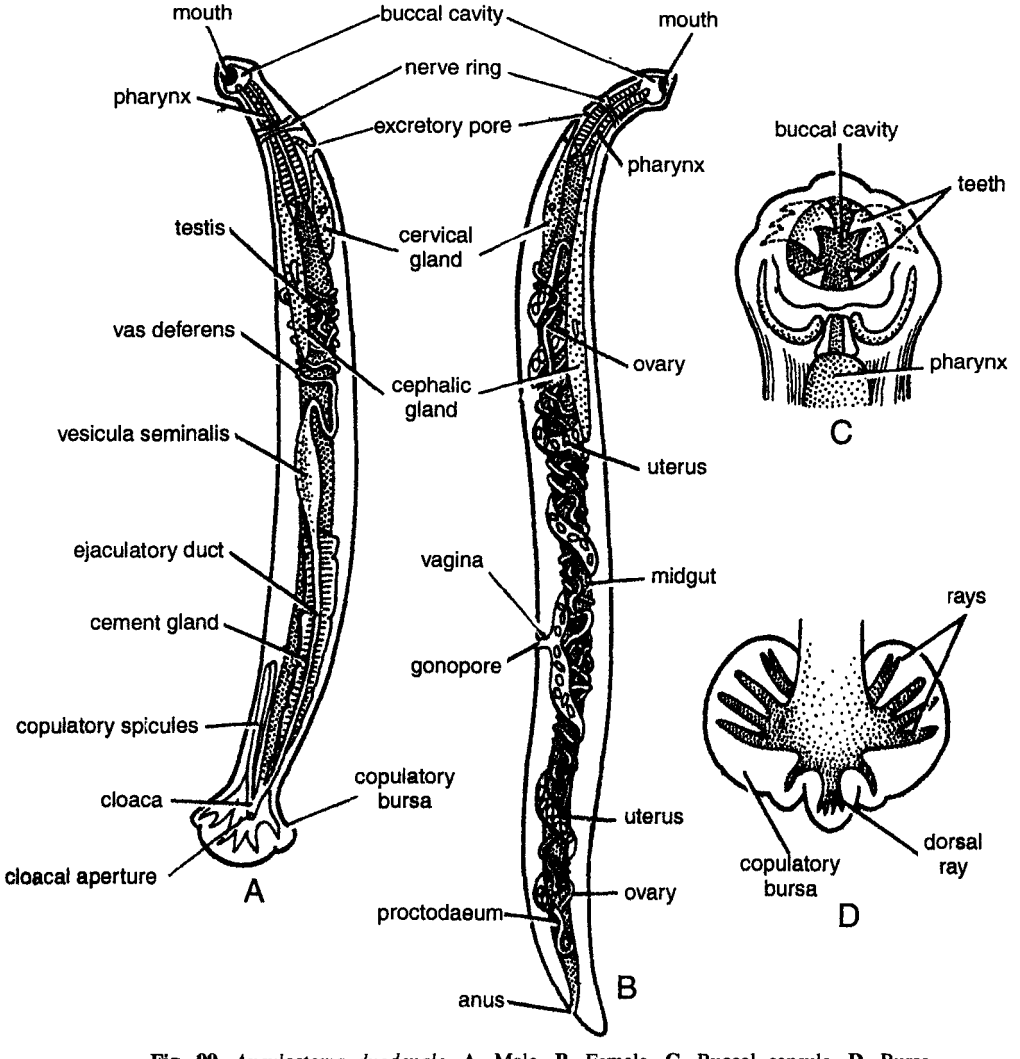


Fig. 99. *Ancylostoma duodenale.* **A.** Male, **B** Female, **C.** Buccal capsule, **D.** Bursa.

Habit and habitat : ***Ancylostoma duodenale*** is a common intestinal, blood-sucking **strongylate** and **bursate** nematode of man and other domesticated animals, e.g. dogs, cats, etc. The adult hookworms reside in the small intestine, where they draw a bit of mucous membrane into their buccal capsule and nourish themselves on blood tissue juices which they suck.

Distribution : Infection has been reported from Europe, Asia, America, Africa, Japan, India and Chile etc.

Comments :

(1) **Commonly** called as **hook worm** (Fig.99).

(2) **Males** smaller than females.

(3) Males measure 8 to 11 mm in length and 0.4 to 0.5 mm in breadth, while females 10 to 13 mm by 0.6 mm.

(4) Anterior end in both **sexes** is bent dorsally and is provided with **large and cup-shaped buccal capsule** for **attachment** with mucous membrane of the intestine.

(5) Buccal capsule contains a **pair of chitinous plates** and a median **dental process or teeth.**

(6) Tail end of **female** is **pointed**, while that of **male contains copulatory bursa.** Males can be easily recognized by the bursa and its **muscular rays.** The single **dorsal ray** and **equal spread** of 3 **lateral rays** cause good mark to identification. **Bursal rays are of taxonomic importance.**

(7) **Alimentary canal** consists of **mouth, pharynx, intestine, rectum, anus in female** and **cloaca in males. Nerve** ring and **excretory pores** anteriorly situated.

(8) **Sexes** are separate. **Male reproductive system** consists of **testis, sperm duct, seminal vesicle, ejaculatory duct, cloaca** and **spicules. Female system** consists of **ovaries, oviduct, uteri** and **vulva.**

(9) Mode of infection is **skin penetration.**

Economic status : The infection causes various diseases. Migratory larvae in skin cause creeping eruption **dermatitis** and **allergic reactions.** In lungs larval cause **pneuomonia** and **haemorhage.** Adult parasites implant their buccal capsule in the mucose of the intestine, suck blood and destroy haemoglobin causing, **anaemia.**

Identification : Since the parasite contains teeth in buccal capsule, bursa in males and all above characters hence it is ***Ancylostoma.***

100. *Dracunculus medinensis*

Classification :

Phylum..... Aschelminthes	→	Cavity bearing animals.
Class..... Nematoda	→	Pseudocoelomic round worms.
Order..... Drachunculoidea	→	Buccal capsule absent.
Genus..... *Dracunculus*		
Species..... *medinensis*		

Habit and habitat : Adult parasites inhabit deeper sub-cutaneous tissues of man and other animals especially in foot region.

Distribution : Distributed in India (Madhya Pradesh and Rajasthan), America, tropical countries and Africa.

Comments :

(1) **Commonly** called as **guinea worm, median worm, serpent worm** or **dragon worm.** It is **first animal parasitic nematode** to be discovered (Fig. 100).

(2) Worms are elongated, cylindrical with blunt anterior end. Posterior extremity hook like for anchorage in sub-cutaneous tissues.

(3) **Males** measure 12 to 29 mm in length and 0.4 mm in breadth. Tail end contains 4 pairs of **pre-anal** and 6 pairs of **post-anal** papillae.

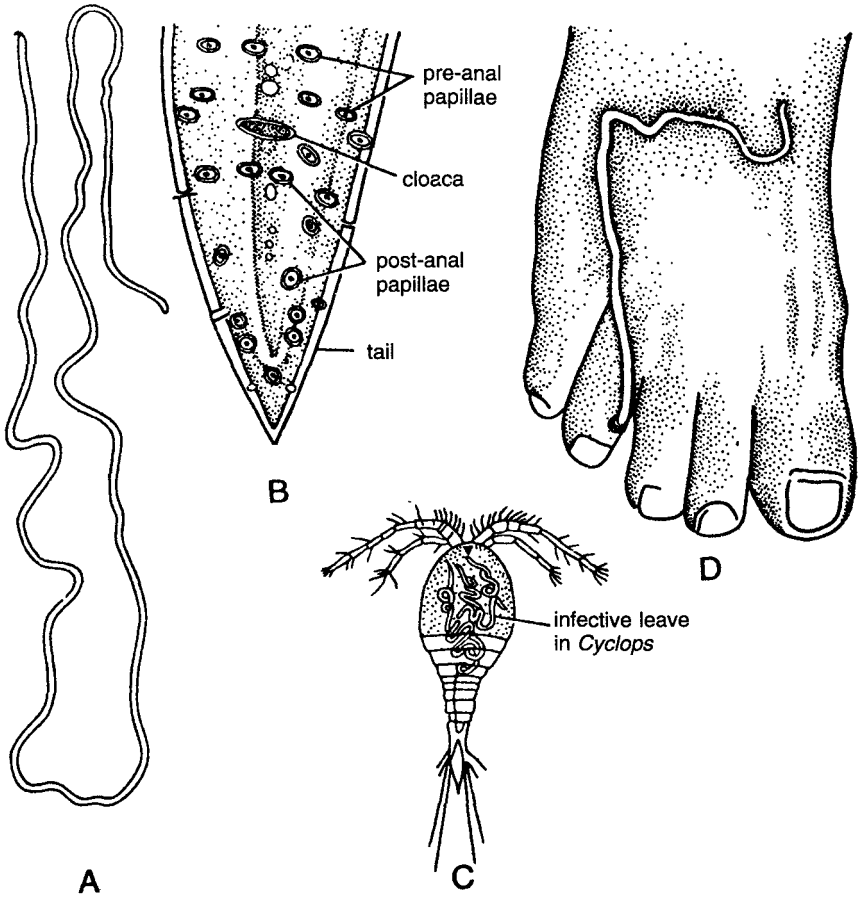


Fig. 100. *Dracunculus medinensis.* **A.** Female, **B.** Tail end of male, **C.** *Cyclops*, **D.** Adult female partially removed from ruptured leison.

(4) Females are much larger than male measuring 70 to 120 mm in length and 0.9 to 1.7 cm in breadth. **Females** come out from the ruptured leison in foot.

(5) **Life-cycle digenetic. Man** is definitive host. ***Cyclops*** is a intermediate host. Man becomes infected by drinking pond water contaminated with ***Cyclops***. ***Cyclops*** are infected by engesting eggs of ***Dracunculus*** which are released in water.

Pathogenesis : Adult female causes severe disease known as **dracunculiasis. Metabolites** and **toxins** are produced by the worm causing blister formation on foot, hand, trunk, arms, buttocks, shoulders and thigh muscles. Infection causes nausea, vomiting and giddiness.

Identification : Since tail end of male contains 10 pairs of caudal papillae and all above features, hence it is ***Dracunculus medinensis.***

PHYLUM ANNELIDA

Coelomate and Metamerically Segmented Animals

Annelids are truelly coelomate animals. The coelome is found between body wall and alimentary canal. It is lined with visceral and parietal layers. Excretory organs are connected with coelom and genital organs and originate from coelomic epithelium. The animals are metamerically segmented showing serial repitition of body parts.

101. *Tubifex*

Classification :

Phylum..... Annelida	→	Metamerically segmented, coelomate and bilaterally symmetrical.
Class..... Oligochaeta	→	Few setae.
Order..... Archioligochaeta	→	Small and fresh-water forms.
Genus..... *Tubifex*		

Habit and habitat : ***Tubifex*** is tubicolous fresh-water archioligo chaete, found abundantly on the bottom of deep lakes (Fig. 101).

Distribution : It has **cosmopolitan** distribution.

Comments :

(1) Animal lives in tubes, made up of mud and minerals glued together by mucus.
(2) Body is cylindrical, red coloured and is about 4 cm length.
(3) Each segment contains bundles of setae on dorsal and ventral sides.
(4) **Prostomium** is conical containing mouth.
(5) Other structures seen are **heart, dorsal blood vessel, intestine** and **anus.**
(6) **Clitellum** is found in 11 to 12 segments, heart in the 8th segment, o-genital pore in the 11th segment and o-genital pore in the 12th segment.
(7) It reproduces **sexually** only.

Identification : Since it has clitellum in 11 to 12 segments and all above features hence it is ***Tubifex.***

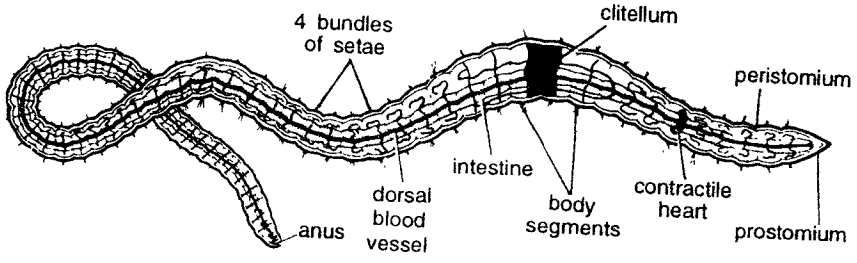


Fig. 101. *Tubifex.*

102. *Aelosoma*

Classification : Same as that of ***Tubifex.***

Habit and habitat : It is small fresh-water worm, found among aquatic algae.

Distribution : Cosmopolitan.

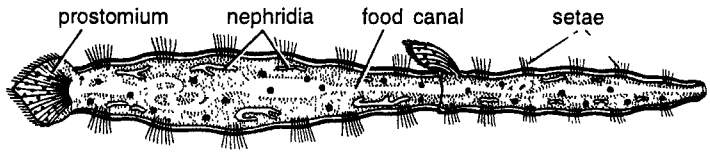


Fig. 102. *Aelosoma.*

Comments :

(1) **Body** is transparent, irregular in outline, spotted with red, green or yellow oil globules in the integument and measuring about 1 to 10 mm.
(2) Animal contains 7 to 10 segments which are not clearly marked.
(3) **Prostomium** is ciliated **ventrally** and bears a pair of ciliated pits. **Prostomium** has mouth which leads into food canal.
(4) **Clitellum** is found on ventral sides of 5 to 7 segments. Each segment behind peristomium bears 4 bundles of hair-like setae.
(5) The nephridia are paired, metamerically repeated and act as gonoducts also.
(6) ***Aelosoma*** is a primitive worm reproduces asexually by transverse fission.

Identification : Since animal has clitellum in 5 to 7 segments and all above features, hence it is ***Aelosoma***.

103. Earthworm : M.L.S. of Anterior Region

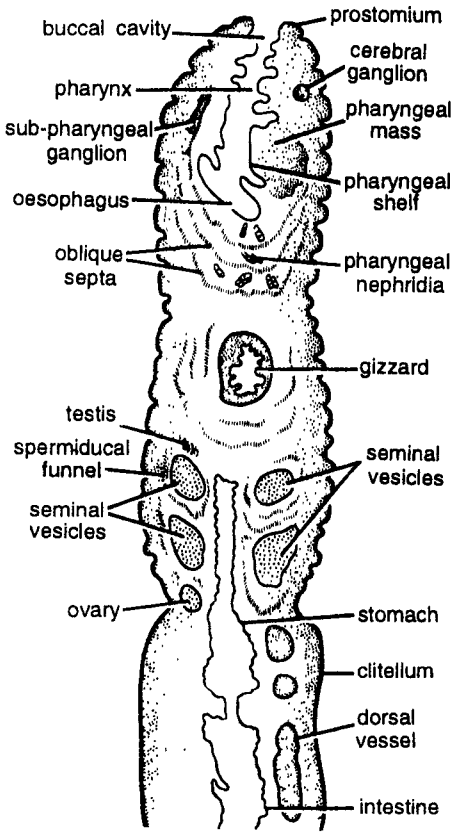


Fig. 103. Earthworm. M.L.S. of anterior region.

Comments : The section includes structures around **pharyngeal, oesophageal, gizzard, stomach** and **intestinal regions**.

(1) Histologically section reveals triploblastic layeration metameric segmentation and true coelom.
(2) **Body wall** is composed of **cuticle, epidermis** and **muscle layers**.
(3) **Cuticle** is very thin, elastic, non-cellular, transparent, iridescent, and double-layered membrane, composed of collagen, protein polysaccharide and gelatin. Cuticle is perforated for glands.
(4) **Epidermis** or **hypodermis** is single layered having supporting cells, basal cells, gland cells and receptor cells.
(5) **Muscle layer** consists of **outer circular** and **inner longitudinal fibres**.
(6) Alimentary canal consists of **prostomium, buccal cavity, muscular pharynx** with **pharyngeal mass** and glands **pharyngeal shelf, pharyngeal cavity, narrow oesophagus, muscular gizzard, stomach** and **wide intestine. Stomach** and **intestine** are separated by a **junction**, having a narrow lumen in **clitellar** region.
(7) In **pharyngeal region cerebral ganglion, pharyngeal nephridia inter-segmental septa** and **pharyngeal muscles**.
(8) **Genital organs** such as **testes, spermiducal funnels, seminal vesicles containing spermatozoa** and **organs** are seen between **gizzard** and **clitellum**.
(9) Body, from prostomiun upto clitellar region and after it, gives **segmented apperance**.

Identification : Since section has segmented appearance, smooth body wall in clitellum and all above features, hence it is **MLS anterior region of Earthworm.**

104. Earthworm : T.S. Passing Through Pharynx

Comments : The section shows organ grade of construction triploblastic layeration and true coelom. Pharynx is clearly seen.

(1) **Pharynx** is a wide pear-shaped and thick-walled **muscular chamber**. Pharyngeal cavity is dorsoventrally compressed.

(2) Body wall is composed of **cuticle, epidermis, musculature** and **parietal epithelial layer**.

(3) **Cuticle** is thin, non-cellular, double layered, iridescent and made up of collagen, protein, gelatin and polysaccharide.

(4) **Epidermis** consists of single-layered distinct **columnar cells** with **gland cells, supporting cells, basal cells** and **receptor cells.**

(5) **Musculature** comprises outer continuous **circular muscle fibres** and **inner longitudinal muscle fibres** cut in bundles.

(6) Pharynx contains **visceral epithelial layer, pharyngeal gland cells, musculo-vascular tissue** and **lumen** of the pharynx.

(7) Lumen is divided by a **incomplete horizontal shelf** into **upper salivary chamber** and lower **conducting** or **ventral chamber**. Salivary chamber contains **ciliated pharyngeal epithelial layers** dorsally.

(8) From the **pharyngeal** wall radial muscles strand run outward upto body wall. Their contractions dilate the pharyngeal cavity which works as suction pump.

(9) Besides the above structures, sections of **dorsal blood** vessel, **ventral blood** vessel, **ventral nerve cord** and **muscle strands** are also visible.

Identification : Since the section contains thick pharyngeal, salivary and ventral chambers, and all above features, hence it is **T.S. of Earthworm passing through pharynx.**

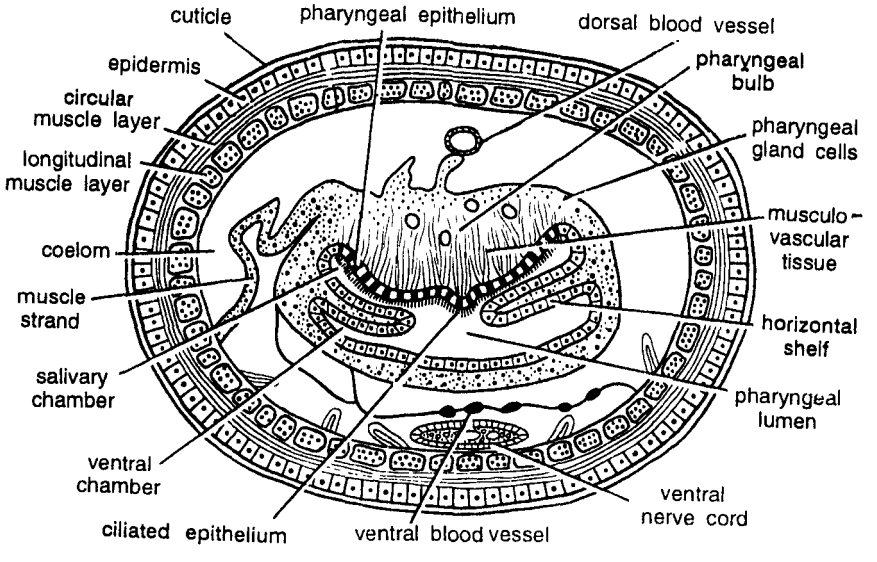


Fig. 104. Earthworm. T.S. passing through pharynx.

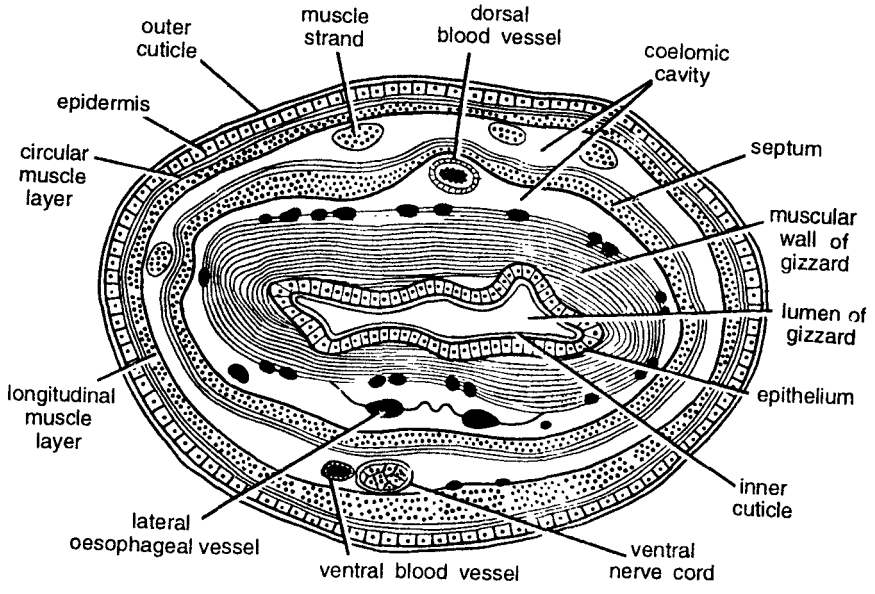


Fig. 105. Earthworm. T.S. passing through gizzard.

105. Earthworm : T.S. Passing Through Gizzard

Comments : The section shows organ grade of construction with triploblastic layeration and true coelom.

(1) Oesophagus terminates into prominent oval, hard, thick-walled and distinct **gizzard lying in 8th** and **9th segments.**

(2) Body wall is composed of a thin **cuticle, columnar epidermis,** thin **circular muscle layer** and **thick longitudinal muscle bundles,** parietal epithelial layer and a thick circular **septum.**

(3) **Gizzard** is a hard muscular organ, composed of visceral coelomic epithelial layer **thick circular muscle fibres** and lined internally by columnar epithelial cells and thin cuticle.

(4) Gizzard is a **masticatory** apparatus and breaks food into small particles.

(5) Gizzard can at once be recognized by thick continuous circular muscle fibres and various blood vessels.

(6) Section also contains **dorsal** and **ventral vessels, ventral nerve cord, integumentary nephridia,** and **lateral oesophageal vessels.**

(7) Few muscle strands are also seen in the section.

Identification : Since the section contains **circular muscles** in gizzard, and all above features, hence it is **T.S. of Earthworm passing through gizzard.**

106. Earthworm : T.S. Passing Through Spermathecal Region

Comments : Spermathecae open to exterior through four pairs of small elliptical apertures called as spermathecal pores present in the inter-segmental grooves 5/6, 6/7, 7/8 and 8/9. Section shows triploblastic layeration with organ grade construction and true coelom.

(1) Earthworm has 4 pairs of **spermathecae** on each side in aboves segments (Fig. 106).

(2) Body wall is composed of a thin **cuticle, columnar epidermis, thin circular muscle layer** and **thick longitudinal muscle bundles,** parietal coelomic epithelial layer separated by connective tissue septa.

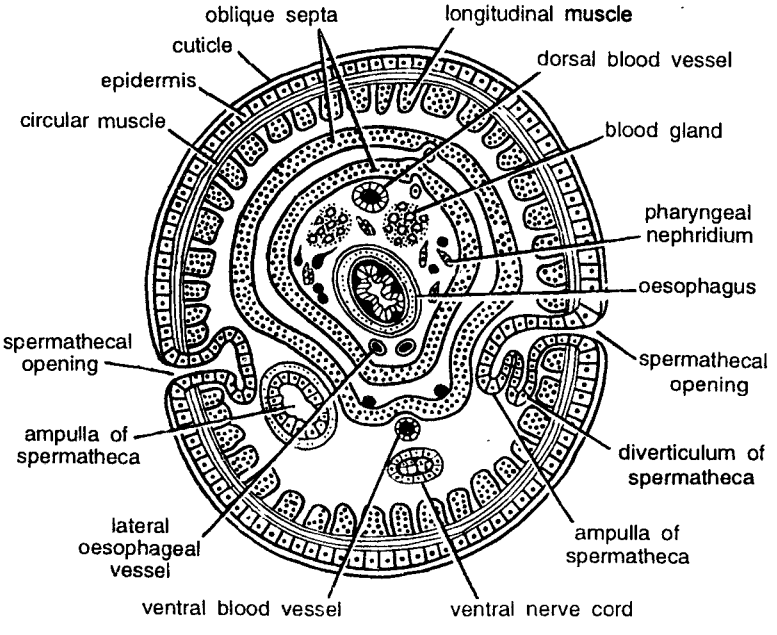


Fig. 106. Earthworm. T.S. passing through spermathecal region.

(3) Spermathecae are **flask-shaped** and distinguished into a **pear-shaped ampulla** and a narrow **neck** opening on body margins.
(4) Each neck has a **ciliated diverticulum**, which retains, spermatozoa received during copulation.
(5) Two **circular inter-segmental septa**, **dorsal** and **ventral blood vessels**, **ventral nerve cord** and **oesophagus** sections are also observed.
(6) Few **blood glands** are found on each side of the dorsal blood vessel.

Identification : Since the section contains ampulla on lower side and all above features, hence it is **T.S. of Earthworm passing through spermathecae**.

107. Earthworm : T.S. Passing Through 11th Segment

Comments : The section shows triploblastic layeration with organ grade construction and true coelom. The following histological details are observed (Fig. 107).

(1) Section passes through the middle of the llth segment, having **finger-like testes** and **girdle-shaped seminal vesicles**.
(2) Body wall is composed of a thin **cuticle**, **epidermis**, thin **circular muscle** layer and thick **longitudinal** muscle bundles, parietal coelomic epithelial layer separated by septa.
(3) A pair of finger-like testes enclosed in testis sacs, two pairs of sperm ducts and a pair of elongated seminal vesicles containing numerous spermatozoa are present.
(4) **Sperm ducts** have **ciliated epithelial layer** internally.
(5) **Testis sacs** are supposed to be closed coelomic chambers, while seminal vesicles are as extension of septa.
(6) **Seminal vesicle** are large pouch-like structures, found on either side of the oesophagus. They lie enclosed in the **testis sac** of the same segment.

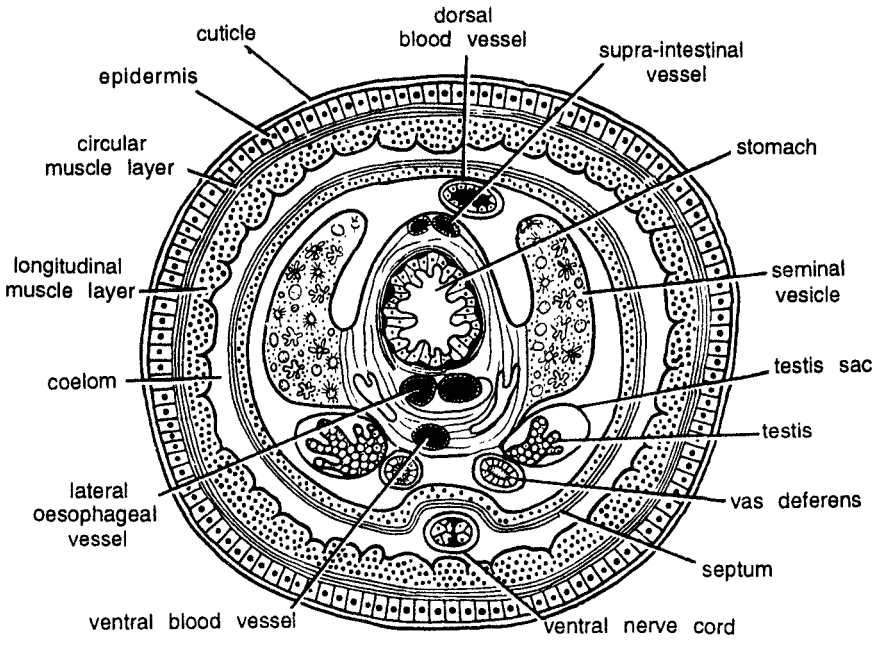


Fig. 107. Earthworm. T.S. passing through 11th segment.

(7) **Dorsal** and **ventral vessels, ventral nerve cord, oesophagus, supra-intestinal** and **lateral oesophageal vessels** are also seen.

(8) **A circular septum separates** oesophagus and **body wall layers.**

Identification : Since the section girdle-shaped seminal vesicle, enclosing finger like testes and all above features, hence it is the **T.S. of Earthworm passing through testes.**

108. Earthworm : T.S. Passing Through 12th Segment

Comments : The section shows triploblastic layeration, organ grade construction and true coelom with the following histological details (Fig. 108).

(1) Section passes through anterior region of the 12th **segment**, containing seminal vesicle and sperm ducts.

(2) **Body wall** is composed of thin **cuticle, epidermis,** thin **circular muscle** layer and thick longitudinal muscle bands and parietal coelomic epithelial layer.

(3) The **seminal vesicles** are elongate, sac-like structures full of **sperms** and lie free and hence are seen in this section as separate elongated sac-like structures.

(4) **Double sperm duct tubes** are closely attached having ciliated epithelial layer internally.

(5) **Dorsal** and **ventral vessels, ventral nerve cord, supra-intestinal vessel, heart** and **stomach** are seen. Stomach has thin **circular muscle layers** and **slightly folded internal epithelial layer**. Stomach is enclosed by visceral coelomic epithelial layer.

(6) Seminal vesicles are found on each side of the **coelomic epithelial layer.**

Identification : Since the section contains **seminal vesicle** and **sperm ducts** and all above features, hence it is **T.S. of Earthworm passing through seminal vesicle.**

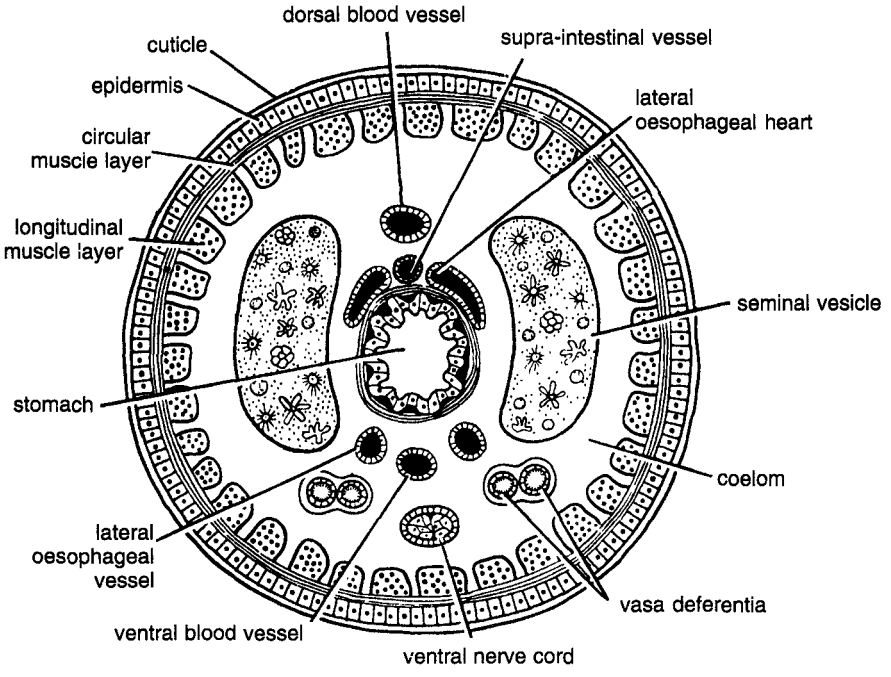


Fig. 108. Earthworm. T.S. passing through 12th segment.

109. Earthworm : T.S. Passing Through 18th Segment

Comments : The section shows triploblastic layeration, organ grade construction and true coelom.
(1) Section passing through 18th **segment** contains a pair of **prostate glands** and **genital papillae**.
(2) **Triploblastic**, coelomate, segmented and organ grade.

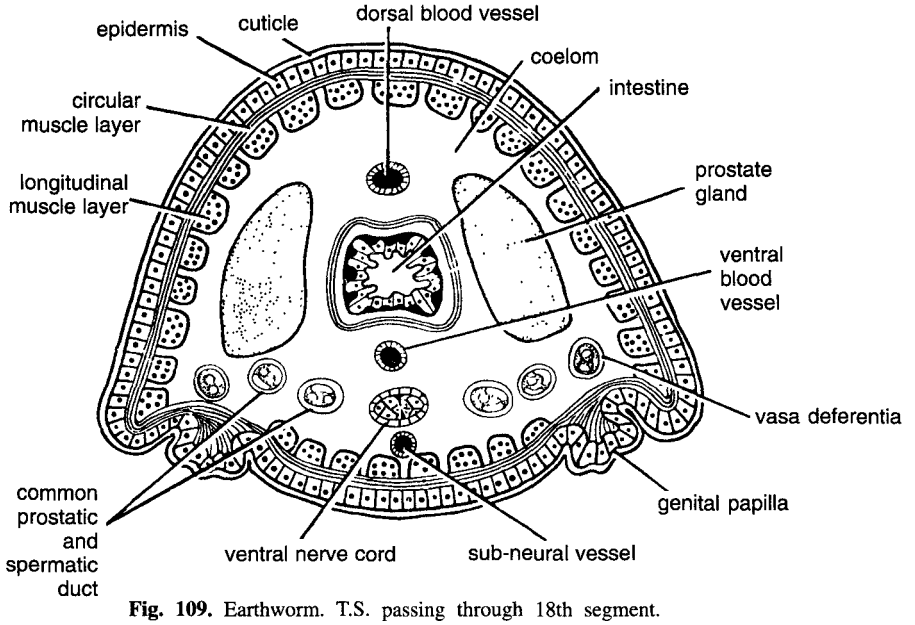


Fig. 109. Earthworm. T.S. passing through 18th segment.

(3) **Body wall** is composed of a thin **cuticle**, **epidermis**, thin **circular muscle** layer and thick **longitudinal muscle** bundles and parietal coelomic epithelial layer.
(4) **Prostate glands** are of irregular shape, differentiated into **glandular** and **non-glandular regions**.
(5) Latter part forms prostatic duct, which joins with **sperm duct** and is enclosed in a common sheath.
(6) Common duct, comprising of sperm duct and prostate duct, opens by male genital pore on genital papilla.
(7) **Dorsal vessel**, **ventral vessel**, **ventral nerve cord** and **intestinal sections** are also present.
(8) Prostate glands manufacture of fluid of unknown function. Intestine is covered by **visceral coelomic epithelial** layer.

Identification : Since the section contains **genital papillae** common prostatic and spermatic duct and all above features, hence it is **T.S. of Earthworm through prostate gland (18th segment)**.

110. Earthworm : T.S. Passing Through Typhlosolar Region

Comments : Intestine starts after 15th segment. It shows beaded appearance. Section is triploblastic with organ grade of construction and true coelom.

(1) **Intestine** is divisible into 3 regions; (i) **pre-typhlosolar** (15 to 26 segments), (ii) **typhlosolar** region (from 26th segment to rectum), and (iii) **post-typhlosolar** (rectum). Typhlosolar region has median dorsal internal **fold**.
(2) **Body wall** is composed of a thin **cuticle**, columnar **epidermis**, thin **circular** muscle layer and thick **longitudinal muscle** layer parietal coelomic epithelial layer.
(3) Intestine is composed of outer visceral coelomic epithelial layer, **intermediate longitudinal** and **circular muscle layers** and its lining is made up of **endodermal columnar epithelial cells**. In the **typhlosolar** region the epithelial cells are raised to form **typhlosole**.

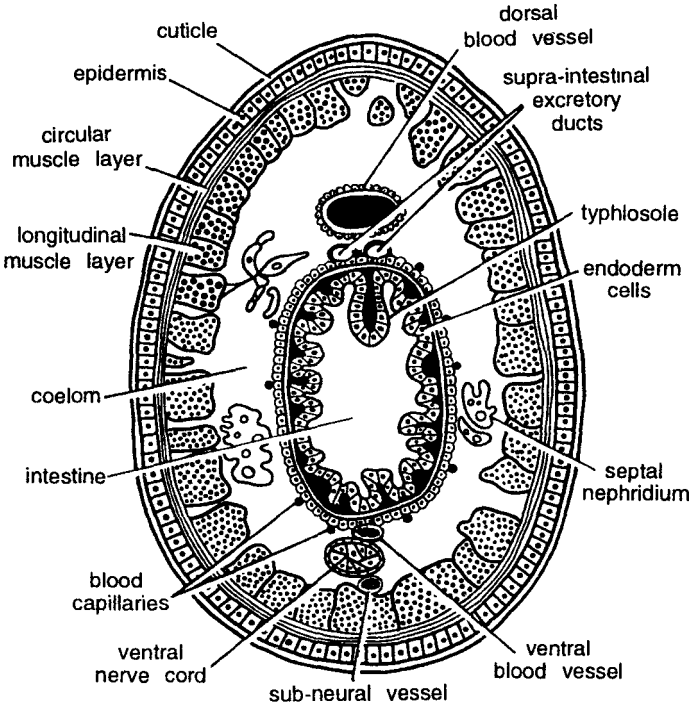


Fig. 110. Earthworm. T.S. passing through typhlosolar region.

(4) **Typhlosole** is a median internal fold of dorsal wall, having **chloragogen cells** and a capillary blood vessel.
(5) Typhlosole **increases the surface area for absorption.**
(6) **Dorsal blood vessel, supra-intestinal excretory duct, ventral blood vessel, nerve cord, sub-neural vessel, blood capillaries** and **coelom** are also seen in section.

Identification : Since the section contains typhlosole in the intestine and all above features, hence it is **T.S. of Earthworm through typhlosolar region.**

111. Earthworm : *Setae in situ*

Comments :

(1) ***Setae in situ*** (Setae intact in body wall) are seen in V.S. (Vertical section) of skin and in whole mount of body wall.
(2) V.S. through skin shows body wall layers consisting of **cuticle epidermis, circular muscle layer, circular muscle strand, protractor muscles, retractor muscles, longitudinal muscle, coelomic epithelium, seta forming cells** and **setal sac.**
(3) **Setae** are locomotory organs and are secreted by invaginated, epidermal cells, called as **setal sacs,** in which they are embedded. Setal sac is granular.
(4) A seta consists of three parts— **base, body** and **neck.**
(5) Movement of setae is guided by two **sets of muscles,** namely a pair of **protractors** which join with **circular muscle fibres,** and a single **retractor joining** with circular muscle strand.
(6) Middle part of the seta is swollen and is called as **nodule.**
(7) In a beautifully stained slide, setae appear as transparent, hook-like structures in rows.
(8) Earthworm moves by the help of setae, body muscles and buccal chamber.

Identification : Since the mount contains hook-like structures in rows, hence it is ***Setae in situ.***

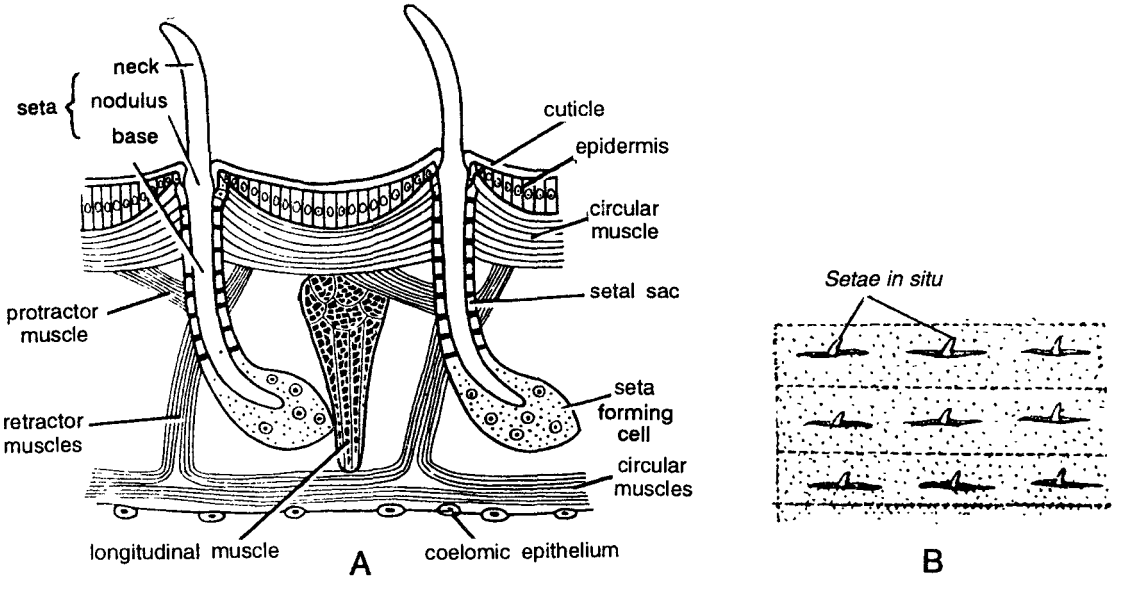


Fig. 111. Earthworm. **A.** V. S. of body wall showing *Setae in situ*, **B.** *Setae in situ* in skin preparation.

112. Earthworm : Ovary

Comments :

(1) A pair of ovaries is situated in the thirteenth segment.
(2) They are pyriform, semi-transparent, hanging freely into coelom and attached by their broad ends to septum of the **12th** and **13th segments**.
(3) Each ovary is a white compact mass made up of finger-like **processes**.
(4) **Each ovary contains ova in a linear series**.
(5) Each ovum is large, having a distinct **nucleus** and a **nucleolus**.

Identification : Since the mount has finger like ovarian lobes and all above features, hence it is whole mount of **ovary of Earthworm**.

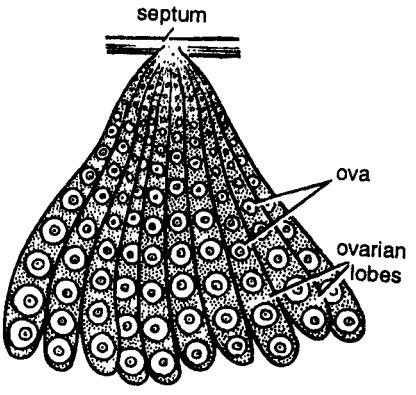


Fig. 112. Earthworm. Ovary.

113. Earthworm : Septal Nephridia

Comments :

(1) Complete mounted septum shows bunch of septal nephridia, septal excretory canal and supra-intestinal excretory ducts.
(2) Each septal nephridium is **micronephridia** and is composed of **ciliated funnel** or **nephrostome opening** into **coelom**, a short, **narrow neck** and **body**, having a **short straight lobe** and a **long spirally twisted loop**.
(3) **Twisted loop** is further differentiated into **proximal limb**, **distal limb** and **apical limb**.
(4) Straight lobe contains 4 ciliary tracts divided into **outer lobe** and **inner lobe**.
(5) **Ciliary movement in the funnel** and tract may be seen in a freshly killed earthworm and mounting the nephridium in saline under high magnification.
(6) Septal nephridia are found in large numbers on each side of the intersegmental septum.
(7) **Apical limb** is suspended in the coelom.
(8) Septal nephridia are **enteronephric** since they discharge the excretory product into the lumen of the gut.
(9) **Septal nephridia** are excretory organs. They eliminate excretory matter consisting of 40% urea, 20% ammonia and 40% amino acids and other nitrogenous compounds. They prevent loss of water and hence osmoregulatory in function also.

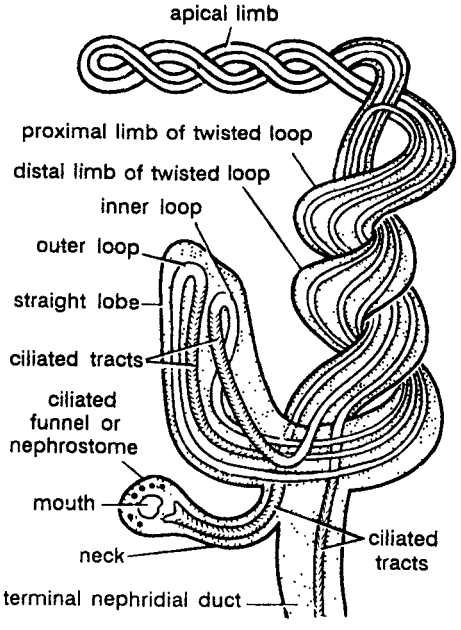


Fig. 113. Earthworm. A single septal nephridium.

Identification : Since the mouth contains twisted loops, straight lobe, nephrostome and all above features, hence it is W.M. of **septal nephridia of earthworm**.

114. *Nereis* : T.S. of Body Through Parapodia

Comments : The section shows **triploblastic layeration** with organ grade construction and **true coelom.**

(1) Section passes through stomach region with **parapodia** on either side.

(2) Body-wall is composed of **cuticle, epidermis** and **musculature.**

(3) **Cuticle** is thin, chitinous, iridescent, tough, perforated and made up of glucosamine.

(4) Epidermis lies beneath the cuticle. It is a single-layered cell of glandular, sensory, columnar and supporting nature. Ventral epidermis is more thickened.

(5) Musculature complicated. Below epidermis a continuous **circular muscle layer** and beneath the C.M.L. are two **discontinuous longitudinal muscle band,** 2 **dorso-lateral** and **ventral-lateral.** Two pairs of **oblique muscles** and **parapodial muscles** are found in each segment. Muscles are of smooth fibres.

(6) **Parapodium** on each side is differentiated into **notopodium** and **neuropodium.** It repeats body wall layers (cuticle, epidermis and circular fibres), having **notopodial setae, neuropodial setae, parapodial muscles** and **blood vessels.**

(7) **Dorsal vessel, ventral nerve cord, nephridial body, stomach, gonads** and **dorsal ciliated organs** are also observed.

(8) Except prostomium, peristomium and pygidium, each segment contains a pair of locomotory and respiratory parapodia.

Identification : Since the section contains parapodia on sides and all above features, hence it is T.S. of *Nereis* **through parapodia.**

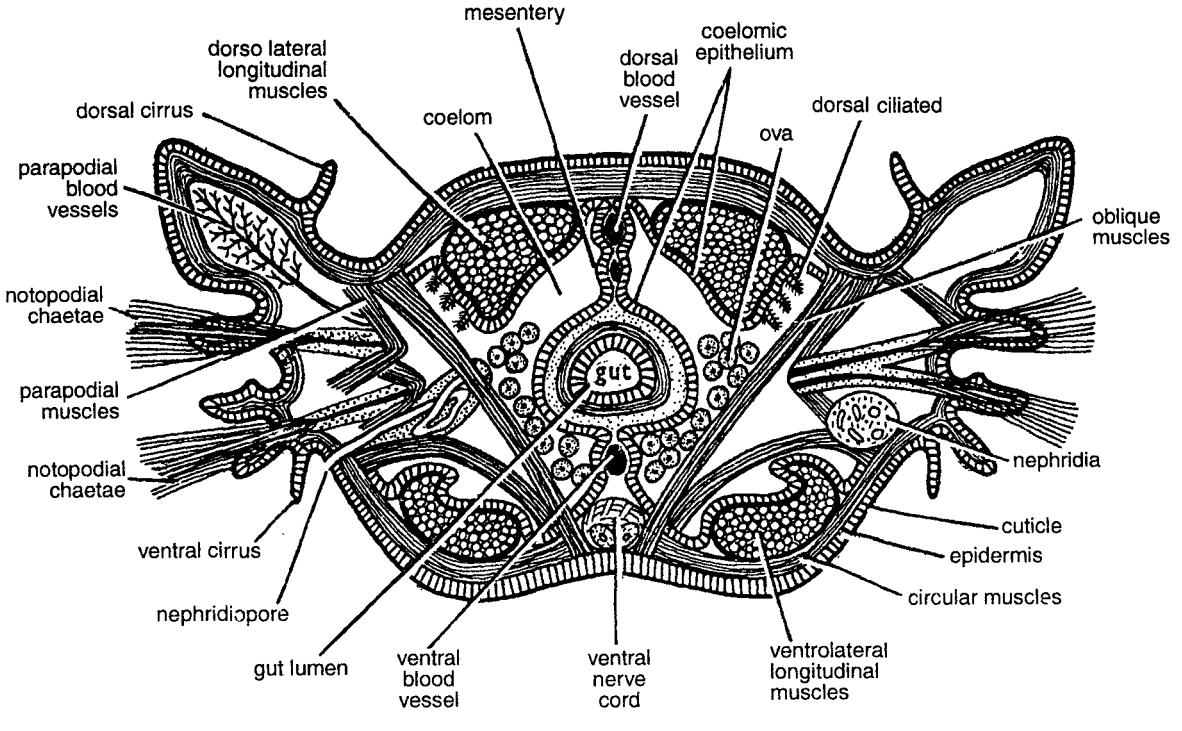


Fig. 114. *Nereis.* T.S of body through parapodia.

115. *Nereis* : T.S. of the Body Without Parapodia

Comments : The section shows triploblastic layeration with organ grade construction and coelom.

(1) Body wall is composed of **cuticle**, **epidermis** and **musculature**.
(2) **Cuticle** is thin made up of glucosamine.
(3) Beneath cuticle **epidermis** is present, which is made up glandular, sensory columnar and supporting cells.
(4) Muscle layer consist of circular muscle layer and bundles of 2 **dorsolateral** and 2 **ventrolateral muscle** bands.
(5) In section oblique muscles, **dorsal vessel**, **ventral nerve cord**, **nephridical body**, **stomach**, **gonads** and **dorsal ciliated organs are seen**.

Identification : Since the section is rounded and has above features hence it is T.S. of body without parapodia of ***Nereis***.

116. *Nereis* : Parapodium

Comments :

(1) **Parapodium**, cut from segment and stained, shows the following structure.
(2) Each segment of the body except the peristomium and pygidium bears on lateral side a flat hollow fleshy and ventral flap-like outgrowth, called as **parapodium**, name given by Huxley.
(3) Parapodium is **bilobed**, and setae-bearing organ composed of **upper notopodium** and **lower neuropodium**.
(4) **Notopodium** has two **unequal lobes** upper larger and lower smaller.
(5) **Neuropodium** has two **equal fleshy** and **much smaller** lobes.

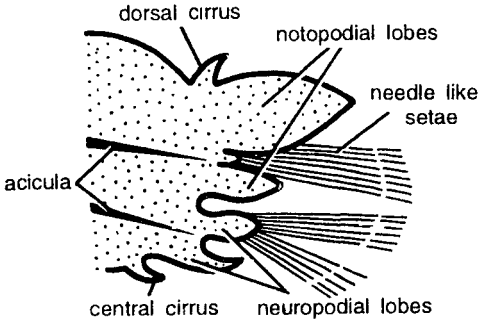


Fig. 115. *Nereis.* Parapodium.

(6) Dorsal and ventral **cirri**, attached to notopodial and neuropodial bases are present.
(7) Notopodium and neuropodium bear several, **spine-like setae**, lodged in setigerous sacs. They are supported by skeletal rods, called acicula.
(8) First 2 pairs of parapodia lack the notopodial setae.
(9) Parapodia are highly **muscularised**, **glandularised** and **vascularised** to function as **locomotory** and **respiratory** organs. They are adapted for **crawling** movement also.

Identification : Since the mount contains **notopodium** and **neuropodium** having spine like setae, hence it is ***Nereis* parapodium**.

117. *Heteronereis* : Parapodium

Comments : The sexual phase of ***Nereis*** is called as ***Heteronereis***. During this phase, animal becomes free-swimming and hence some parapodia become modified for swimming.

(1) Body of the ***Heteronereis*** is divided into anterior asexual region or **atoke** and posterior sexual region or **epitoke** (Fig. 116).
(2) **Parapodium**, detached from epitoke (sexual phase) and stained shows structures different then normal parapodium.

(3) Parapodium of ***Heteronereis*** phase is **thin** and **foliaceous** developing more outgrowths, and becomes more vascularised for more rapid respiration.
(4) Upper **notopodial lobes** are reduced and become of same size. The **dorsal neuropodial lobe become enlarged** and **fanlike** white ventral one remains small.
(5) Dorsal and ventral cirri are elongated.
(6) **Notopodial** and **neuropodial setae**, instead of being spine-like, **become oar-like.**
(7) Oar-like setae, foliaceous lobes are **swimming adaptations** because animal has to swim swiftly for spawning etc.

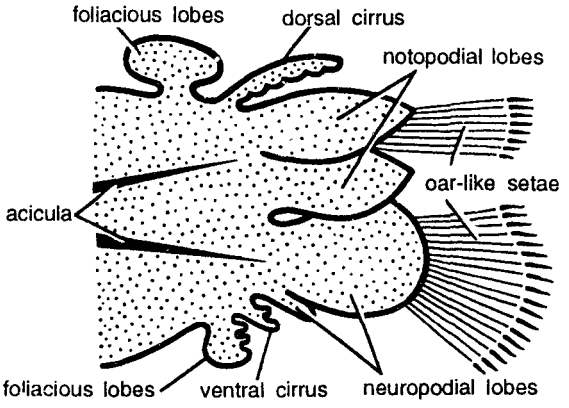


Fig. 116. *Heteronereis.* Parapodium.

Identification : Since **notopodium** and **neuropodium** contain **oar** like setae and all above features, hence it is **parapodium** ***Heteronereis***.

118. *Nereis* : Trochophore Larva

Comments :
(1) In the development of ***Nereis***, **trochophore larva** is formed after gastrulation.
(2) Larva is conical in shape, microscopic and fast swimmer.
(3) Anterior end contains **apical sensory organ**, having **tuft of cilia**. **Nerve ganglion** is present below it.
(4) Digestive system consists of open **mouth, rounded stomach, intestine** and **anus.**
(5) There are two ciliated bands for swimming—(i) pre-oral ciliated band or **prototroch** and (ii) post oral ciliated band or **metatroch.**
(6) Internally, larva contains **coelom, larval nephridium, mesoderm, eye spot** and **larval muscles.**
(7) After metamorphosis, trochophore larva changes to adult.

Identification : Since larva has ciliated bands and all above features, hence it is **Trochophore larva** of ***Nereis***.

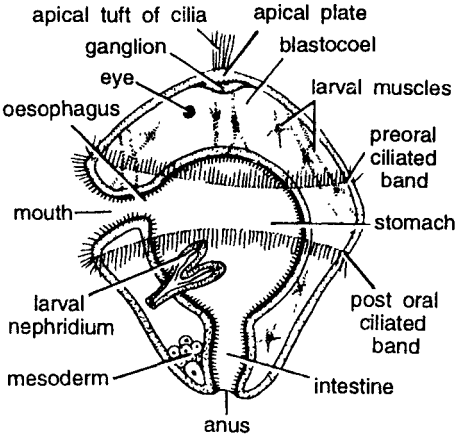


Fig. 117. *Nereis.* Trochophore larva.

119. Leech : T.S. Passing Through Buccal Cavity and Jaws

Comments : The section is triploblastic and coelomate.
(1) Section includes **three jaws** embedded in buccal chamber (Fig. 118).
(2) **Body wall** is composed of thick **cuticle, epidermis, dermis, muscle layers** and **botryoidal tissue.**
(3) **Cuticle** is delicate, colourless and transparent, forming protective covering.
(4) Epidermis lying below cuticle consists of single-layered **columnar**, hammer-shaped cells **pigment cells** and haemocoelomic **capillaries**. Some epidermal cells are modified to form unicellular gland cells and multicellular receptor cells.
(5) **Dermis** forms a network of fibrous tissue between epidermis and musculature which consists of **circular, oblique, longitudinal, dorso-ventral, vertical** and **radial muscle fibres.**

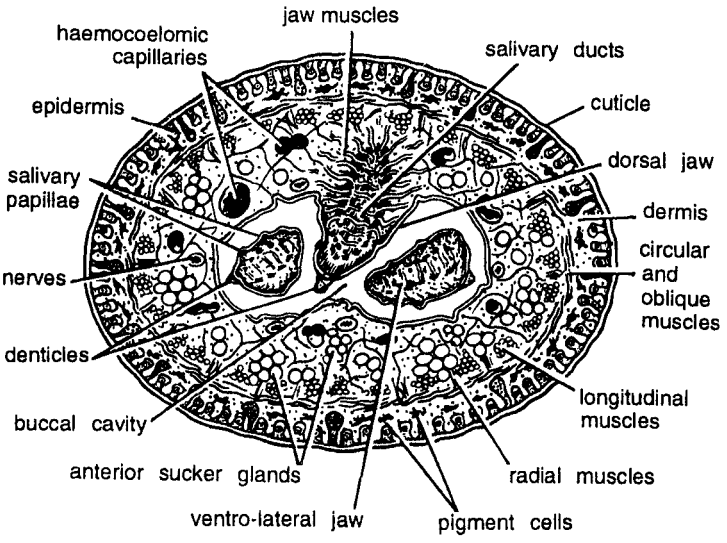


Fig. 118. Leech. T.S. through buccal cavity and jaws.

(6) **Botryoidal tissue** is a spongy tissue which reduces the original coelom into **four haemocoelomic channels** one **mid dorsal**, **one mid ventral** and **two laterals**. Haemocoelomic capillaries and sucker glands are found embedded in botryoidal tissue.

(7) Jaws are **one median** dorsal and **two ventro-lateral**. They are composed of diagonal, peripheral and longitudinal muscles, cushion-like, having monostichodont denticles or teeth and salivary papillae. Number of denticles is 103-128 on the median jaw and 85 to 115 on lateral jaw. Antagonistic muscles, attached to each jaw, guide grinding movement.

(8) Jaws acting together produce a characteristic triradiate bite or Y-shaped wound in the skin of the host.

Identification : Since the section contains one dorsal and two ventro-lateral jaws and all above features, hence it is **T.S. of leech through buccal cavity and jaws.**

120. Leech : T.S. Passing Through Crop with Diverticula

Comments : Section is triploblastic and coelomate showing the following histological details.

(1) **Crop** contains 10 **pairs of diverticula** extending from **IX to XVIII segment** and each segment contains two diverticula so that in T.S. it looks three-chambered (Fig. 119).

(2) Coelomic cavity is filled with **botryoidal tissue.**

(3) **Body wall** is composed of thin **cuticle**, **epidermis dermis** (fibrous and ramified) **thin circular muscle layer**, **thick longitudinal muscle layer**, **dorso-ventral**, **oblique** and **vertical muscles** and **botryoidal tissue**. Detailed body wall structure is same as in T.S. buccal cavity.

(4) Crop is composed of **cuticle**, **longitudinal** and **circular muscles** and thin **internal**, **epithelial lining** of **prismatic nucleated cells.**

(5) Epithelial lining is thrown into short folds.

(6) **Dorsal**, **ventral** and **lateral haemocoelomic channels** along with their vessels and ventral nerve cord in ventral vessel are present.

(7) Cavity of the crop and its diverticula is continuous giving three chambered appearance.

(8) Segmental organs or **nephridia** are also seen.

(9) **Crop** and its **diverticula** are capable of great dilatation to store large quantity of blood.

(10) Other parts seen are **dorsal sinus**, **ventral sinus** and **ventral nerve cord.**

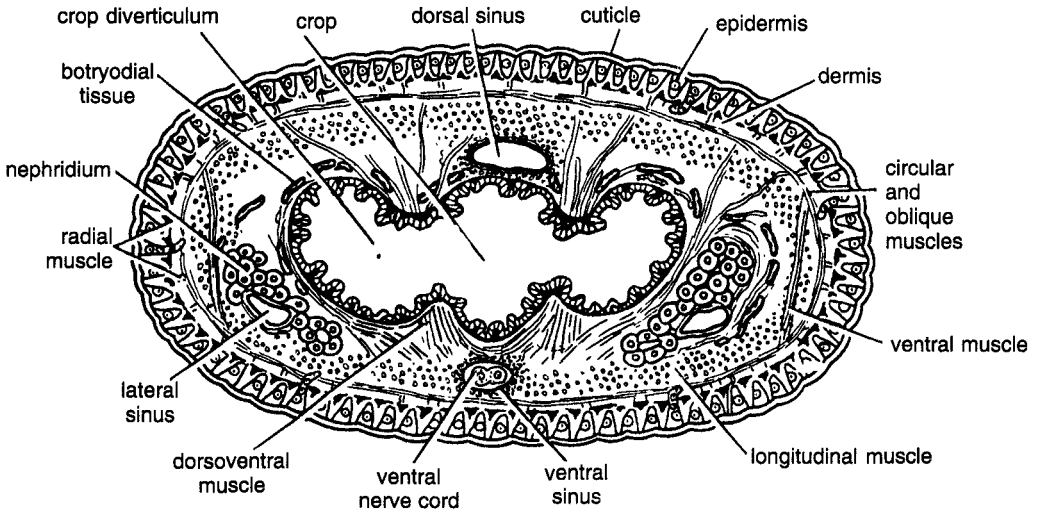


Fig. 119. Leech. T.S. passing through crop with diverticula.

Identification : Since the **three chambers of the crop are continuous** and section has all above features, hence it is **T.S. Crop of leech passing through diverticula.**

121. Leech : T.S. Passing Through Crop without Diverticula

Comments : The section is triploblastic and coelomate. It shows the following histological details.

(1) Section passes through the crop excluding its diverticula, and hence contains **single crop chamber.**

(2) **Coelomic cavity** is filled with botryoidal tissue.

(3) **Body wall** is composed of thick **cuticle, epidermis, fibrous** and **ramified dermis,** thin **circular** and **thick longitudinal muscle layer, dorso-ventral, oblique** and **vertical muscles** and **botryoidal tissue.**

(4) Single crop chamber is composed of thin **cuticle,** muscle layers and internal prismatic folded epithelial lining.

(5) **Haemocoelomic vessels— dorsal, ventral** (containing ventral **nerve cord**) and **laterals** are also present.

(6) On the posterior region of the section there are two large nephridial vesicles, one on each side of the crop.

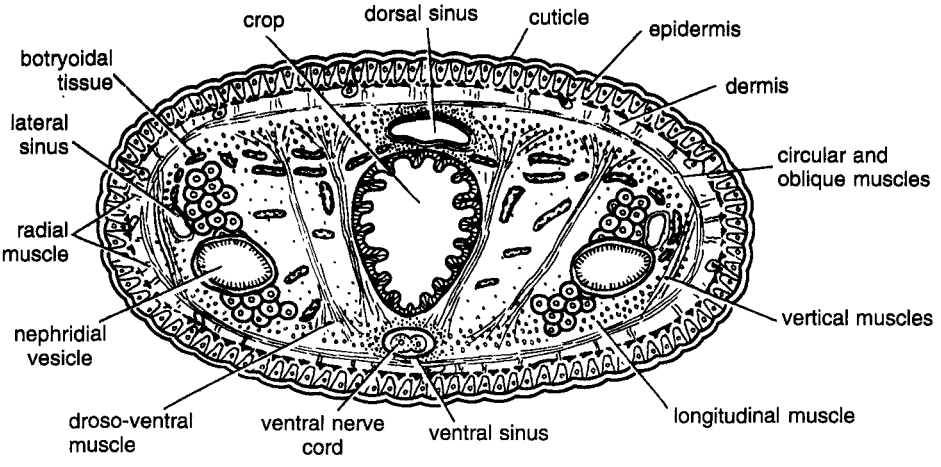


Fig. 120. Leech. T.S. passing through crop without diverticula.

Identification : Since the section contains **single crop chamber** and all above features, hence it is T.S. passing through the **crop of leech without diverticula.**

122. Leech : T.S. Passing Through Stomach

Comments : The section is triploblastic coelomate and exhibits the following histological details.

(1) This section passes through narrow stomach with crop diverticula on sides; crop and stomach are histologically distinguished.

(2) **Coelomic cavity** is filled with **botryoidal tissue.**

(3) **Body wall** is composed of thick **cuticle, epidermis** and **fibrous** and ramified dermis. **Muscle layers** are thin **circular, thick longitudinal, dorso-ventral, oblique** and **vertical muscle.** Detailed structure of body wall is same as in T.S. buccal cavity.

(4) Lumen of **stomach** is less wide than crop.

(5) T.S. stomach consists of outer cuticle, longitudinal and circular muscle layer and endodermal epithelial cells.

(6) Folds of epithelial lining narrower than crop.

(7) **Dorsal haemocoelomic vessel, ventral vessel** having **ventral nerve cord** and two **lateral vessels nephridial vesicles** are also seen.

Identification : Since the section contains, 3 **separate unconnected chambers** and all above features, hence it is **T.S. through stomach** and **crop diverticula of leech.**

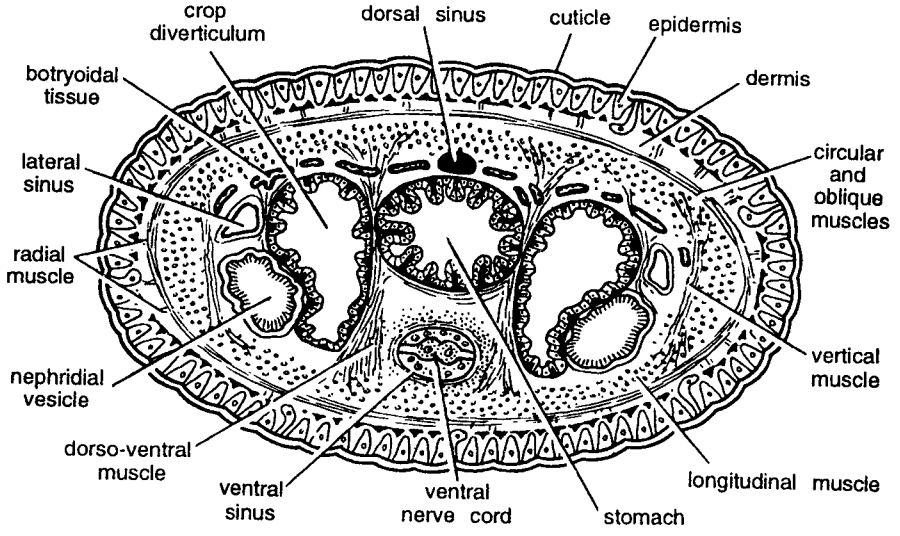


Fig. 121. Leech. T.S. passing through stomach and crop diverticula.

123. Leech : T.S. Passing Through Penis-Sac and Epididymis

Comments : Section has triploblastic layeration and coelom showing the following histological details.

(1) Section passes through atrium, lying in the 9th and 10th segments. The atrium contains penis and prostatic apparatus. A short duct from epididymis opens into atrium.

(2) **Coelomic cavity** is filled with **botryoidal tissue.**

(3) **Body wall** is composed of thick **cuticle, epidermis** and **fibrous ramified dermis; muscle layers** are

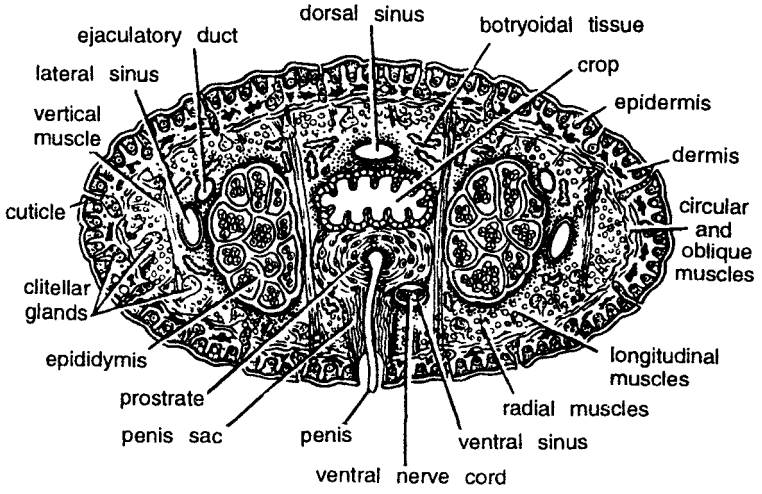


Fig. 122. Leech. T.S. passing through penis-sac and epididymis.

thin circular muscular layer and thick **longitudinal muscle layer**, **dorsoventral muscles**, **oblique muscles** and **vertical muscles**.

(4) **Atrium** is sac-like structure and is differentiated into anterior thick muscular prostate containing prostate **glands**, and **posterior panis-sac** containing **penis**, which is a backwardly directed protruding through **genital pore**.

(5) **Epididymis** on each side of **atrium** is highly coiled, containing numerous spermatozoa.

(6) Middle chamber of crop is seen over penis-sac.

(7) **Dorsal haemocoelomic vessel**, **ventral vessel containing ventral nerve cord**, **lateral vessels** and **haemocoelomic capillaries** are seen in the section.

Identification : Since the section contains epididymis and penis and all above structures, hence it is **T.S. through penis sac** and **epididymis of leech**.

124. Leech : T.S. Passing Through Rectum and Posterior Sucker

Comments : The section is triploblastic, coelomate and showing the following histological details.

(1) Section passing through intestine possesses same histological details as those of stomach except that the internal epithelial lining of intestine has numerous thin folds or villi (Fig. 123).

(2) **Intestine** is thinner in diameter than stomach.

(3) **Coelomic cavity** is filled with **botryoidal tissue**.

(4) **Body wall** is composed of thick **cuticle**, **epidermis**, fibrous and ramified dermis; muscle layers are thin circular and thick longitudinal, dorsal-ventral, oblique and vertical muscles.

(5) Three chambers are separated. The middle one is of **rectum**, while two side ones are of **long crop diverticula**.

(6) Rectum and crop diverticulum are composed of **cuticle**, **longitudinal** muscle layer, **circular** muscle layer and **endodermal columnar epithelial** cells.

(7) Section also shows the presence of **dorsal**, **sinus**, **ventral**, **sinus**, **lateral sinus** and **ventral nerve cord**.

(8) Section of posterior sucker is found below the body section. It shows presence of **cuticle**, **epidermis**, **circular** muscle layer and **longitudinal** muscle layer.

Identification : Since the section has 3 **separate chambers**, **posterior sucker** and all above features, hence it is **T.S. leech through rectum posterior sucker**.

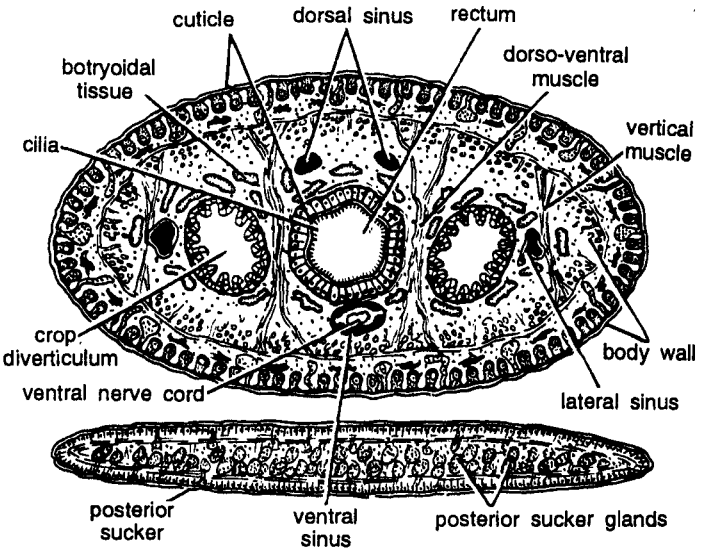


Fig. 123. Leech. T.S. passing through rectum and posterior sucker.

125. Leech : Jaws

Comments :

(1) Buccal cavity contains **one median** and two **ventro-lateral jaws.**
(2) Each jaw contains **monsostichodont denticles** or teeth at the free age and **salivary papillae.**
(3) Median jaw contains 103 to 128 denticles while lateral jaw 85 to 115 denticles.
(4) Jaws are attached together by **antagonistic muscles.**
(5) Jaws acting together produce a characteristic **triradiate bite or Y-shaped** wound in the skin of the host to suck the blood.
(6) On each side of the jaw are present about 42 to 45 button-shaped protuberances, called as **salivary papillae.** Each papillae contains openings of **salivary glands.**

126. Leech : Salivary Glands

Comments :

(1) On the external surface of the pharynx there are large number of **unicellular salivary glands.**
(2) Each gland is **uninucleated pyriform** having a duct which runs anteriorly and enters the jaw to open into the salivary papillae.
(3) Secretion of the gland contains a anticoagulant chemical called as **hirudin.**
(4) **Hirudin** is secreted at the bite to prevent coagulation of the blood over the skin of the host for continuous sucking of the blood.
(5) Leech leaves the host when the stomach is completely filled with blood.

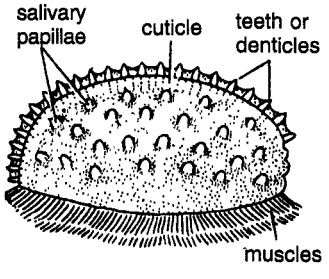


Fig. 124. Leech. Jaws.

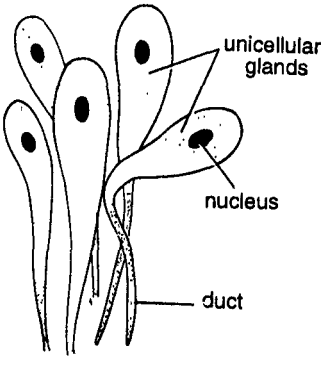


Fig. 125. Leech. Salivary glands.

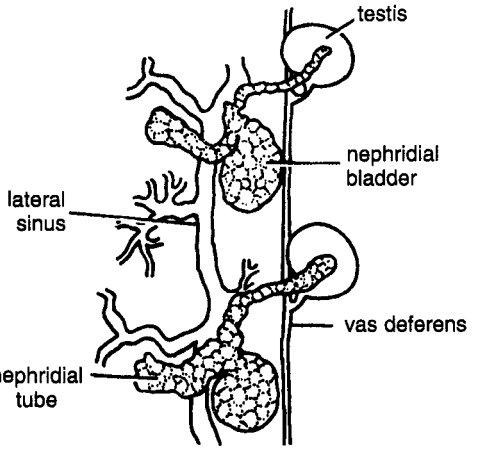


Fig. 126. Leech. Nephridium.

127. Leech : Nephridium

The nephridium consists of **initial lobe**, **main lobe** and **excretory vesicle**. The initial lobe is associated with **testis sac**.

PHYLUM MOLLUSCA

Animals with Shell and Mantle

All the molluscs have shell and mantle. For the first time animals have developed hard shell for protection. The shell is secreted by mantle.

128. *Unio* : T.S. of Gill-Lamina

Comments :

(1) Each **gill-lamina** is composed of outer and inner lamellae and in a transverse section it looks ladder-like.

(2) In T.S., the **two lamellae** are connected together by **inter-lamellar junctions** at regular intervals and spaces formed by them are called as **water tubes**, which open in **supra-branchial chamber**.

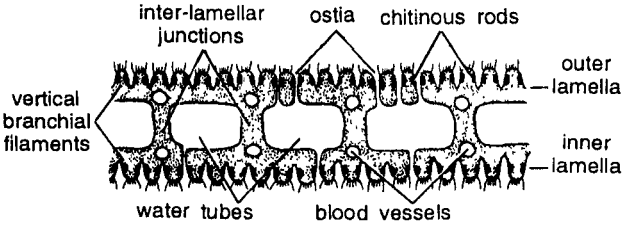


Fig. 127. *Unio.* T.S. gill-lamina.

(3) Histologically the gill-lamella is composed of **columnar ciliated epithelial cells** and is supported by chitinous rods.

(4) Blood vessels are also found on either side of the inter-lamellar junctions.

(5) Laminae are double-fold structures composed of two parallel vertical plates, called as lamellae.

(6) Outer and inner lamellae contain vertical, branchial filaments perforated by various inhalent ostia.

(7) Gill-lamellae are supplied with blood vessels i.e. they are of **eulamellibranchiate** type.

Identification : Since the mount has chitinous rods, water tubes and all above features, hence it is T.S. gill-lamina.

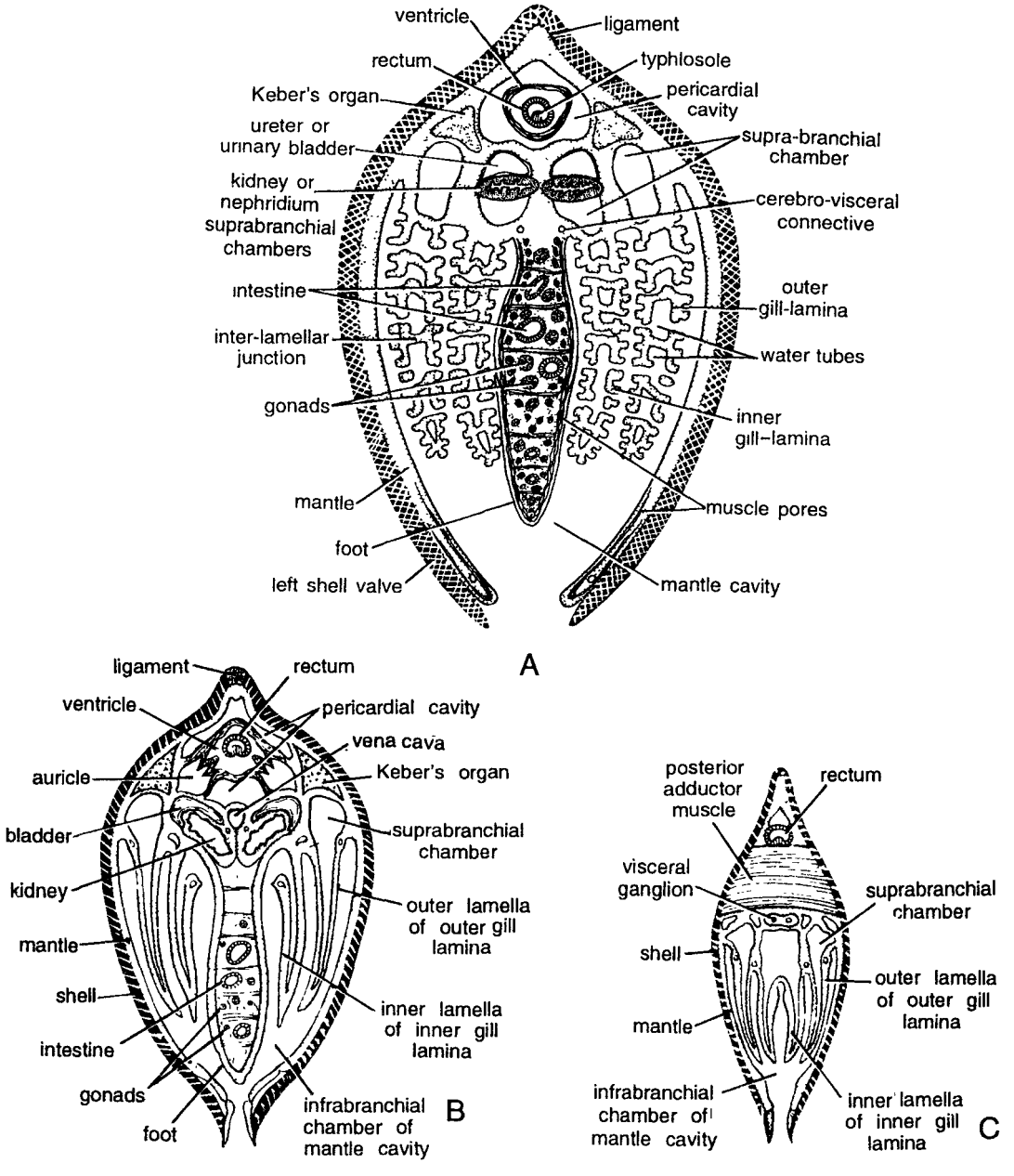


Fig. 128. *Unio.* **A.** T.S. Anterior region, **B.** T.S. Through middle region, **C.** T.S. Through posterior region.

129. *Unio* : Cross Section of Body

Comments : Cross sections of ***unio*** body can be studied through three regions-anterior, middle and posterior.

A. T.S. through anterior region :

(1) Section has **shell**, **mantle**, **foot** and other structures (Fig. 128).
(2) Mantle is associated with gill laminae (external and internal). Each gill lamina is made up to two folds called **outer** and **inner gill lamellae**.

(3) **Foot** and **gonads** are seen posteriorly.
(4) **Kidney** or **nephridium, suprabranchial chambers, pericardial cavity** enclosing **ventricles** and **rectum** with **typholosole** are seen anteriorly. On the sides of pericardium are **Keber's organs.**
(5) **Ligament, mantle cavity** and **muscle fibers** are also seen.

Identification : Since the section contains foot, gill **Keber's organ** and all above features, hence it is cross section anterior region of ***Unio***.

B. T.S. through middle region :

Section reveals **gonad, outer** and **inner gill laminae, watertubes, shell mantle, foot, intestine, kidney, bladder, auricle, ligament, rectum, pericardial cavity, vena cava, Keber's organ** and **supra-branchial chambers.** Diameter of the section much less than cross section anterior region.

Identification : Since section contains **vena cava** and all above features, hence it is the section of **middle** region of ***Unio***.

C. T.S. through posterior region :

Section reveals **shell, mantle, outer gill lamina, inner gill lamina, supra-branchial chamber, infrabranchial chamber, visceral ganglia, posterior adductor muscle** and **rectum.**

Identification : Since section has **adductor** muscle, visceral ganglia and all above features, hence it is T.S. through **posterior region of the body** of ***Unio***.

130. *Unio* : Glochidium Larva

Comments :

(1) It is a **molluscan larva**, found in the development of Bivalvia or Pelecypoda *(Unio).*
(2) It is a microscopic bivalved larva, consisting of conical shell containing **incurved hooks** ventrally and mantle.
(3) Mantle is produced into sensory brush-like hairs.
(4) **Shell valves** are operated by a large **adductor muscle** situated at the base and joined by **hinge.**
(5) A **byssus gland** is present near adductor muscle, through which a long filament-like structure arises, called as **byssus.**
(6) **Glochidium larva** attaches itself to fish skin and leads an **ectoparasitic** life during which it absorbs food from fish and changes adult form.
(7) Late glochidium detaches from the fish when adult leads free life.

Identification : Since the larva has bivalve shell, byssus gland and byssus, hence it is **Glochidium larva.**

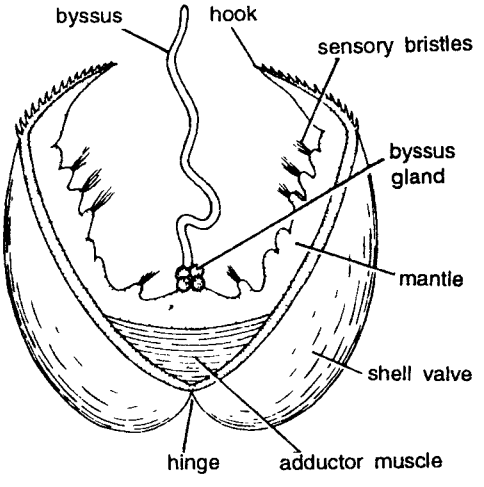


Fig. 129. *Unio.* Glochidium larva.

131. *Unio* : T.S. of Shell

Comments :

(1) **Shell** is secreted by the mantle and is composed of organic and inorganic material.
(2) Histologically it is composed of four layers.
(3) The outermost layer is made up of organic matter consisting of translucent, chitin-like substance called as **conchiolin.** This layer is called as **periostracum.**
(4) Middle layer is called as **ostracum** or **prismatic layer.** It consists of tiny calcium carbonate prisms.

(5) Prisms are separated by thin layers of conchiolin, arranged vertically.
(6) Below prismatic layer is **lamellated layers.**
(7) Innermost layer is called as **nacreous layer** which is the **mother-of-pearl.**
(8) **Nacre** or **nacreous** layer is iridescent layer, consisting of alternate layers of calcium carbonate and conchiolin, arranged parallel to the surface of the shell.

Identification : Since the section has **Periostracum, Ostracum** and all above features, hence it is **T.S. shell** of ***Unio***.

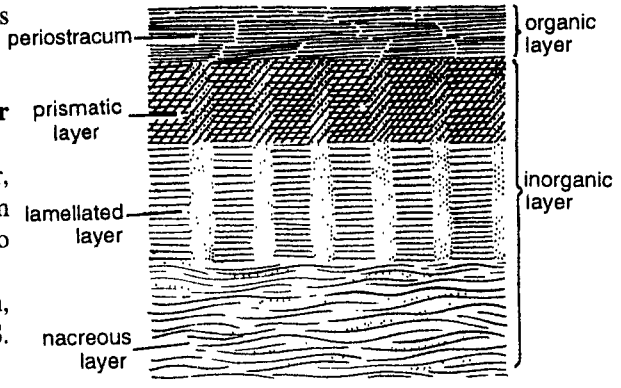


Fig. 130. *Unio.* T.S. of Shell.

132. *Pila* : L.S. Osphradium

Comments :
(1) It is a small lobe-like structure, attached to the mantle near the left nuchal lobe (Fig. 131).
(2) In a longitudinal section, it consists of 22 to 28 **oblong leaflets arranged** around a **central axis**. This arrangement is called as **bipectinate.**
(3) One end of the **leaflet** is attached to the mantle, while inner side attached with the axis.
(4) Side leaflets are smaller, while middle ones are larger.
(5) **Osphradium** is covered with epithelium.
(6) Epithelium consists of ciliated supporting cells, non-ciliated supporting cells, glandular cells, mucocytes and neurosensory cells.
(7) It acts as **rheoreceptor** and **chemo-receptor**, i.e. it detects the nature of water current and chemical juices.

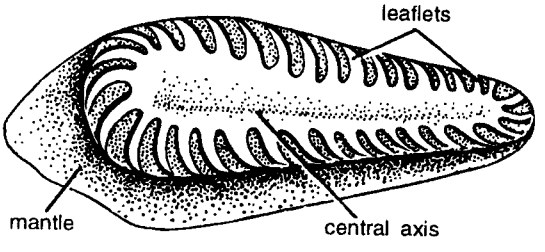
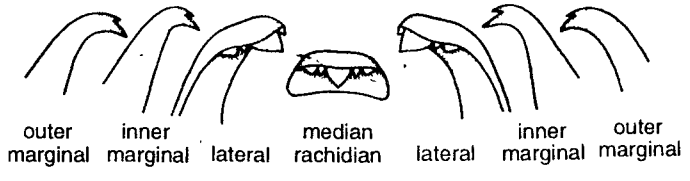


Fig. 131. *Pila.* L.S. Osphradium.

Identification : Since the section has 22 to 28 oblong leaflets, hence it is **L.S. osphradium of *Pila*.**

133. *Pila* : Radula

Comments :
(1) It is a **masticatory apparatus**, found in the buccal mass. It lies posteriorly in the buccal cavity over the odontophore (Fig. 132).
(2) **Radula** is a ribbon-shaped, chitinous plate. It consists of several recurved, **horny teeth** arranged transversely in several rows.



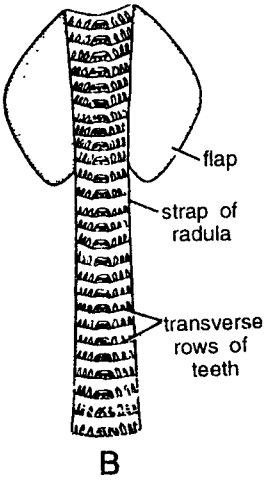


Fig. 132. *Pila.* **A.** Single row of teeth of radula, **B.** Complete radula.

(3) Each row comprises of definitely arranged 7 **teeth**. One is central or **rachidium**, one lateral and two marginals or **uncini**.
(4) It is **taenioglosate** type. Its teeth formula is 2 (M), 1 (L), 1 (R), 1 (L), 2 (M), or 2 : 1 : 1 : 1 : 2.
(5) Posterior part of the radula lies in the radular sac. The wall of the radular sac consists of **odontoblast** cells, which secrete teeth of radula.
(6) Radula is operated by complex muscles.
(7) Food is broken into small pieces by **to** and **fro** movements of the radular teeth.

Identification : Since the mounting has ribbon shaped chitinous plate having transverse rows of teeth and hence **it radula of *Pila***.

PHYLUM ARTHROPODA

Animals with Jointed Appendages

Arthropods possess higher grade of organization. For the first times jointed appendages development was observed in Arthropods. They also developed hard body covering made up of chitin. Arthropods are economically and socially most important animals.

134. *Peripatus* : T.S. Passing Through Body

Comments : The transverse section passing through the body of ***Peripatus*** along with legs shows the following histological details.
(1) **Body wall** composed of **cuticle**, **epidermis**, **dermis** and **muscular**.
(2) **Cuticle** thin flexible, water proof, chitinous and covered by several velvety processes.
(3) Beneath cuticle are single layered epidermis basement membrane and dermis of connective tissue.
(4) **Musculature** consists of **circular** muscle fibers, **transverse** fibers, dorsal **longitudinal** fibers lateral longitudinal fibers and ventral longitudinal fibers.

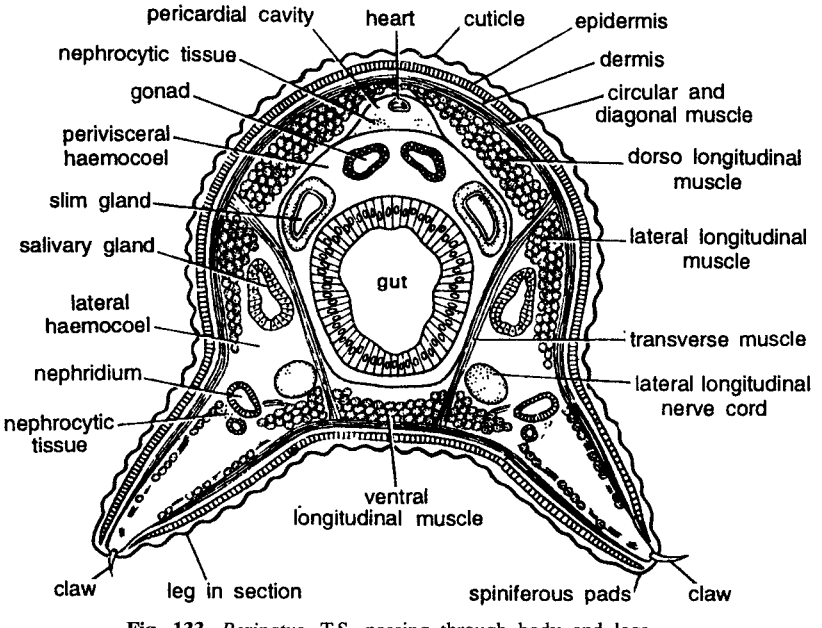


Fig. 133. *Peripatus*. T.S. passing through body and legs.

(5) All the **longitudinal fibers** are seen in **thick bundles**.
(6) Between gut wall and body wall is periviceral haemocoel.
(7) Section also shows cut parts of **heart**, **pericardial cavity**, **nephrocytic tissues**, **gonad**, **perivisceral haemocoel**, **slim gland**, **salivary gland**, **lateral haemocoel**, **nephridium**, **leg pad** and **terminal claw**.

Identification : Since the section contains longitudinal muscles in bundles and all above features and hence it is **T.S.** ***Peripatus***.

135. *Culex* : Egg Raft

Comments :

(1) ***Culex*** lays eggs in clusters in the form of **egg raft** on the surface of the **water**.
(2) Whitish eggs, cigar-shaped with anterior pointed ends.
(3) Eggs contain air bubbles in the anterior tip which help in floating.
(4) Number of eggs laid is 200 to 400.

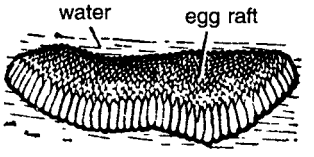


Fig. 134. *Culex.* Egg-raft.

Identification : Since the mount contains raft-shape eggs, hence it is **egg raft** of ***Culex***.

136. *Anopheles* : Eggs

Comments :

(1) ***Anopheles*** lays single eggs on the surface of the water.
(2) Whitish eggs, **boat-shaped with two lateral**, fin-like **air floats**, which help in floating.
(3) Eggs remain in horizontal position.
(4) Number of eggs laid is 40 to 100.

Identification : Since the eggs are spindle-shaped, hence it is eggs of ***Anopheles***.

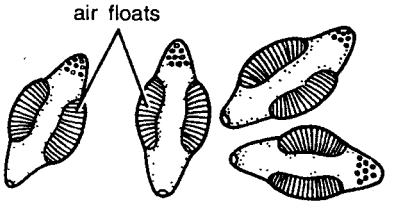


Fig. 135. *Anopheles.* Eggs.

137. *Culex* : Larva

Comments :

(1) **Commonly** called as **wriggler** as it swims by wriggling movement. It is **bottom feeder**.
(2) ***Culex*** egg hatches into free swimming larva in 2 to 3 days.
(3) Larva is transparent, 1 mm and is differentiated into **head**, **thorax** and **abdomen**.
(4) **Head** contains **compound eyes**, simple **antennae**, chewing **mandibles** and **maxillae** and feeding brushes.
(5) **Abdomen** is 9-segmented. Each segment has lateral tufts of **bristles**.
(6) Eighth abdominal segment has long **respiratory siphon** with **spiracle** at the top. Tracheal system opens to outside through spiracle. Eight segment also contains comb.
(7) Ninth abdominal segment has **abdominal plate**, **tracheal gills**, **dorsal** and **ventral brushes**.

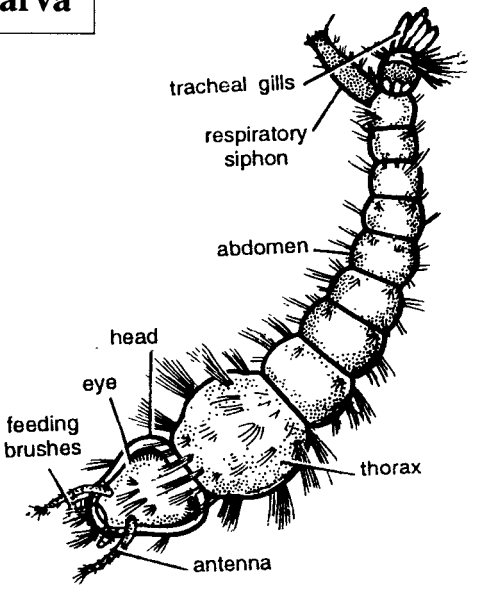


Fig. 136. *Culex.* Larva.

(8) Larval body along with the head hangs downwards at an angle with the surface of water.

Identification : Single eighth abdominal segment has **long respiratory siphon** and all above features, hence it is ***Culex* larva.**

138. *Anopheles* : Larva

Comments :

(1) ***Anopheles*** eggs hatch into **larvae** in 24 to 48 hours.
(2) ***Anopheles*** larva is relatively smaller and darker than ***Culex*** larva. It is **surface feeder.**
(3) **Body** divisible into **head, thorax** and **abdomen.**
(4) **Head** contains a pair of **antennae, compound eyes, dorsal** and **ventral feeding brushes.**
(5) **Thorax** unsegmented, broader than head and contains tuft of hairs.
(6) **Abdomen** has **nine** segments, each segment bearing plamate hairs.
(7) Eighth segment has a pair of **quadrilateral plate** with 2 spiracles.
(8) Ninth segment has dorsal, ventral brushes and **tracheal gills.**
(9) Respiratory **siphon** and **comb rows** on ninth segment absent.
(10) During intake of air head lies horizontally, parallel to the surface of water.

Identification : Since eighth segment has a pair of quadrilateral plate with 2 spiracles and all above features, hence it is ***Anopheles* larva.**

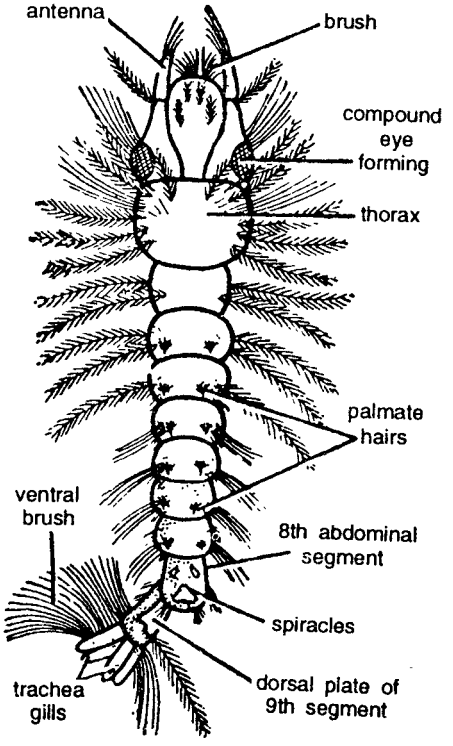


Fig. 137. *Anopheles.* Larva.

139. *Culex* : Pupa

Comments :

(1) ***Culex*** larva undergoes moulting four times and is transformed into **pupa** stage. Pupa is colourless.
(2) Larva is coma-shaped. Body divisible into **cephalothorax** (head + thorax) and abdomen.
(3) Head contains **antennae** and **compound** eyes.
(4) **Cephalothorax** has a pair of long **respiratory, trumpets** and rudiments of appendages.
(5) **Abdomen** has nine segments without palmate hairs.
(6) Each abdominal segment bears a pair of **paddle.** Each paddle has long bristles.

Identification : Since larva has long respiratory trumpets and all above features, hence it is ***Culex* pupa.**

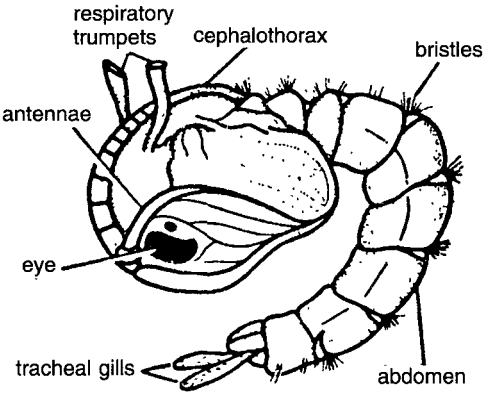


Fig. 138. *Culex.* Pupa.

140. *Anopheles* : Pupa

Comments :

(1) It is the second developmental stage of the mosquito insect.
(2) ***Anopheles*** larva, after fourth ecdysis changes to green-coloured, pupal stage, called a **tumbler**.
(3) Body is **comma-shaped, composed of cephalothorax** and ventrally **flexed abdomen.**
(4) **Cephalothorax** contains **eyes, antennae** and short **respiratory siphons.**
(5) **Abdomen consists** of 9 **segments**, having **palmate hairs** and **caudal fins** on the eighth segment for swimming.
(6) Each **paddle** contains long and short **bristles.**
(7) Rudiments of some of the prospective appendages are seen.

Identification : Since the larva has **short siphon** or **breathing trumpets** and **bristles** and all above features, hence it is ***Anopheles*** **pupa.**

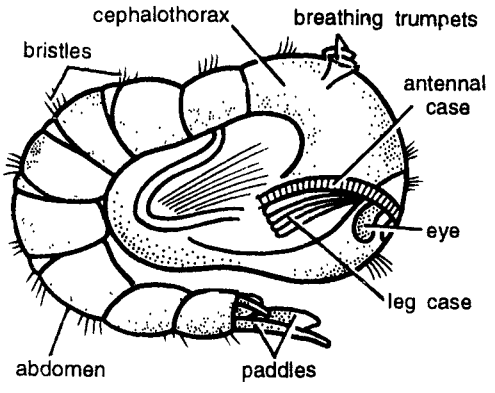


Fig. 139. *Anopheles.* Pupa.

141. *Culex* : Male : Head and Mouth Parts

Comments :

(1) **Head** and the **mouth** parts are seen clearly under low magnification of the microscope.
(2) **Body** is differentiated into **head, thorax** and **abdomen.**
(3) In male ***Culex***, **maxillary palps** are longer than **labium** and **antennae** possess long and bushy delicate hairs in bunches **(plumose antenna).**
(4) **Head** is freely movable on a narrow neck, having large **black compound eyes** and **antennae** and **clypeus articulates** with **labrum-epipharynx.**
(5) Mouth parts contain **labrum-epipharynx, needle shaped mandibles** and **maxillae, hypopharynx, maxillary palps** and **labium** with tactile hairs.
(6) **Mouth parts** are of **sucking** type.
(7) It communicates **filariasis** (causing **elephantiasis**).

Identification : Since the mount has long maxillary palps, hence it is **head** and **mouth parts of male *Culex*.**

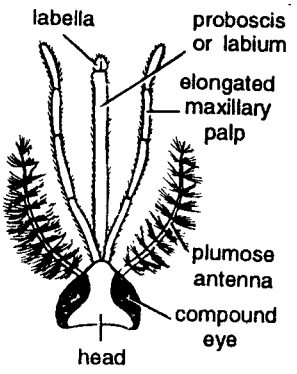


Fig. 140. *Culex.* Head and mouth parts of male.

142. *Culex* : Female : Head and Mouth Parts

Comments :

(1) In female ***Culex***, **maxillary palps** are exceedingly short and **antennae** contain a few short hairs at joints (Fig. 141).
(2) **Head** is freely movable on a slender neck, having large black compound eyes and antennae.
(3) **Clypeus articulates** with **labrum-epipharynx.**
(4) **Mouth parts** are of **peircing** and **sucking type**, composed of **labrum-epipharynx, needle-like mandibles** and **maxillae** and **hypopharynx. Maxillary palps** are three-jointed.
(5) **Maxillary palps** and **labium containing tactile hairs** forming **proboscis sheath.**

(6) It helps in transmission of **elephantiasis** disease.

Identification : Since the mount has short maxillary palps, hence it is **head and mouth parts of female *Culex*.**

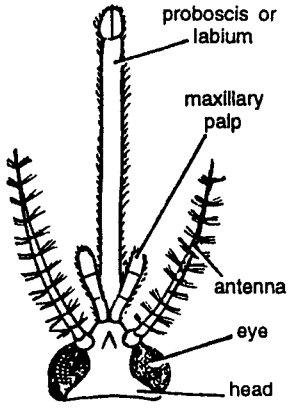


Fig. 141. *Culex.* Head and mouth parts of female.

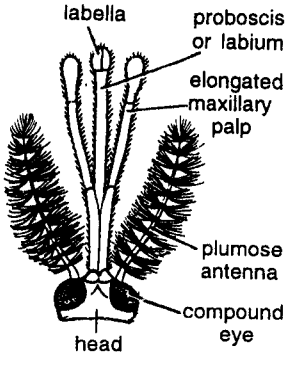


Fig. 142. *Anopheles.* Head and mouth parts of male.

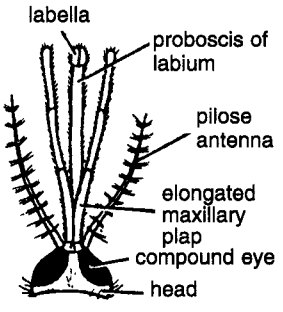


Fig. 143. *Anopheles.* Head and mouth parts of female.

143. *Anopheles* : Male : Head and Mouth Parts

Comments :

(1) **Head** and its **mouth parts** are distinct, which can be observed under dissecting microscope and in low magnification of the microscope (Fig. 143).

(2) **Head** is freely movable on a slender neck, having large black compound eyes and antennae.

(3) **Clypeus** articulates with **labrum** and **epipharynx**.

(4) Mouth parts are **piercing** and **sucking type** composed of **labrum-epipharynx**, **needle-shaped**, **mandibles** and **maxillae hypopharynx**, **maxillary palps** and **labium**. **Maxillary palps** are **club-shaped** and are nearly equal to labium or **proboscis**; and **antennae** have long, bushy hairs at their joints.

(5) It does not help in transmission of **malarial disease** and feeds on plant juices.

Identification : Since the mount has club-shaped maxillary palps, hence it is **head and mouth parts of male *Anopheles*.**

144. *Anopheles* : Female : Head and Mouth Parts

Comments :

(1) **Head** and its **mouth parts** are clearly seen under dissecting microscope under low magnification of compound microscope (Fig. 142).

(2) **Antennae** possess a few short hairs at joints.

(3) **Head** is freely movable on a delicate and slender neck, having large black **compound eyes** and **pilose antennae**.

(4) **Clypeus** articulates with **labrum** and **epipharynx**.

(5) **Mouth parts are piercing** and **sucking type**, composed of **labrum-epipharynx**, **needle-shaped mandibles** and maxillae, **hypopharynx**, **maxillary palps** and **labium**. **Maxillary palps** are simple and equal to labium or proboscis.

(6) It transmits **malarial disease** and acts as **intermediate** host for ***Plasmodium***.

Identification : Since the mount contains simple maxillary palps, hence it is head and mouth parts of female ***Anopheles***.

145. *Musca domestica* : Housefly : Head and Mouth Parts

Comments :

(1) ***Musca domestica*** or **housefly** belongs to order **Diptera** and contains **sponging** mouth parts, adapted for **sucking** liquid food.
(2) These insects lack the cutting apparatus.
(3) Head bears **Ocelli** on ocular plate and large compound eyes and mouth parts. Antennae are aristate.
(4) **Mouth parts** are composed of **proboscis**, **short maxillary palps**, **labrum-epipharynx** and **hypopharynx**. **Mandibles** are absent.
(5) **Maxillae** are represented by short and unjointed **maxillary palps** before the rostrum.
(6) **Labrum** is fused with the epipharynx and forms a narrow slender tube opening ventrally.
(7) **Hypopharynx** is narrow structure. Containing salivary duct and fits into the tube constituted by labrum-epipharynx.
(8) **Proboscis is retractile**, **fleshy** and differentiated into **basal rostrum**, **middle haustellum** and **upper labellum**. **Lebellum** contains **pseudotracheal**, **canals**, bounded by **pseudotracheal membrane**. Labium forms a tube and encloses **labrum-epipharynx** and **hypopharynx**.

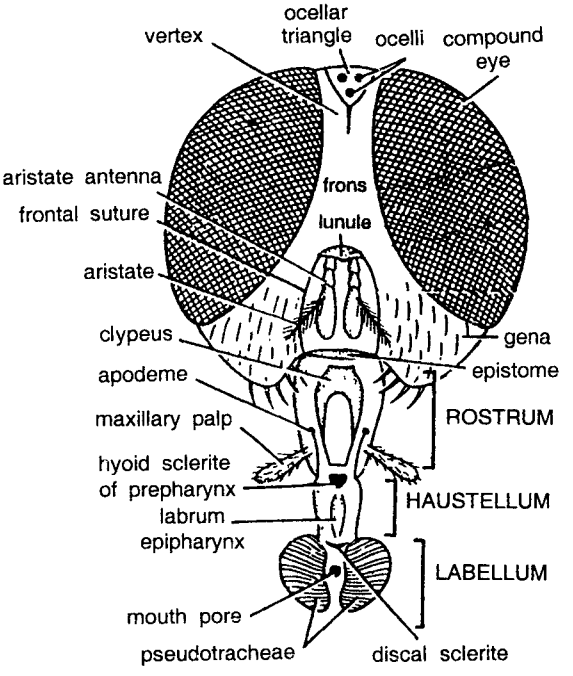


Fig. 144. Head and mouth parts of housefly.

(9) **Hypopharynx** and labrum constitute the food channel. Other structures seen are **gene**, **epistome**, **apodeme**, **discal sclerite** and **hyoid sclerite**.

Identification : Since the mouth contains pseudotracheae in labellum, and all above features, hence it is **W.M. head and mouth parts of *Musca domestica*.**

146. Butterfly : Head and Mouth Parts

Comments :

(1) Butterfly, belonging to order **Lepidoptera**, contains siphoning or **sucking mouth parts**. Head may be examined under binocular microscope for mouth parts (Fig. 145).
(2) **Head** of butterfly is composed of large **compound eyes** and **antennae**. It is broad and **contains siphoning** type of **mouth parts**.
(3) **Mouth parts** are composed of small labrum in front of **clypeus**, **triangular labium** and **coiled proboscis**.
(4) **Mandibles** are absent.
(5) Proboscis is composed of elastic cuticle and greatly elongated **galeae of maxillae**, **grooved internally forming food canal for nectar**.
(6) **Proboscis** lies in **coiled stage**, but it immediately uncoils and protrudes in response to a food stimulus, due to rise in blood pressure.

(7) **Labium** is triangular and plate-like containing labial palps.
(8) Other joints of maxillae and maxillary palps are reduced or vestigial.
(9) Head contains ventral groove for proboscis.

Identification : Since the mouth contains coiled proboscis, hence it is the mouth parts of **butterfly**.

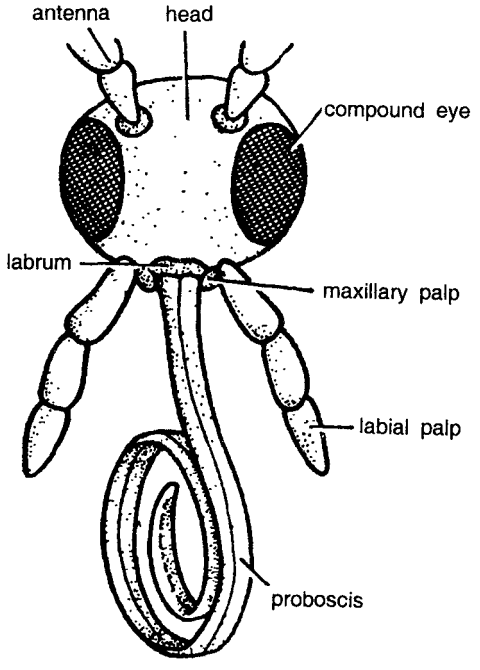


Fig. 145. Head and mouth parts of butterfly.

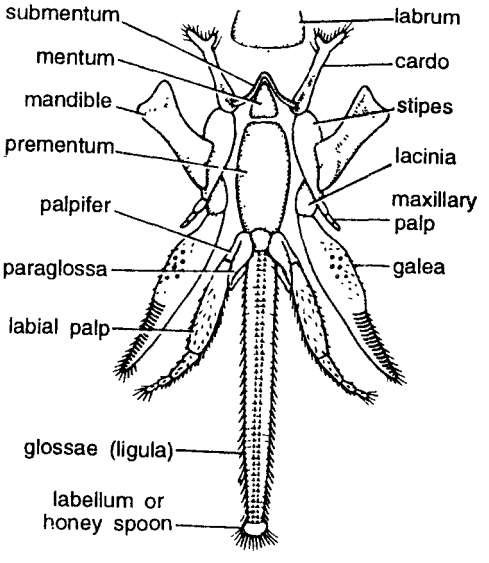


Fig. 146. *Apis.* Honey-bee. Mouth parts of worker.

147. *Apis* : Honey-bee : Mouth Parts of Worker

Comments :

(1) **Honey-bee** belonging to the order **Hymenoptera**, contains **rasping** and **lapping** mouth parts, adapted for collection of **nectar** and **pollen**.
(2) **Head** is triangular, containing large **compound eyes**, 3 **ocelli antennae** and **mouth parts**.
(3) Mouth parts are composed of **spoonshaped mandibles, labrum** and **maxillae** devoid of lacinia.
(4) **Mandibles** are smooth and **spatulate type**, found on either side of the labrum.
(5) It contains **vestigial maxillary palps** and **blade-like galea**.
(6) Labellum is **spoon-shaped, grooved internally** forming a tube and is called as tongue.
(7) **Epipharynx** is soft and triangular lying below the **labrum**. **Cardo** and **stipes** are well developed.
(8) Liquid food taken along tongue is converted into honey in honey-sac by enzymes from salivary glands.
(9) **Prementum** contains segmented **labial palps, paraglossae** and **glossae**.
(10) Honey-bee also **moulds waxes** in its hive.

Identification : Since the mount contains spoon-shaped labellum, hence these are **mouth parts of worker**, honey-bee.

148. *Apis* : Honey-bee : Legs

Comments :

(1) Thorax contains 3 pairs of walking legs, which bear dense hairs. Each leg is composed of coxa, **trochanter**, **femur**, **tibia** and 5-**jointed tarsus**, which ends in a **pulvillus** (Fig. 147).

A. First pairs of legs :

(2) It is found in the prothoracic region; inner surface of **tibia** bears **pollen brush; posterior surface of tibia** contains a **vellar process**, which fits into the tarsal notch; and the bristles of the tarsal notch form **antenna comb**.

(3) Anterior edge of the first tarsal segment contains **eye brush** to remove particles from the eyes.

B. Second pair of legs :

(4) It originates from **mesothorax** containing 5 **podomers**.

(5) Inner end of Tibia bears spine-like **pollen spur** for removing pollen from the pollen basket. The outer surface bears **pollen brush**. Terminal part of tarsus contains **pulvilus** and **claw**.

C. Third pair of legs :

(6) It originates from the **metathorax**. The proximal tarsus contains stiff hairs, which help in removing the pollen from the body. The tibial podomere is slightly concave and is fringed with long hairs to forming **pollen basket** or **corbicula**.

(7) Distal end of tibia has stiff bristles called as **pecten**. Just below pecten is a plate like structure called **auricle**. Pecten and auricle form **wax pincher** for removing wax from **abdomen**.

(8) Outer surface of tarsus has **pollen brush** while inner surface has **pollen comb** or **scopa**. Terminal segment of tarsus contain **claw** and **pulvillus**.

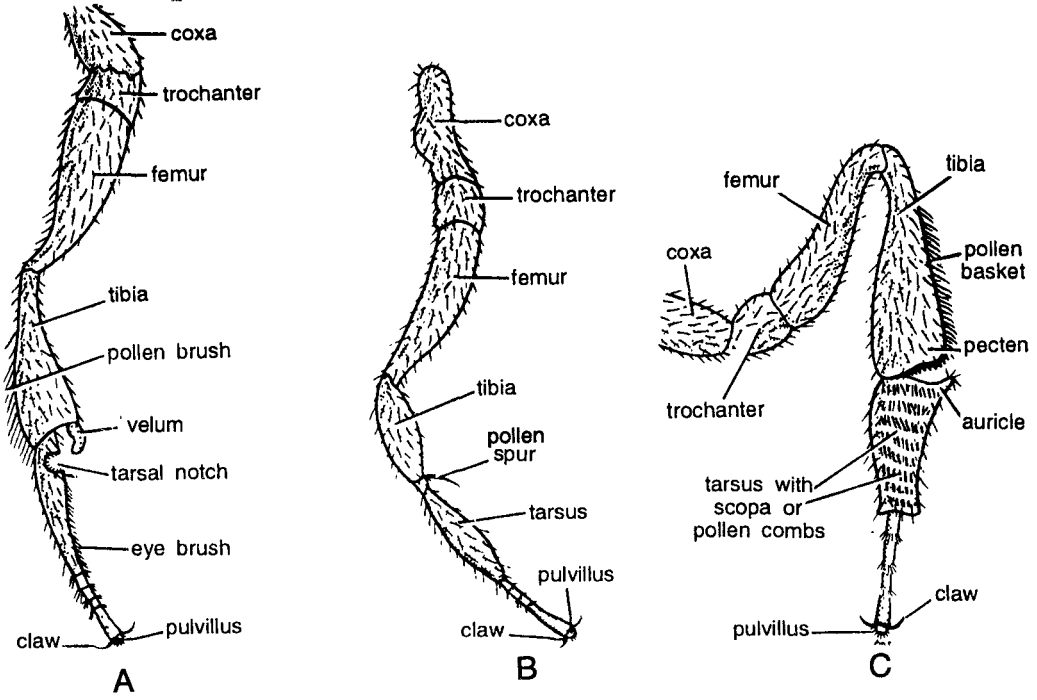


Fig. 147. Legs of honey-bee. **A.** First leg, **B.** Second leg, **C.** Third leg.

149. *Apis* : Honey-bee : Sting Apparatus

Comments :

(1) **Sting apparatus** of honey-bee is a modified **ovipositor**, found at the posterior extremity of abdomen in queens and workers (Fig. 148).
(2) It is composed of **sting** or **terebra, bulb, levering plates** and **glands.**
(3) Sting is made up of 2 pairs of **gonapophyses** : those of the 8th segment forming **stylets** and of the 9th segment **stylet sheath,** which enclose **poison canal.** .
(4) Distally the stylet sheath and **stylet contain pointed spines** or **barbs.**
(5) Stylet sheath is expanded into the bulb at the base of the sting.
(6) There are 3 pairs of plates. The anterior one is triangular **fulcral** plate, the **postero-dorsal** is **quadrate plate** and the innermost is **oblong** plate bearing sting palp.
(7) There are two glands namely **poison gland,** opening into the poison-sac and a small **alkaline gland,** opening into sting bulb. The bite of the **sting** causes burning sensation, pain and swelling of the part concerned.

Identification : Since the mount contains sting and poison gland hence it is sting apparatus of ***Apis***.

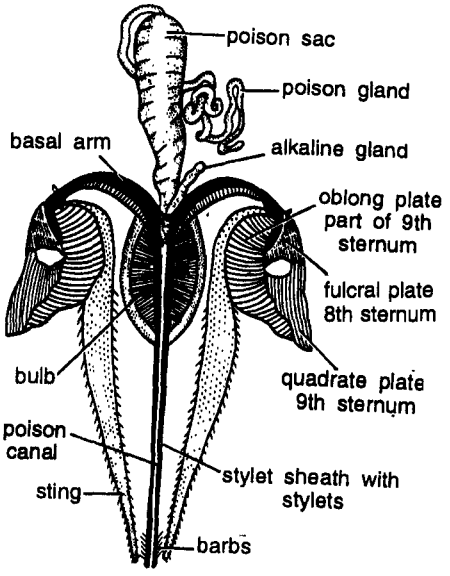


Fig. 148. Sting apparatus of honey-bee.

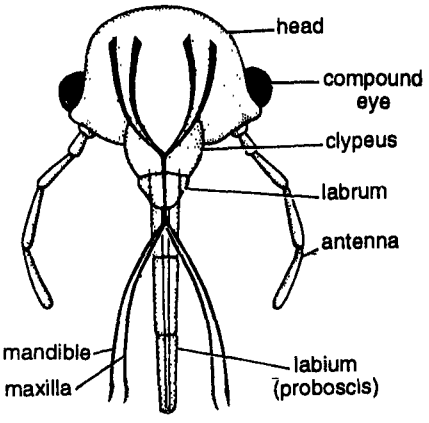


Fig. 149. *Cimex.* Bed bug. Mouth parts.

150. *Cimex* : Bed bug : Mouth Parts

Comments :

(1) ***Cimex*** or **bed bug,** belonging to order **Heteroptera,** contains **piercing** and **sucking** mouth parts.
(2) Head is broad and short, composed of large **compound eyes, antennae** and **mouth parts** (Fig. 149).
(3) Antennae are 5-jointed.
(4) **Mouth parts** consist of **labrum** which is elongated, forming rostrum or **proboscis,** needle shaped **mandibles** and **maxillae.**

(5) **Labial palps** and **maxillary palps** are absent.
(6) **Proboscis** is grooved.
(7) Bed bug is **ectoparasite** and sucks the blood of man. It acts as **carrier of various diseases.**

Identification : Since mandible and maxillae are needle shaped and mouth parts have all above features, hence it is mouth parts of ***Cimex***.

151. *Periplaneta americana* : Cockroach : Mouth Parts

Comments :

(1) Cockroach, belonging to order **Orthoptera**, contains **chewing** mouth parts (Fig. 150).
(2) Head is dorso-ventrally elongated and is composed of **antennae**, large **compound eyes** and **mouth parts.**
(3) Mouth parts consist of (i) **labrum**, (ii) **mandibles** and (iii) **maxillae.**
(4) Labrum protects the mouth. Mandibles are simple and toothed.
(5) Maxilla has two parts-cardo and **stipes**. Stipes contains internally **lacinia**, medially **galea** and externally **maxillary palp.**
(6) **Labium** is composed of **submentum, postmentum** and **prementum.**
(7) Prementum carries **glossa internally, paraglossa medially** and **palpiger externally.**
(8) **Maxillary** and **labial palps** are tasting organs.

Identification : Since the mount shows definitely arranged various parts especially labium maxilla and all above features, hence it is **mouth parts of cockroach.**

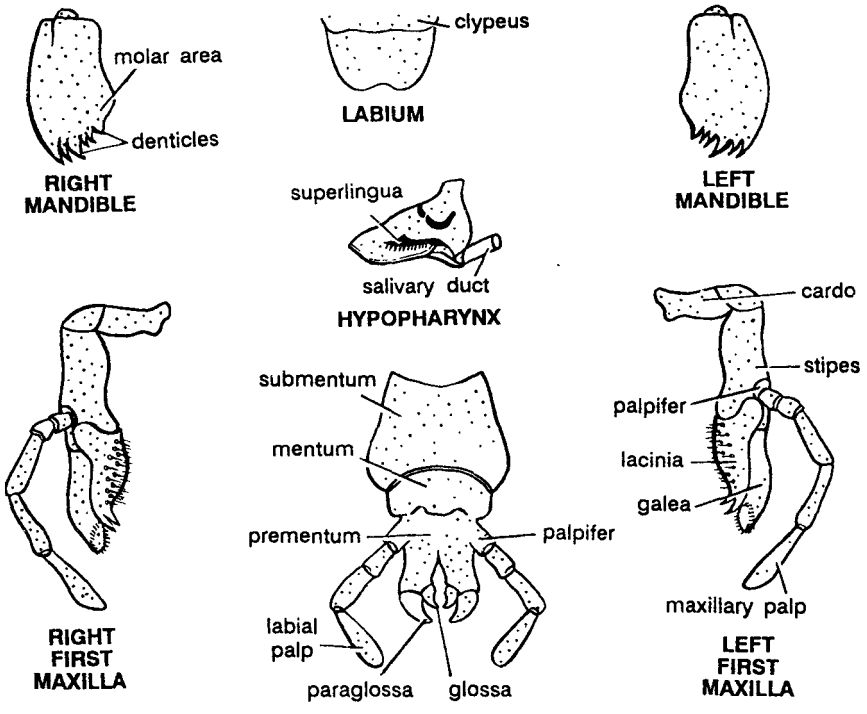


Fig. 150. Mouth parts of cockroach.

152. *Xenopsylla* : Rat Flea

Classification :

Phylum.....Arthropoda	→	Jointed appendages.
Class.....Insecta	→	Body differentiated into head, thorax and abdomen. Abdominal appendages absent.
Sub-class.....Pterygota	→	Winged insects with incomplete or complete metamorphosis.
Division.....Endopterygota	→	Wings originate internally metamorphosis complete.
Order.....Siphonoptera	→	Secondarily wingless ectoparasites with piercing and sucking mouth parts.
Genus.....*Xenopsylla* (Rat flea)		

Habit and habitat : ***Xenopsylla*** is an important blood sucking and jumping insect found as ectoparasite on skin between hairs of dogs, rats, birds and man.

Distribution : It is found in India, Malaysia, Myanmar and Srilanka.

Comments :

(1) **Commonly** called as **rat flea.**

(2) **Body** is laterally compressed to facilitate gliding between hairs and feathers of their hosts. Body indivisible into **head thorax** and **abdomen.**

(3) **Head** is broadly joined to relatively **small thorax. Abdomen** has 10 segments.

(4) Head contains **ocelli** (compound eyes) **antennae** and **mouth parts.**

(5) Body is furnished with backwardly projecting **bristles,** which help the flea in forcing its way between dense hairs and prevent it from slipping backward.

(6) **Legs** are long and powerful with enormously developed **coxae** besides 5 tarsi.

(7) Wings are absent.

(8) **Mouth parts** are composed of **serrated mandibles, triangular maxillae** and **maxillary palps, reduced labium, hypopharynx** and **large labrum-epipharynx.** The mouth parts are **piercing** and **sucking type.**

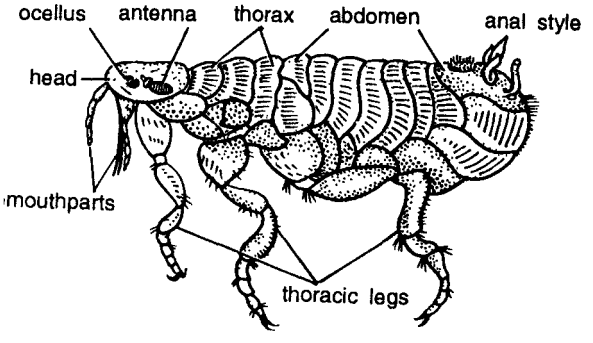


Fig. 151. *Xenopsylla.* Rat flea.

Economic status : Fleas are prime **transmitters** of two diseases of outstanding importance : (i) **Plague** and (ii) **endemic typhus.** They also transmit **Tularemia** in rodents and ***Myxomatosis*** in rabbits. They also act as intermediate host of certain tapeworms.

Identification : Since the bristles over body and animal has long legs and all above features, hence it is ***Xenopsylla.***

153. *Pediculus humanus* : Human Body Louse

Classification :

Phylum.....Arthropoda	→	Jointed appendages.
Class.....Insecta	→	Body differentiated into head, thorax and abdomen. Abdominal appendages absent.
Sub-class.....Pterygota	→	Winged insects with incomplete or complete metamorphosis.
Division.....Exopterygota	→	Wings externally originated with simple metamorphosis.
Order.....Anoplura	→	Mouth parts piercing and sucking ectoparasites without metamorphosis.
Genus.....*Pediculus*		
Species.....*humanus*		

Habit and habitat : ***Pediculus humanus*** is a medically important ectoparasite found on man and other mammals. The lice occur on the hairy part of the body. There are two forms of this species, the **head louse** which occurs on the head and glues its eggs to the head hairs, and the **body louse** which occurs chiefly on the clothes and reaches to adjacent body areas to feed. The body louse glues its eggs to cloth strands.

Distribution : It has world-wide distribution.

Comments :

(1) **Commonly** called as **human body louse** or **cootie**.
(2) It is **wingless** flattened blood sucking insect.
(3) Body is dorso-ventrally flattened, pale coloured with dark sides and divided.
(4) **Head** contains feebly developed **compound** eyes a pair of 5-segmented **antennae** and **mouth** parts. Head is distinctly separated from the thorax.
(5) **Mouth parts** are adapted for **piercing** and **sucking**.
(6) **Mandibles** are **rudimentary; maxillae** and **labium** from dorsal and ventral stylets.
(7) Thoracic segments are fused in one mass and contain clawed legs, which form clinging organs with the tissue of the host.
(8) **Abdomen** is 9-segmented.
(9) In male, posterior end is turned upwards and in female, it does not turn upwards. Males are 2 to 3 mm long and females are 3 to 4 mm long.

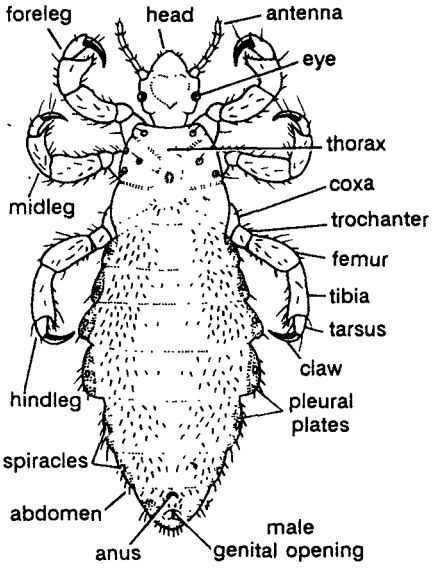


Fig. 152. *Pediculus humanus.* Human body louse.

Economic status : ***Pediculus humanus*** is a major factor in transmitting three important human diseases **relapsing fever, typhus** and **trench fever**. The cootie has vied the mosquito in shaping destiny of history. Under unsanitary crowded camp or trench conditions soldiers with heavy clothing provided ideal hosts for cooties. Typhus and trench fever in epidemic form had disastrous results. Napoleon's army in Russia was decimated as much by louse-borne diseases as by hunger and exposure.

Identification : Since the insect has clawed legs dorsoventrally flattened body and all above features, hence it is ***Pediculus humanus***.

154. *Cyclops*

Classification :

Phylum..... Arthropoda	→	Jointed appendages.
Class..... Crustacea	→	Aquatic arthropoda with 2 pairs of antennae.
Sub-class..... Copepoda	→	Free, commensal or parasitic Crustacea. Eye, carapace and abdominal appendages absent.
Order..... Eucopepoda	→	Free-living and parasitic copepods. Females contain ovisacs generally.
Genus..... *Cyclops*		

Habit and habitat : ***Cyclops*** is the most familiar fresh-water copepod, found in ponds, ditches and small water reservoirs, it is also found in brackish water (Fig. 153).

Distribution : It is commonly found in Europe, Asia, U.K., U.S.A., India, Srilanka and Myanmar.

Comments :

(1) **Body** is elongated with somewhat broad anterior and narrow posterior end.
(2) It measures 1.7 to 5.5 mm in length.

(3) Body is differentiated into **cephalothorax** and **abdomen**. The **head** and first thoracic segment fuse to form cephalothorax, which is covered by **carapace**.
(4) A **median eye** is present over carapace.
(5) There are 5 **thoracic** and 5 **abdominal segments**.
(6) Fourth abdominal segment bears a **caudal style** or **forked tail** and **anus dorsally**.
(7) **Body** appendages are **uniramous antennules**, **short antennae**, **mandibles**, **maxillulae**, **maxillipedes** and **legs**.
(8) Mature females carry two lateral **ovisacs** attached to upper abdominal segment.
(9) Male ***Cyclops*** is easily recognized by the absence of the ovisacs.

Economic status : ***Cyclops*** serves as **food** for fishes and as intermediate host for various **helminth worms**. The most important disease which they communicate to human beings is **dracunculiasis** a serious nematode disease especially in Rajasthan.

Identification : Since the animal has median eye, caudal styles eggs sac and all above features, hence it is **female** ***Cyclops***.

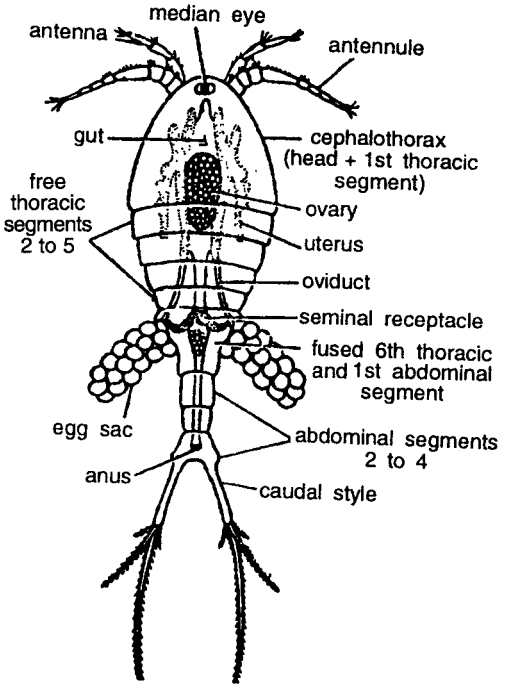


Fig. 153. *Cyclops.* Female.

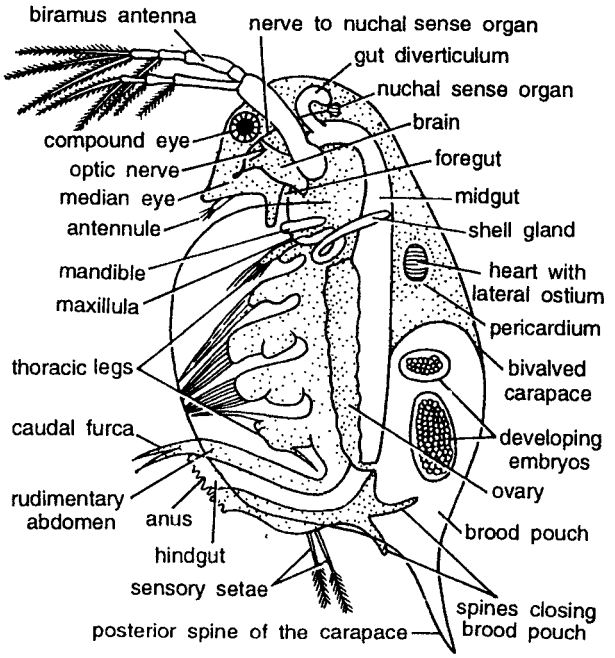


Fig. 154. *Daphnia.*

155. *Daphnia*

Classification :

Phylum.....Arthropoda	→	Jointed appendages.
Class.....Crustacea	→	Aquatic arthropods with 2 pairs of antennae.
Sub-class.....Branchiopoda	→	Trunk appendages serve as gills.
Order.....Cladocera	→	Four to six pairs of thoracic limbs.
Genus.....*Daphnia*		

Habit and habitat : ***Daphnia*** is a freshwater branchiopod, cosmopolitan and is commonly found in ditches and ponds.

Distribution : Widely distributed in India, Asia, Europe and U.S.A.

Comments :

(1) **Commonly** called as **water flea** (Fig. 154).
(2) Body is bilaterally compressed and enclosed in a vestigeal bivalve carapace ending anteriorly into a backwardly directed **rostrum** and posteriorly into a **spine**.
(3) **Head** not separated from the body by a dorsal notch.
(4) Head is rounded and bears large **biramous antennae** which help in **swimming**, small unjointed **antennules**, **mandibles**, **maxillulae**, and large **sessile eyes** are very distinct.
(5) **Abdominal** appendages are absent and thoracic appendages are 5 pairs and leaf-like.
(6) Posteriorly female carries a **broad pouch** containing various developing embryos.
(7) **Brood pouch** is found near the back.
(8) In a stained slide heart, nerve to muchal sense organs, **gut diverticulum**, **foregut**, **mid-gut**, **hind-gut**, **anus**, **sensory setae**, **shell gland** and **ovary** in female are seen.
(9) Thoracic appendages form efficient food-catching organs.
(10) Sexes are separate. Brood pouch is absent in male.

Identification : Since animal contains rostrum, spine and all above features, hence it is ***Daphnia.***

156. *Branchipus*

Classification :

Phylum..... ..Arthropoda	→	Jointed appendages.
Class..... Crustacea	→	Exoskeleton thick, antennae 3 pairs, jaw 3 pairs.
Sub-class..... Branchiopoda	→	Appendages uniform.
Order..... Anostraca	→	Carapace absent.

Genus..... *Branchipus* (Fairy, Shrimp)

Habit and habitat : ***Branchipus*** is commonly found in fresh-water lakes.

Distribution : It has **cosmopolitan** distribution.

Comments :

(1) **Commonly** called as **brine shrimp**.
(2) Small branchiopod Crustacea, **comma-shaped**, about 2.5 cm in length.
(3) Primitive animal with transparent and pinkish body without carapace.
(4) **Body** is divisible into **head**, **thorax** and **abdomen**.
(5) **Head** contains downward **bent rostrum**, large **antennae** modified into **prehensile organs**, small **antennules**, **pedicellate eyes**, **mandible** and shell glands.

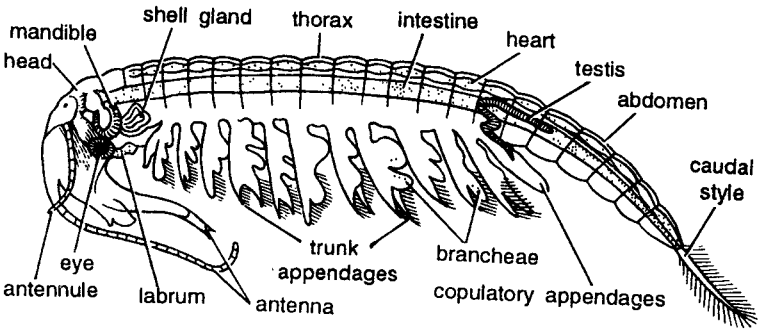


Fig. 155. *Branchipus.*

(6) Thorax forms major part of the body and contains several flattened, **swimming appendages** associated with branchiae. The animal swims on its back.
(7) **Abdomen** is short and is without appendages. The last segment contains **style**.
(8) **Sexes** are separate. Antennae are reduced in females. The eggs are laid in summer, remain buried in the mud; withstand drying and cold; and hatch in the following summer.

Identification : Since the animal contains prehensile antennae and all above features, hence it is ***Branchipus***.

157. *Cypris*

Classification :

Phylum..... Arthropoda	→	Jointed appendages.
Class..... Crustacea	→	Body enclosed in a bivalve carapace.
Sub-class..... Ostracoda	→	Body enclosed in a bivalve carapace.
Order..... Podocopa	→	Antennae uniramus.
Genus..... *Cypris*		

Habit and habitat : ***Cypris*** commonly inhabits stagnant pools. It is carnivorous feeding on small organisms (Fig. 156).

Distribution : Cosmopolitan.

Comments :

(1) **Commonly** called as **mussel shrimp**.
(2) Unsegmented body about 2 mm long is completely enclosed in a protective bivalve carapace looking like miniature clam. There are no lines of growth on **carapace**. Two valves are connected by a large **adductor muscle**.
(3) A pair of **lateral eyes** present. Compound eye and heart absent.

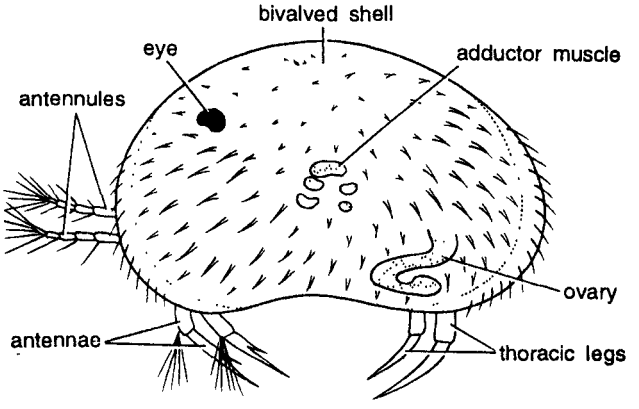


Fig. 156. *Cypris.*

(4) **Head** bears four pairs of appendages **antennules**, **antennae**, **mandibles** and **maxillae**. **Antennules** and **antennae** help in swimming.
(5) Three pairs of **appendages** are found in thorax. First thoracic helps in swimming.
(6) No appendages in abdomen.
(7) Generally eggs develop parthenogenetically.

Identification : Since the animal has protective bivalve carapace and all above features, hence it is ***Cypris***.

158. *Argulus*

Classification :

Phylum..... Arthropoda	→	Jointed appendages
Class..... Crustacea	→	Thick exoskeleton.
Sub-class..... Brahchiura	→	Parasitic Crustacea.
Genus..... *Argulus* (Carp louse)		

Habit and habitat : ***Argulus*** is the most familiar Branchiura, found as an ectoparasite in the skin or banchial chamber of fishes.

Distribution : It is found in India, U.S.A. on the marine fishes of the Atlantic coast and New England coast.

Comments :

(1) **Commonly** called as **carp louse** or **fish louse**.
(2) Animal is not permanently attached but it crawls freely over the surface of the host.
(3) Boc'y consist of an oval, flattened **cephalothorax** and small bilobed abdomen.
(4) Anteriorly there is a **poisonous spine** or **stylet**, **antennule** and **antennae**.
(5) Second, third and fourth segments are free, fifth and sixth segments are fused with abdomen and notched posteriorly.
(6) Second, third and fourth segments are free. Fifth and sixth segmenttore fused with abdomen and **notched** posteriorly. Last abdominal segment is produced into **caudal furca**.
(7) Mouth parts of ***Argulus*** are greatly reduced and the most striking feature is the modification of the second maxillae, into two suction cups or sucking discs by which the parasite holds into its host.

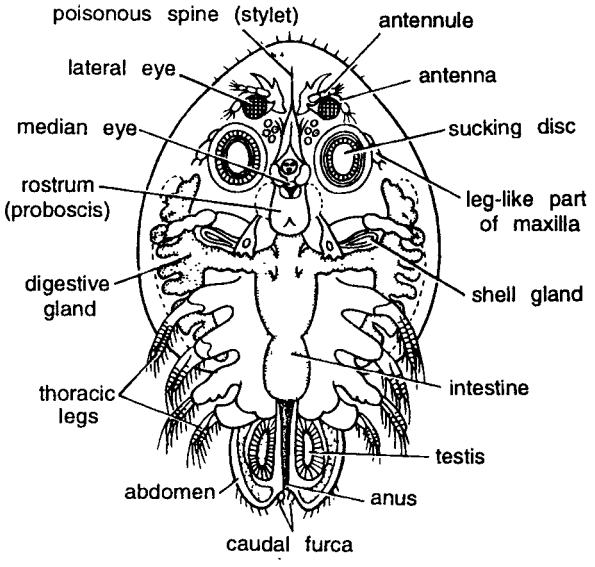


Fig. 157. *Argulus.*

(8) **Head** contains two prominent **lateral compound eyes** and a **median eye**.
(9) There are four pairs of swimming feet or thoracic legs.
(10) There are four pairs of swimming feet or thoracic legs. Other structures seen are **rostrum**, **leg like part of maxilla**, **shell gland**, **digestive gland**, **intestine** and **anus**.

Identification : Since the ectoparasite contains sucking disc and all above features, hence it is ***Argulus***.

159. *Nebalia*

Classification :

Phylum..... Arthropoda	→	Jointed appendages.
Class..... Crustacea	→	Thick exoskeleton.
Sub-class..... Malacostraca	→	Body distinctly segmented.
Order..... Nebaliacia	→	Primitive forms.
Genus..... *Nebalia*		

Habit and habitat : ***Nebalia*** is a common, small shrimp-like, primitive crustacean, measuring 6-8 mm in length. The animal feeds by straining minute food particles by setae on thoracic limbs.

Distribution : It is found in India, Srilanka, Asia and Europe.

Comments :

(1) **Body** is divided into **head**, 8-**segmented thorax** and 7-**segmented abdomen**, ending in a telson bearing a pair of caudal styles.
(2) Leaving the last four abdominal segments, the rest of the body is covered by a bivalved **carapace**, which terminates into rostrum.
(3) **Head** contains large **compound** eyes, **short antennules** and **long antennae**.
(4) **Thorax** bears 8 pairs of **leaf-like gills**.

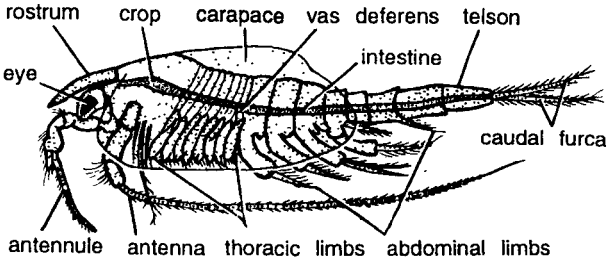


Fig. 158. *Nebalia.*

(5) **Abdomen** bears 6 pairs of large **biramous swimming feet.**
(6) Last abdominal segment is produced into two **caudal furca.**
(7) Other structures seen are carapace, crop, intestine and vas deference.

Identification : Since the animal contains elongated antennae and all above features, hence, it is ***Nebalia.***

160. *Lucifer*

Classification :

Phylum.....Arthropoda	→	Jointed appendages.
Class.....Crustacea	→	Thick exoskeleton.
Sub-class.....Malacostraca	→	Body distinctly segmented.
Order.....Decapoda	→	Ten legs.
Sub-order.....Macrura	→	Abdomen well developed and hard.
Genus.....*Lucifer*		

Habit and habitat : ***Lucifer*** is a pelagic Malacostraca.

Distribution : It is found in India, Asia and Europe.

Comments :

(1) Most **aberrant** member of Decapoda.
(2) Animal is minute, slender and delicate.
(3) **Body** is divided into **cephalothorax abdomen** and **telson.**
(4) **Cephalothorax** is smaller than abdomen.
(5) **Head** is extremely elongated and bears **long antennae** and eyes with long stalks.

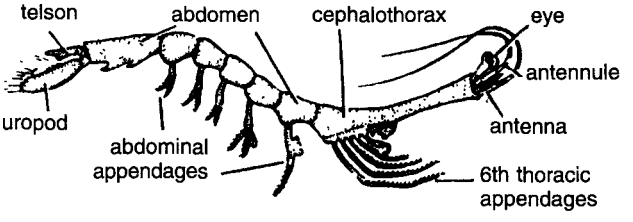


Fig. 159. *Lucifer.*

(6) **Thoracic limbs** are **non-chelate** and the last two thoracic somites are without limbs. Gills are absent.
(7) **Abdomen** contains abdominal appendages, telson contains **uropod.**

Identification : Since the animal has non-chelate thoracic legs and all above features, hence it is ***Lucifer.***

161. *Mysis*

Classification :

Phylum.....Arthropoda **Class.....Crustacea** **Sub-class.....Malacostraca**	→	Characters same as those of ***Nebalia.***
Order.....Mysidacea	→	Carapacetenin.
Genus.....*Mysis*		

Habit and habitat : ***Mysis*** is a small, transparent, marine, pelagic, **shrimp-like** and a bilaterally compressed Malacostraca.

Distribution : It is frequently found in swarms in the North Atlantic.

Comments :

(1) ***Mysis*** is small crustacean which is **transparent** and **shrimp-like.**
(2) **Body** is bilaterally compressed measuring 2 to 6 mm in length.
(3) **Body** divisible into **head, thorax** and **abdomen.**
(4) **Head** contains **antennae, antennules,** and a pairs of movable **compound eyes.**
(5) First pair of thoracic limbs or appendages is modified into **maxillipedes** and rest pairs are **swimming appendages.**

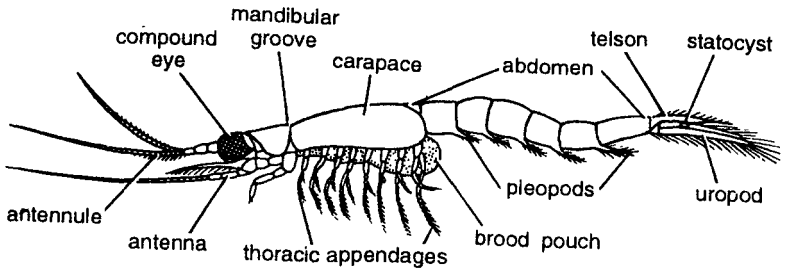


Fig. 160. *Mysis.*

(6) Posterior thoracic region of female contains **broad pouch.**
(7) **Abdomen** contains **six segments.** First five segments contain **swimming appendages** or **pleopods.**
(8) Last abdominal segment contains **uropod** and **telson** which is without **caudal styles.**
(9) **Statocyst** is present on endopodite of each uropod.
(10) Development takes place in **Brood pouch.** Egg hatches into adult without any larval stages.

Identification : Since the animal has statocyst in endopodite of uropod and all above features, hence it is ***Mysis.***

162. *Mysis* : Larva

Comments :

(1) In ***Pennaeus*** and in ***Anomura,*** the Zoaea larva instead of converting into megalopa changes into ***Mysis*** larva with 13 pairs of appendages.
(2) It is called ***Mysis*** **larva** because it resembles adult ***Mysis.***
(3) Body divisible into **cephalothorax** and **abdomen.**
(4) Carapace produced anteriorly into **rostrum.**
(5) **Head** contains talked **compound eyes, antennules** and **antennae.**
(6) **Thoracic** appendages **biramous. Posterior** thoracic legs have **flagellar exopodites** for locomotion.

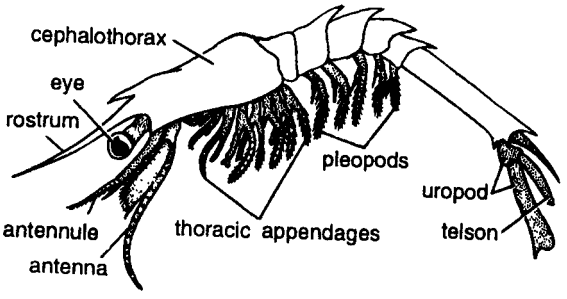


Fig. 161. *Mysis* larva.

(7) **Abdomen** bears 5 **pairs of pleopods,** one pair of uropods and terminates into a **telson.**
(8) ***Mysis*** larva metamorphoses into adult.

Identification : Since the larva has flagellar exopodite and all above features, hence it is ***Mysis*** **larva.**

163. Nauplius Larva

Comments :

(1) In Crustacea, development includes various larval stages. After cleavage, egg hatches into first larva, called as **nauplius larva.**
(2) It is a free-swimming, minute, conical and microscopic creature with broad anterior and narrow posterior end.
(3) **Body** is divided into indistinct **head, trunk** and **bilobed anal region.**

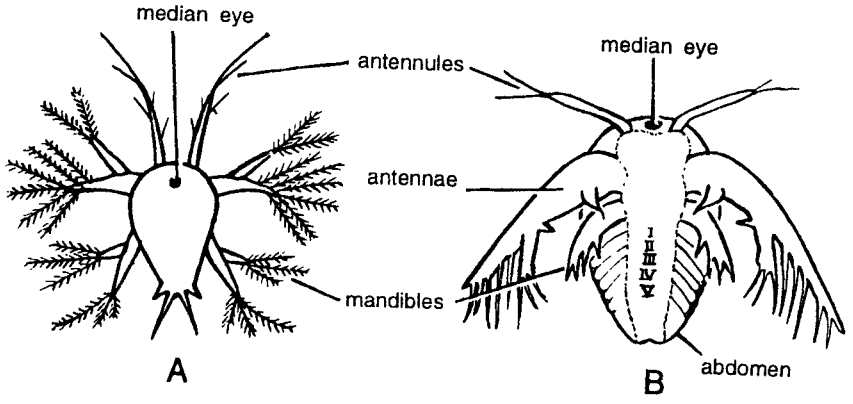


Fig. 162. Nauplius larvae. **A.** *Penaeus,* **B.** *Apus.*

(4) It contains **three pairs of appendages**, namely **uniramous antennules, biramous antennae** and **biramous mandibles**, which assits in swimming.
(5) It also contains a **median eye** and **gut**.
(6) Larva is unsegmented without ventral **nerve cord** and **heart**.
(7) Nauplius larva has great phylogenetic significance and is supposed to be **arthropodised trochophore.**

Identification : Since the larva has conical shape **median eye, biramous antennae** and **mandible,** hence it is **nauplius larva.**

164. Zoaea Larva

Comments :

(1) **Zoaea larva** is another crustacean larva.
(2) Nauplius, after metanauplius or protozoaea, directly changes into zoaea larva.
(3) Body is differentiated into cephalothorax and abdomen.
(4) **Cephalothorax** or carapace is produced into **rostrum** anteriorly and median spine dorsally.
(5) **Head** contains large **compound eyes, antennules, antennae, mandibles, maxillae** and **maxillipedes. Thoracic appendages develop as buds.**
(6) **Abdomen** has 6 **segments**. The last segment contains caudal fork.
(7) Zoaea larva changes to **metazoaea** or **megalopa** larva.

Identification : Since the larva has rostrum, median dorsal spine, rudimentary thoracic appendages, and all above features, hence it is **zoaea larva.**

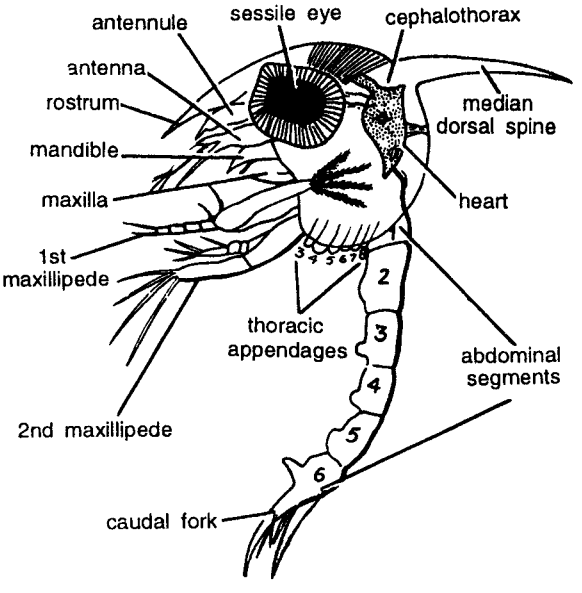


Fig. 163. Zoaea larva of crab.

165. Megalopa Larva

Comments :

(1) **Megalopa** larva develops many adult features and is formed after successive moultings of previous stages.
(2) It considerably resembles the adult stage, composed of broad and **median cephalothorax**, produced into **median spine** and **abdomen**.
(3) Body is crab like being divisible into the unsegmented **cephalothorax** and **segmented abdomen**.
(4) **Head** contains large **pedicellate**, **compound eyes**, **antennules** and **antennae**.
(5) **Thoracic appendages are** 5 **pairs** of legs, out of which the first is chelate.
(6) **Abdominal appendages** have biramous pleopods.
(7) After leading pelagic existence, megalopa transforms to adult prawn.

Identification : Since larva has stalked compound eyes, cephalic legs and all above features, hence it is **Megalopa larva**.

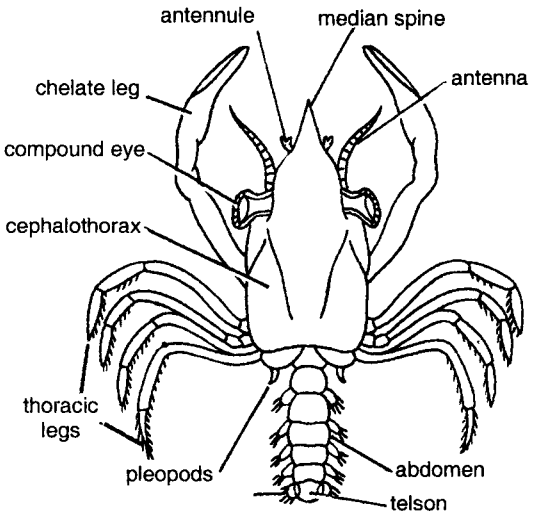


Fig. 164. Megalopa larva.

166. Prawn : Hastate Plate

Comments :

(1) **Hastate plate** is called as gastric mill formed by chitinous plates.
(2) It is a triangular **chitinous plate**, composed of a median **hastate plate**, **combed plate** and **guiding ridges or lateral longitudinal folds.**
(3) Upper surface of hastate plate contains **setae** and **a median ridge**.
(4) Posteriorly, hastate plate communicates with **cardio-pyloric aperture**.
(5) **Combed plate contains** a row of **delicate bristles**.
(6) Hastate plate cuts the food into smaller particles by its **setae** and **bristles.**

Identification : Since the mount has triangular hastate and combed plates and all above characters, hence it is **hastate plate**.

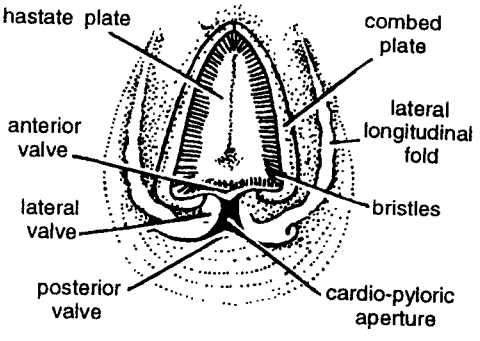


Fig. 165. Prawn. Floor of cardiac stomach showing hastate plate.

167. Prawn : Hand cut T.S. Through Abdomen

Comments :

(1) Transverse section passing through the abdomen reveals the following structures.
(2) Section is more or less rounded in shape composed of **tergum** on dorsal **side**, **pleuron** on lateral sides and **sternum** on **ventral** sides. Swimming appendages **(pleopods)** are seen on ventro-lateral side.

(3) Interior is occupied by the **muscle bands** such as **extensor muscles, flexor muscles** and **appendicular muscles.**

(4) Other structures seen are **supra-intestinal artery, midgut, ventral nerve cord** and **ventral abdominal artery.**

(5) **Coelom** is reduced because of thick muscle bundles.

(6) **Pleopod** contains **coxa, basis, appendix interna, endopodite, exopodite** and **swimnerets.**

Identification : Since the section contains pleopods on sides and all above features hence it is **T.S. Abdomen of Prawn.**

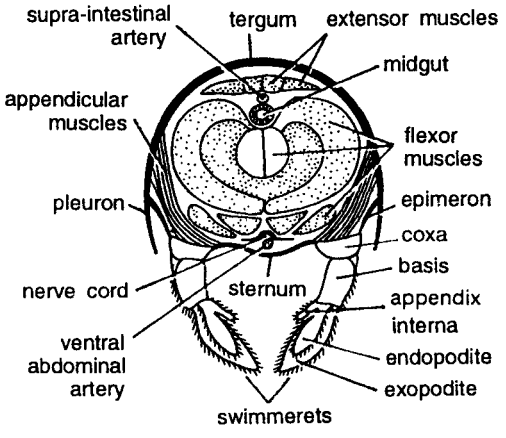


Fig. 166. Prawn. T.S. through abdomen.

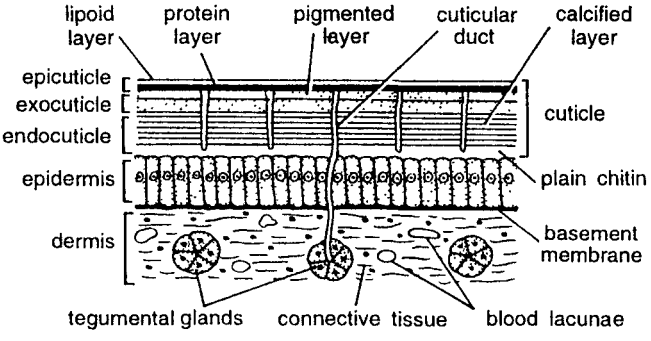


Fig. 167. Prawn. V.S. cuticle and body wall.

168. Prawn : V.S. of Cuticle and Body Wall

Comments :

(1) **Body wall** is made up **of cuticle, epidermis** and **dermis.**

(2) **Cuticle** is divisible into outer thin, non-chitinous **epicuticle** and inner thick chitinous **endocuticle.**

(3) Epicuticle is made up of outer thin **lipoid** layer and an inner thick **protein** layer.

(4) Lipoid layer is permeable to water. Proteins layer is hard and pigmented containing oxidised phenolic compounds.

(5) **Endocuticle** is lamellar containing three layers of chitin (i) Outer pigmented layer having chromatophores called as exocuticle, (ii) Middle calcified layer and (iii) Inner uncalcified layer.

(6) **Epidermis** or **hypodermis** is composed of single layer of glandular columnar nucleated epithelial cells. Epidermis secretes endocuticle.

(7) Beneath epidermis is basement membrane.

(8) Dermis is innermost layer made up of loose connective tissue. Dermis contains 3 types of tegumental glands which secrete epicuticle.

Identification : Since the section contains epicuticle, cuticle and endocuticle and all above feature, hence it is **V.S. Cuticle of Prawn.**

169. Prawn : V.S. of Compound Eye

Comments :

(1) **Compound eye** of prawn contains several radially arranged independent **visual units** called as **Ommatidia**.
(2) Compound eye consists two regions : (i) **Dioptrical region**, (ii) **Receptor region**.
(3) **Diptical** region consists of outer **cornea** follow by **corneagen cells**, then **crystalline cone**, **cone cells** or **vitrellae**.
(4) **Cornea** has number of squares or **facets**. Below each **facet** lies are **ommatidium**. Under each facet lies two **corneagen** cells which secrete new cornea.
(5) Beneath 2 corneagen cells is a spindle shaped **crystalline cone** surrounded by **cone cells**.
(6) Lower part of crystalline contain **iris pigment** on each side.
(7) Below crystalline cone is **rod-shaped rhabdomes**.
(8) **Rhabdome** is secreted and surrounded by **retinal cells**. **Rhabdomes** and the **retinal cells** form receptor region of the eye.
(9) Posterior end of rhabdome ends on **nerve fibres** of **optic nerve**.
(10) In prawn three kinds of images vision occurs : (i) Mosaic or peripheral vision (ii) **Apposition image** in bright light and (iii) **Superimposition** image in dim light.

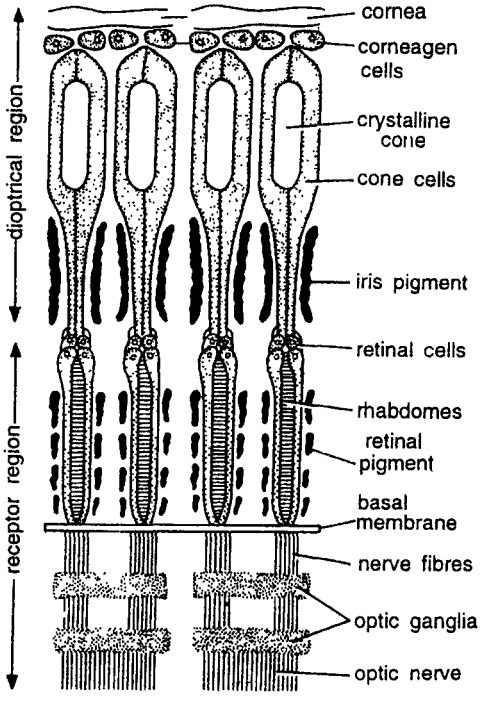


Fig. 168. Prawn. V.S. compound eye.

Identification : Since the section has **ommatidia** and all above features, hence it is **V.S. of compound eye of prawn**.

170. Prawn : Statocyst

Comments :

(1) Statocyst is a pedicellate, whitish and vesicle-like structure supplied by nerves and opening by small aperture in a concavity.
(2) It is a **hydrostatic structure**.
(3) In a section the cavity of **statocyst** contains a circlet of delicate and elongated **sensory setae**.
(4) **Each seta** is innervated by **nerves** and functions as a receptor.
(5) Statocyst helps in **orientation** and **balance**.
(6) **Sand particles** function as **statolith**.
(7) Any change in swimming position brings change in position of sand particles, which stimulate setae and the animal comes in proper position.

Identification : Since the section has circular setae, hence it is **T.S. Statocyst of prawn**.

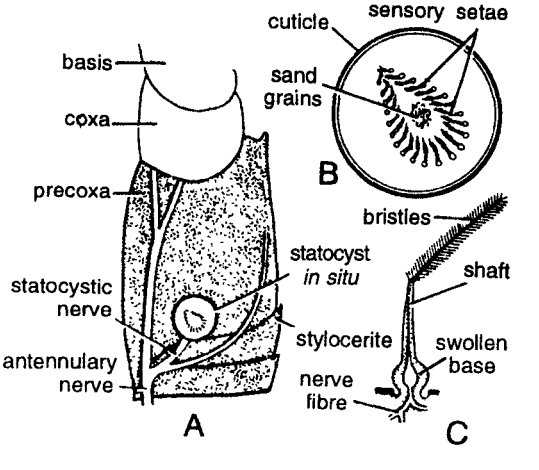


Fig. 169. Prawn statocyst : **A.** Statocyst *in situ*, **B.** T.S. of statocyst, **C.** A sensory seta.

171. Scorpion : Book-lung

Comments :

(1) There are four pairs of **whitish book-lungs** or pulmonary chambers situated inside mesosomatic segments.
(2) **Each book-lung** may be easily taken out from the inner side of the sternal segments.
(3) Each book-lung is composed of **pulmonary chamber** and **atrial chamber.**
(4) Pulmonary chamber is dorsal, composed of about 150 vertical and **parallel lamellae** arranged like book-pages and hence called as book-lung.
(5) Atrial chamber communicates with **stigmata.**
(6) Book-lungs are supplied with blood vessels and are respiratory in function.

Identification : Since the mount contains lamellae like leaves of the book, hence it is **Book-lung of Scorpion.**

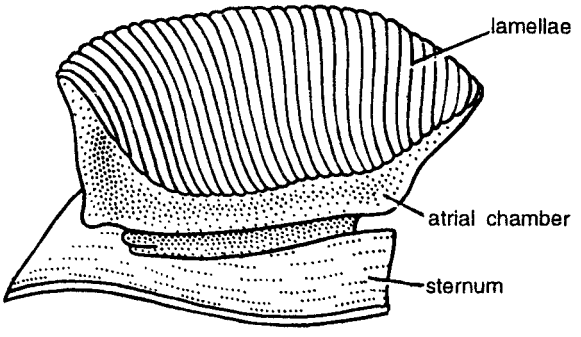


Fig. 170. Scorpion. Book-lung.

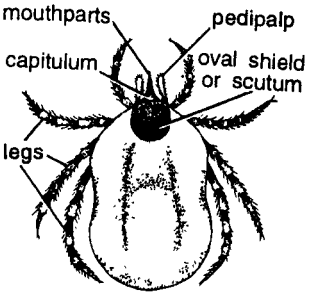


Fig. 171. *Ixodes.* Tick.

172. *Ixodes* : Tick

Classification :

Phylum.....Arthropoda	→	Jointed appendages.
Class.....Arachnida	→	Spider-like.
Order.....Acarina	→	No distinct divisions of the body.
Genus.....*Ixodes* (Tick)		

Habit and habitat : ***Ixodes*** is an ectoparasite, found on the body of the sheep.

Distribution : Commonly found in India, Myanmar, Srilanka, U.S.A. and U.K.

Comments :

(1) It is a small arachnid with oval and compact body.
(2) **Body** is not differentiated into **prosoma** and **opisthosoma. Pedicel** and the **telson** is absent.
(3) **Chelicerae** and **pedipalps** are small associated with **mouth parts**, which are modified for **biting, sawing, piercing** and **sucking** functions.
(4) **Head** is covered by **scutum** and **capitulum.**
(5) Legs are composed of 7 **segments.** Respiration is by trachea or cutaneous.

Economic status : Ticks have biological importance, as they are parasitic, predaceous, scavengers and also act as carriers of various **diseases** such as **tick fever.**

Identification : Since the animal contains small cheliceral pedipalp and all above character, hence it is ***Ixodes***.

PHYLUM ECHINODERMATA

Spiny Skinned Animals

Echinoderms reveal supreme example of invertebrate evolution being at top amongst the invertebrate and very close to chordates. For the first time echinoderms have developed mesodermal endoskeleton of calcium carbonate in the form of ambulacral ossicles or dermal ossicles.

173. Starfish : T.S. of Arm

Comments :

(1) Section of a single arm in transverse plane includes **tube feet, nervous tissue, pyloric caeca** and body-wall appendages.
(2) Pentaradiate, coelomate and spiny skinned.
(3) **Body wall** is composed of two-layered **cuticle, tall flagellated columnar epidermis, connective tissue, dermis**, containing **dermal ossicles** and **haemal spaces** and **musculature** having outer circular and inner longitudinal fibres.
(4) Aboral surface contains **spines, pedicellariae** and **branchiae**.
(5) Oral side has **V-shaped ambulacral groove**, which is occupied by tube **feet** or **podia**. Podium has 3 parts - **ampulla, tube foot** and **sucker**. Ampulla projects in perivisceral coelom.
(6) **Radial nerve, radial canal** and **perihaemal canals are also seen**.

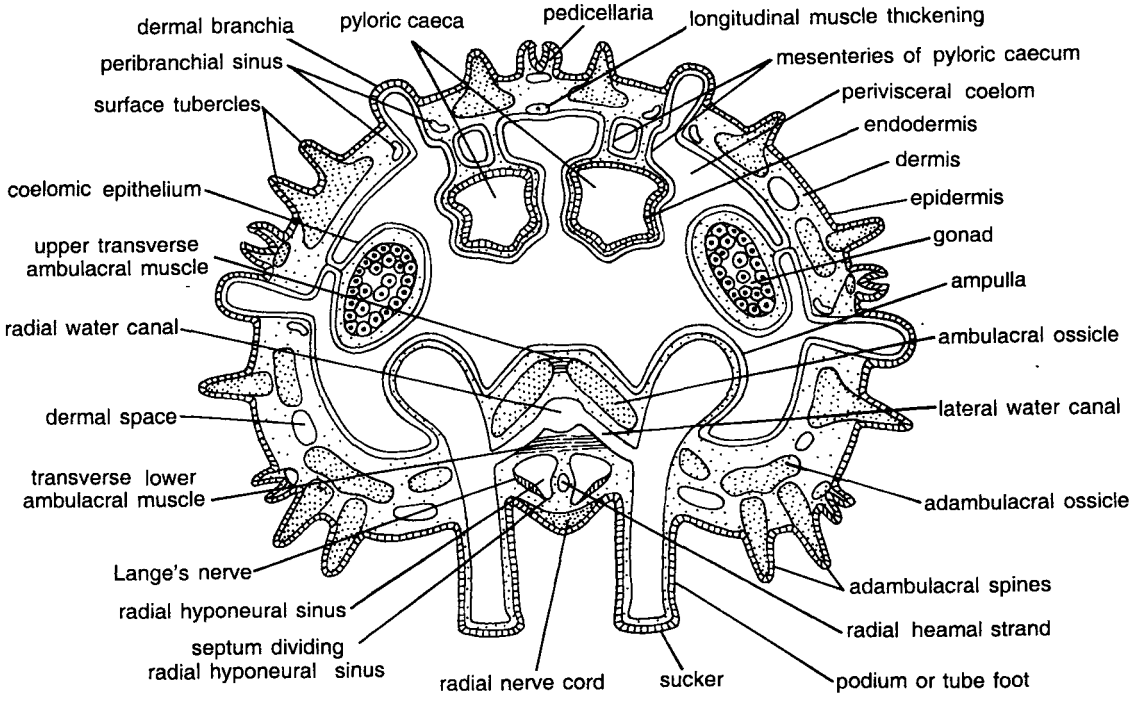


Fig. 172. Starfish. T.S. of arm.

(7) **Perivisceral coelom contains extension of pyloric caeca and gonads.**
(8) Other structures seen are **radial nerve, radial canal, perihaemal canal, radial hyponeural sinus, septum dividing radial hyponeural sinus, lower ambulacral muscles, upper transverse ambulacral muscle, peribranchial sinus, longitudinal muscle thickening, radial water canal, ambulacral spines** and **radial haemale strand.**

Identification : Since the section has tube feet dermal ossicles, dermal spines and all above features, hence it is **T.S. of arm of starfish.**

174. Starfish : L.S. of Arm

Comments :

(1) Longitudinal section (L. S.) passing through the central disk and a arm shows **madreporite, stomach, pyloric caeca, mouth, anus** and **tube feet** (Fig. 173).
(2) Body is composed of **epidermis** and **dermis.**
(3) Epidermis shows cut parts of **epidermal spikes Pedicellarae, tube feet** and **dermal bronchae.**
(4) Cut parts of **water vascular system** is seen such as **madreporite stone canal, axial gland, axial sinus, water ring canal, radial water canal.**
(5) **Digestive** system contains **mouth, cardial stomach, intestinal caecum, pyloric caecum, rectum** and **anus.**
(6) **Dorsal sac, peribranchial sinus, coelomic epithelium perivisceral cavity optic cushion, sensory terminal tentacles, septum dividing radial hyponeural sinus, radial haemal strand are seen.**
(7) **Perihaemal ring sinus, haemal ring sinus, radial water vessel** and **aboral pentagonal haemal sinus** are observed.
(8) **Gonads** are clearly seen.

Identification : Since the section has epidermal spines, tube feet and all above features, hence it is **L.S. arm of starfish.**

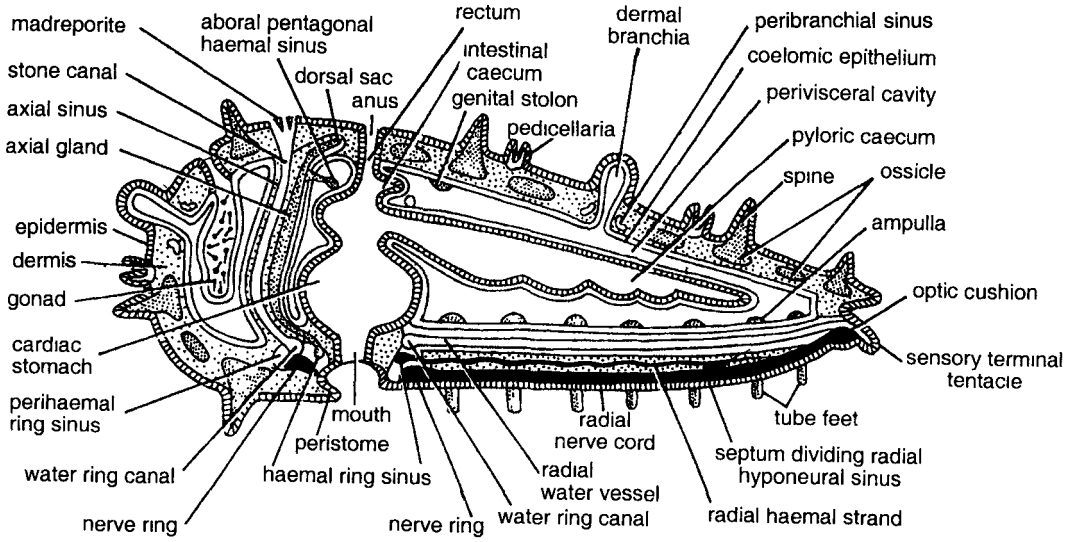


Fig. 173. Starfish. Longitudinal Section of arm.

175. Starfish : Pedicellariae

Comments :

(1) Pedicellariae are organs of **offence** and **defence** and diagnostic of echinoderms.
(2) These are found in order Phanerozonia and Forcipulata and are of three kinds pedunculate, sessile and alveolar.
(3) Generally pedicellariae consist of two **jaws** or **valves** and a basal **calcareous piece**.
(4) Valves are attached to basal piece and are operated by adductor muscles.
(5) Valves are covered or embedded in connective tissue covered by epidermis.
(6) Pedicellariae may be pedicellate, straight or cross.
(7) Jaws contain teeth.

Identification : By **toothed valves**.

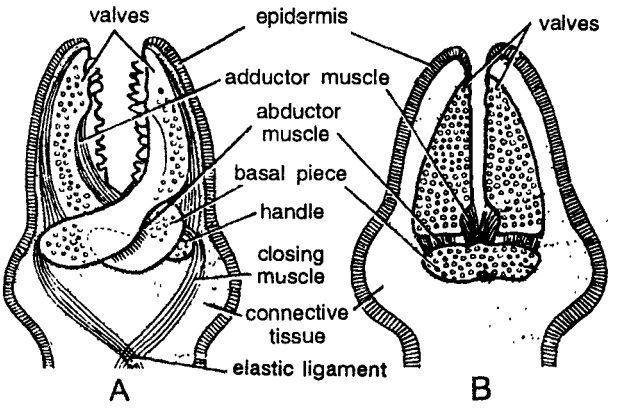


Fig. 174. Starfish. Pedicellariae. **A.** Crossed type, **B.** Straight type.

176. Starfish : Bipinnaria Larva

Comments :

(1) In asteroids, the egg, after holoblastic unequal cleavage and embolic gastrulation, gives rise to a typical eleutherozoan larva called as **bipinnaria larva**.
(2) Larva is formed within few weeks. Although a free-swimming larva is hatched within 24 hours, but it takes few days to develop into bipinnaria.
(3) Newly hatched larva assumes angular form by the time coelomic chambers are separated.
(4) Continuous ciliation is restricted to usual eleutherozoan locomotory bands.
(5) Pre-oral loop encircles around mouth and also extends over the body while the **anal loop** surrounds anus.
(6) Bipinnaria is characterized by having **arm projections** such as **median dorsal arm**, **preoral arm**, **anterodorsal arm**, **posterodorsal arm**, **pos-oral arm**, **postero-lateral arm**, **coelomic compartments**, **carapace**, **axocoel**, **hydrocoel** and **somatocoel**.
(7) Internally larva contain **mouth**, **oesophagus**, **stomach**, **intestine**, **hydropore**, **somatocoels**, **right axohydrocoel** and **dorsal sac**, etc.

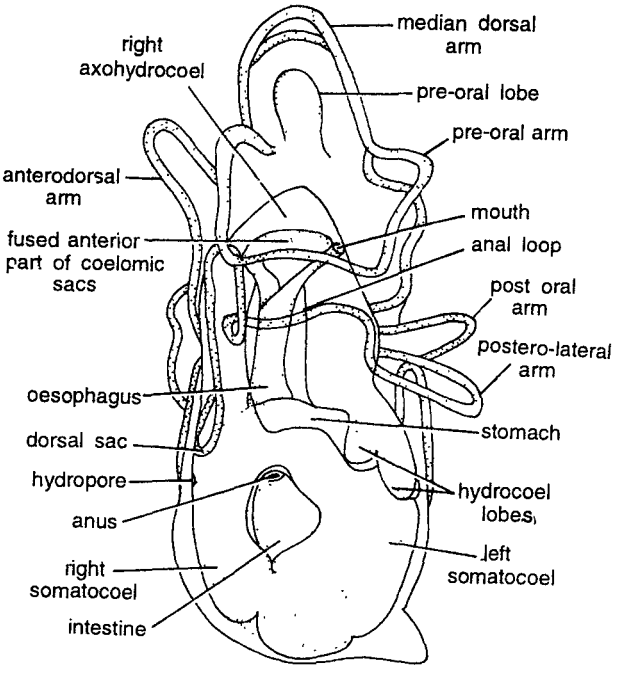


Fig. 175. Starfish. Bipinnaria larva.

(8) Diagram B shows left side of **larva** showing **ciliated bands, mouth, oesophagus stomach, dorsal sac, hydrocoel lobes, aboral side of future starfish** and **left somatocoel.**

Identification : Since the larva has characteristic ciliated loops around arm, coelomic compartments, and all above features, hence it is **bipinnaria larva.**

177. Starfish : Brachiolaria Larva

Comments :

(1) After some days of free-swimming life, Bipinnaria larva changes into next larval stage called as **Brachiolaria** larva.

(2) Brachiolaria is characterised by the development of **three short Brachiolar arms** anterior to pre-oral loop.

(3) Brachiolar arms are short having prolongation of coelous and their tips contain adhesive cells.

(4) One brachiolar arm is anterior and median while two others are lateral and behind.

(5) Between the bases of 3 brachiolar arms is a glandular adhesive area called as **sucker.** Brachiolar arms and adhesive area form hold fast organ.

(6) Other arms are paired **pre-oral arms**, anterior **dorsal arm, postero-dorsal arms, lateral arms, postero-lateral arms** and **post oral arms.**

(7) **Digestive system** consist of **mouth, oesophagus, stomach, intestine** and **anus.**

(8) Other structures are **coelomic compartments** such as **hydrocoel** and coelomic extensions into arm.

Identification : Since the larva contains three brachiolar arms, and all above features, hence it is **Brachiolaria larva.**

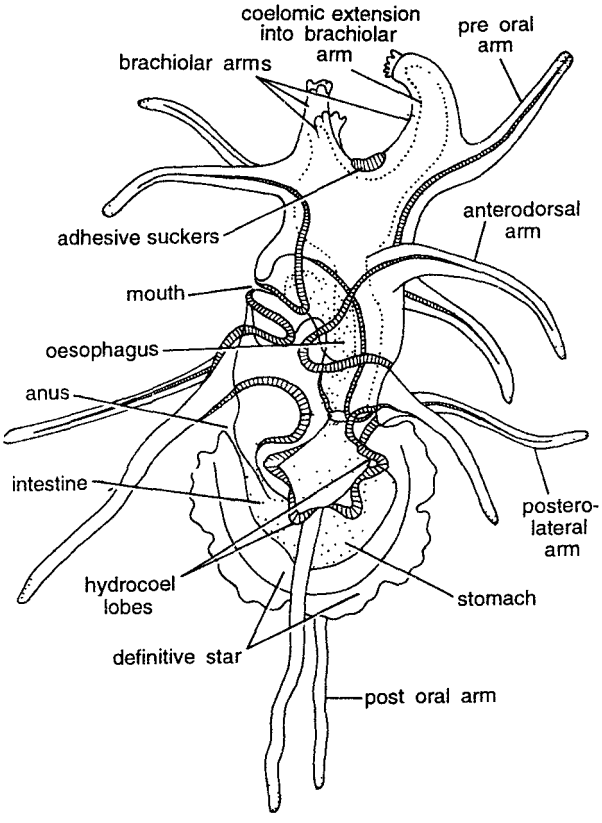


Fig. 176. Starfish. Brachiolaria larva.

178. *Echinus* : Echinopluteus Larva

Comments :

(1) In echinoids, after gastrulation, egg hatches into first stage larva called as **Echinopluteus larva.**

(2) Larva is conical in shape.

(3) Parts of alimentary canal may be differentiated as **oesophagus, stomach** and **intestine. Coelomic chambers** are also present.

(4) **Blastopore** continues as larval anus.

(5) Larva begins to put projections as **arms;** usually 5 **pairs of arms** are found. The arms are definitely arranged and supported by skeletal rods.

(6) On oral side **postoral arms** then **anterolateral arms**, on sides **posterodorsal arms**, then **pre-oral arms, anterodorsal arms** and **posterolateral arms are formed, Ciliated bands** are restricted as certain places as epaulettes.

(7) Pluteus larva (echinopluteus) is a microscopic, pelagic and planktonic creature and develops into adult after metamorphosis in a month or so.

Identification : Since the larva has **epaulets** and all above features, hence it is **Echinopluteus larva.**

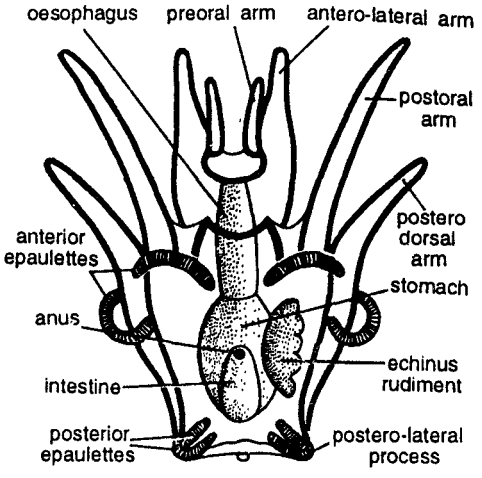


Fig. 177. *Echinus.* Echinopluteus larva.

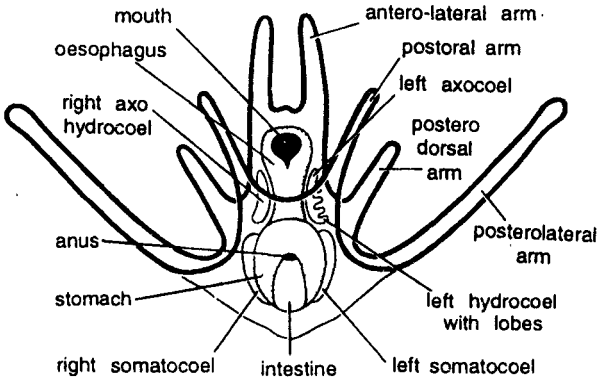


Fig. 178. Brittle star. Ophiopluteus larva.

179. Brittle star : Ophiopluteus Larva

Comments :

(1) After fertilization, cleavages and gastrulation, ophiuroid egg develops into a free-swimming larva called as **Ophiopluteus** larva.
(2) Larva develops arms gradually and ciliated bands line the edges of the arms.
(3) First **postero-lateral** arms are developed. Arms contain skeletal rods for support.
(4) After fourth day **antero-lateral** arms are formed.
(5) After tenth day **post-oral arms** are formed opposite **antero-lateral arms.**
(6) After eighteenth day **posterodorsal arms** are formed.
(7) **Alimentary canal** consists of **mouth oesophagus, stomach, intestine** and **anus.**
(8) **Right hydrocoel, lobulated left hydrocoel** and **left axocoel** are distinct.
(9) Ophiopluteins larvae of different groups show variation in their structures.
(10) After sometimes ophiopluteus metamorphoses into adult **brittle star.**

Identification : Since the larva has lesser number of arms and all above features, hence, it is **Ophiopluteus larva.**

PHYLUM ROTIFERA

Wheeled Animalcule

Peculiar fresh-water wheeled animalcules with corona, eyespots, flame bulbs and germovitellaria. The animals also called as Rotatoria. These are unsegmented pseudocoelomate animals.

Outline classification

Phylum Rotifera includes 3 orders.

Order 1. Seisonida—Ex. *Seison.*
Order 2. Bdelloidea—Ex. *Rotifer, Philodina.*
Order 3. Monogonta—Ex. *Brachionus pedalia.*

180. *Brachionus*

Classification :

Phylum.....Rotifera → Wheeled animalcule.
Order.....Monogonta → Swimming or sessile Rotifera with well-defined sexual dimorphism.
Genus.....*Brachionus*

Habit and habitat : ***Brachionus*** is also one of the commonest fresh-water rotifers, inhabiting ponds, ditches, etc.

Comments :

(1) **Females** are much larger than **males.**
(2) In both male and female body is divisible into anterior corona **trunk** and **foot.**
(3) **Corona** contains 3 ciliated lobes, resting on **circumapical ciliated band.**
(4) Anteriorly brain and **eye spots** are present.
(5) Trunk or main body is covered by **lorica.** Lorica contains **lateral antenna.**

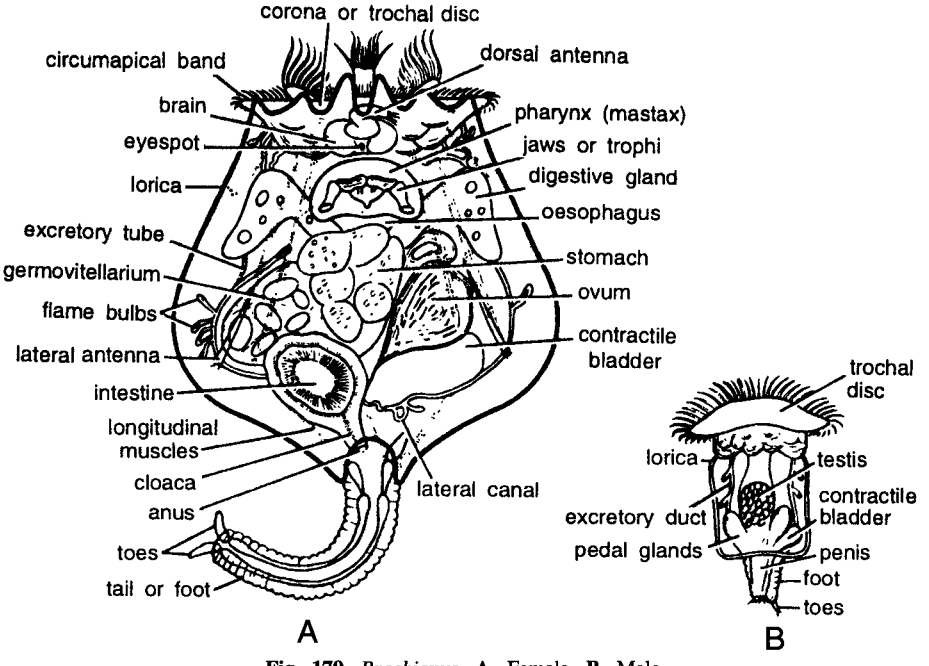


Fig. 179. *Brachionus.* **A.** Female, **B.** Male.

(6) **Digestive system** consist of **Jaws or Trophis digestive gland, oesophagus, stomach, intestine cloaca** and **anus. Longitudinal muscles are present.**
(7) Excretory system consists of **excretory tube flame bulbs contractile bladder** and **lateral canal.**
(8) Reproductive system consists of **germovitellaria** and **ovum.**
(9) Foot contains a part of **toes.**
(10) Male contains **trocheal disc, lorica, excretory duct, pedal glands, testis, contractile bladder, penis, foot** and **toes.**

Identification : Since the animal contains trocheal disc and all above features, hence it is ***Brachionus***.

PHYLUM ECTOPROCTA

Bird's Head Coralline

These animals are colonial and predominantly marine. They are bilaterally symmetrical, sessile and pseudocoelomate.

Outline classification

This phylum includes 2 classes and few orders.

Class 1. Gymnolaemata
- **Order 1. Ctenostomata**—Ex. *Paludicella.*
- **Order 2. Cheilstomata**—Ex. *Bugula, Flustra.*
- **Order 3. Cyclostomata**—Ex. *Crisia.*
- **Order 4. Tryptostomata**—Ex. *Stenopora.*
- **Order 5. Cryptostomata**—Ex. *Fenestella.*

Class 2. Phylactolaemata—Ex. *Cristatella, Plumatella.*

181. *Bugula*

Classification :

Phylum..... Ectoprocta	→	Anus outside.
Class..... Gymnolaemata	→	Marine, mouth without epistome.
Order..... Cheilostomata	→	Zooecia chitinous or calcareous.
Genus..... *Bugula*		

Habit and habitat : ***Bugula avicularia*** is a common, colonial bryozoan occurring as branched brown or purple plant-like tufts attached to shallow sea-water object.

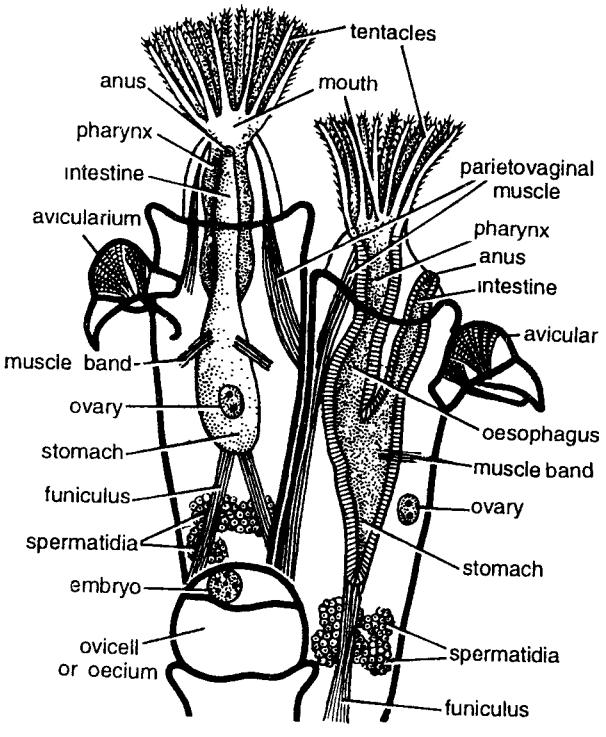


Fig. 180. *Bugula avicularia.*

Comments :

(1) **Commonly** called as **bird's head coralline.**
(2) Animal is 5 to 8 cm long with several zooids.
(3) Colony **is polymorphic.** Externally most zooecia zooids contain bird's head shaped **avicularium** which has jaws. A rounded ooecium lies in front of zooecium.
(4) Anterior end of a living **polypide** or introvert forms a rounded pinnately branched **tentaculated lophophora.**

(5) Digestive system is U-shaped consisting of **mouth**, **pharynx**, **oesophagus**, **stomach**, **intestine** and **anus**.
(6) **Excretory**, **circulatory** and **respiratory organs** are **absent**.
(7) Each zooid is **hermaphroditic**. Male reproductive system comprise **spermatidia** producing sperms. **Female** reproductive system **contains ovary embryo** and **oecium**.
(8) **Brain** lies between mouth and the anus.
(9) **Muscle system** consists of **parieto vaginal** and **funiculus longitudinal muscles** are present.
(10) Asexual reproduction by budding. It is monoecious form. **Sex cells** are derived from coelom. Eggs are enclosed in a broad capsule, called as oecium.

Identification : Since the animal contains avicularium and all above features, hence it is ***Bugula***.

182. *Balanoglossus* : L.S. Through Anterior Region

Comments :

(1) Longitudinal section passing through anterior region reveals detailed structures of proboscis, collar and **trunk** regions.
(2) Body is composed of epidermis, nervous layer, basement membrane, circular muscle layer and longitudinal muscle layers. Arrangement of body wall layers varies in different regions.

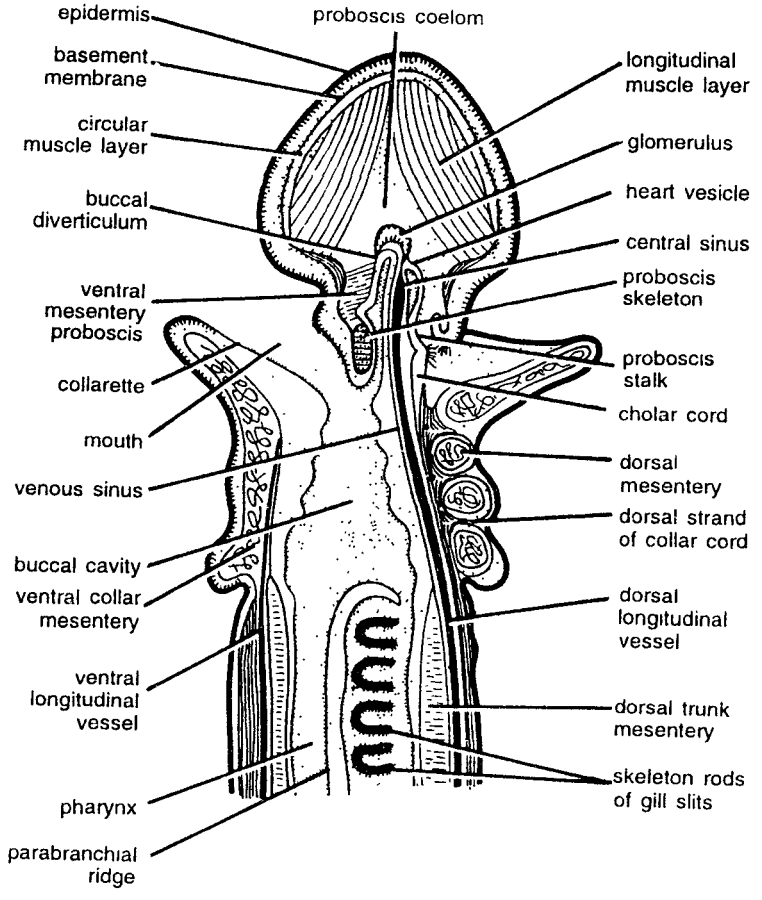


Fig. 181. *Balanoglossus.* L.S. through anterior region.

(3) **Probasch :** Epidermis forms outer covering of proboscis and it contains **epidermal cells, gland cells, neurosensory cells, goblet gland cells** and **reticulate gland cells.**
(4) Below epidermis is a thick **nervous layer.**
(5) Beneath nervous layer is **basement membrane.**
(6) Below basement membrane is **circular muscle layer, longitudinal muscle layer.** In proboscis region other structures seen are **proboscis, coelom, glomerulus, buccal diverticulum, heart vesicle, central sinus, proboscis skeleton, proboscis stalk** and **ventral mesentery.**
(7) In **collar region** body wall layers are epidermis, nervous layer and basement membrane. Other structures seen are collar **cord, cullarette, dorsal mesentery** and **dorsal strand** of **collar cords, venus sinus** and **dorsal longitudinal vessel.**
(8) **Trunk region :** Body wall layers are **epidermis, nervous layer, basement membrane and longitudinal muscle layer. Collar region shows dorsal longitudinal vessel, dorsal trunk mesentery skeletal rods, gill slits, parabranchial ridge** and **ventral longitudinal mesentery.**
(9) Digestive system consists of **mouth buccal cavity** and **pharynx.**

Identification : Since section shows buccal diverticulum and all above features, hence it is **L.S. anterior region** of ***Balanoglossus***.

183. *Balanoglossus* : T.S. Through Post-hepatic Region

Comments :
(1) Section shows structures of post-hepatic intestine.
(2) Body wall layers are **epidermis, nervous layer** and **basement membrane** followed by **thick longitudinal muscle layer.**
(3) Anteriorly section has **dorsal nerve** and **dorsal blood vessel.**
(4) Intestine has **wide lumen. Intestine** shows **diverticulated appearance made** up of endodermal **columnar epithelial cells.**
(5) **Ciliated groove** is present intestine.
(6) Posteriorly **ventral blood vessel** and **ventral nerve cord** are seen.

Identification : Since section has diverticulated intestine and all above features, hence it is **T.S. post hepatic region of *Balanoglossus***.

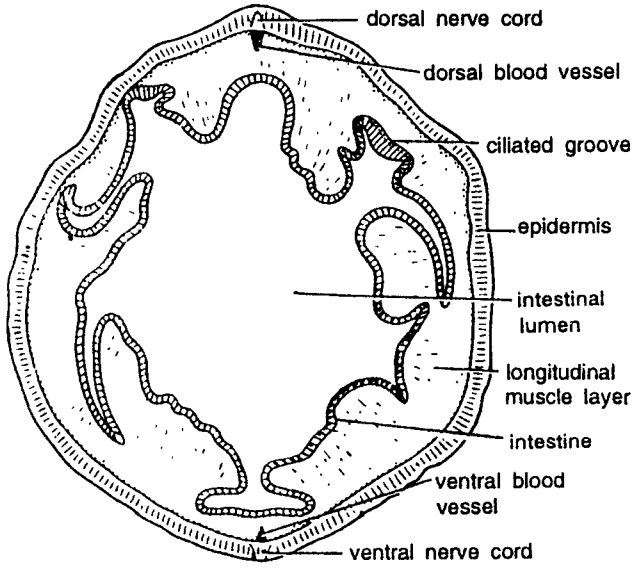


Fig. 182. *Balanoglossus.* T.S. through post hepatic region.

184. *Balanoglossus* : T.S. Through Collar

Comments :
(1) Transverse section passing through collar **shows buccal cavity** and **collar groove.**
(2) Body wall is composed of **epidermis nervous layer** and **basement membrane** and **thin circular muscle fibres only.** No longitudinal muscle fibers in collar region.
(3) **Epidermis** contains **epidermal cells, gland cells** and **neurosensory cells.**
(4) Anteriorly there is **deep groove** called as **collar groove.**

(5) Dorsal and ventral blood vessels are seen above and below buccal cavity.
(6) Space between body wall and buccal cavity is filled with thick anastamosing connective tissue.
(7) Buccal cavity is composed of outer serosa, circular muscle layer. Longitudinal muscle layer and internal lining of endoderm cells.

Identification : Since section has deep collar groove and all above features, hence it is **T. S. collar region of *Balanoglossus*.**

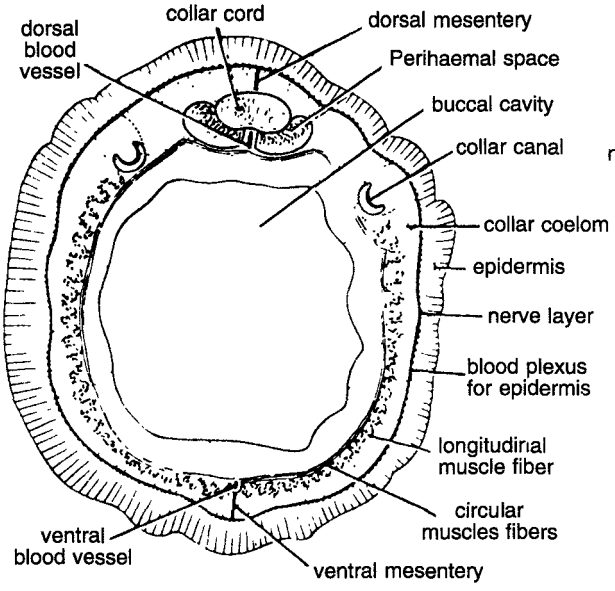


Fig. 183. *Balanoglossus.* T.S. through collar region.

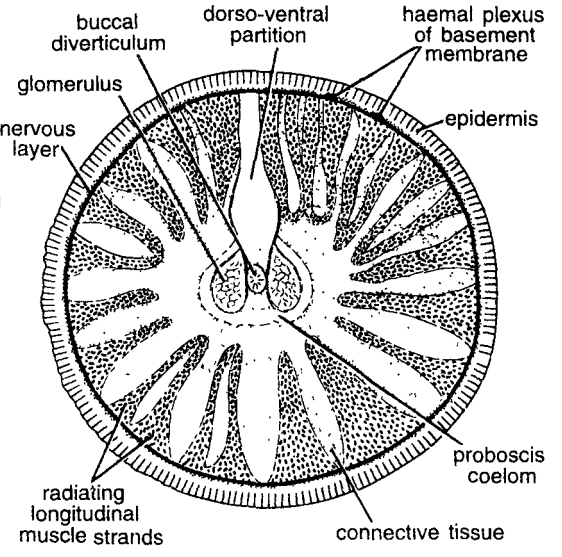


Fig. 184. *Balanoglossus.* T.S. through proboscis region.

185. *Balanoglossus* : T.S. Through Proboscis Region

Comments :
(1) Transverse section through proboscis reveals central complex structures diverticulum.
(2) Body wall is composed of **epidermis, nervous layer** and **basement membrane.** Basement membrane has **haemal plexus.**
(3) Between basement membrane and **proboscis** is **radiating thick longitudinal muscle layer** and **intervening connective tissues.**
(4) **Proboscis region** reveals **proboscis sheath, proboscis coelom, buccal diverticulum** and cut **portion of glomerulus.**
(5) Dorsally **dorso-ventral** partition is seen.

Identification : Since the section contains longitudinal muscle strands and all above features, hence it is **T. S. proboscis of *Balanoglossus*.**

186. Study of Cells and Cell Organelles in Living Conditions

The cell and cell organelles can be studied by intravital stains such as **Neutral red, Congo red, Methylene blue** and **Janus green B.** These stains penetrate cell and cell organelles in living cells and stain specific organelles. Different stains are used for different organelles. For instance neutral red stains cytoplasm, congo red stains vacuole, methylene blue stains Golgi body and Janus. Green B. stains mitochondria (Fig. 186).

1. Study of vacuole

Take a clean slide and put a drop of water from the culture of ***Paramecium***. Add a little amount of east **congo red** in water drop. Stain penetrates vacuole of ***Paramecium*** study under microscopes. Coloured vacuole could be seen in ***Paramecium*** wherever it moves.

2. Study of Golgi complex

Take a clean slide. Add a drop of water from culture medium of ***Paramecium***. Add a little pin head solution of methylene blue in water drop containing ***Paramecia***. **Golgi complex** stains blue, blue coloured lamellae, vacuole etc. could be seen at supranuclear position.

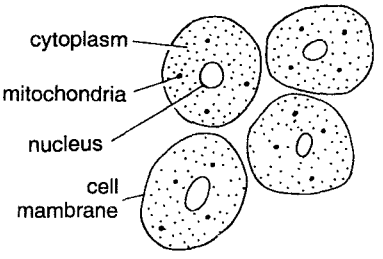


Fig. 185. Mitochondria through Janus green-B strain.

3. Study of mitochondria

Prepare saturated solution of Janus green–B. Take a clean slide. Flood the slide with saturated solution of Janus green-B. Dry the slide. Take a tooth prick and scrape a portion of buccal epithelial cell from the under surface of check. Spread the scrap over the slide. Within few seconds Janus green penetrates mitochondria. Study the slides under microscope. Mitochondria are observed as **green dot shaped structures.**

187. Study of Animal Tissues Through Photographs

[I] Simple cuboidal epithelium

Simple cuboidal epithelial cells can be studied in a T. S. passing through the kidney. Prepare paraffin sections of kidney through **microtomy**. Stain the sections with haematoxylin, eosin and mount in DPX. Let sections become dry. Study the sections under the microscope and take microphotograph (Fig. 186).

Comments :

(1) Cuboidal epithelial cells are distinctly seen in collecting tubules.

(2) Cuboidal cells are compactly placed.

[II] Simple columnar epithelial cells

Simple columnar epithelial cells could be studied by paraffin sections of T. S. intestine of frog, rabbit or earthworm. Take a frog, anaesthesize, dissect and take small portion of intestine 2 to 4 cm. Fix it in 10% formaline for 24 hours. Wash the intestine in running tape water. Process the intestine for paraffin sectioning by microtomy. Stain sections in Haematoxylin-Eosin. Dehydrate, dealcoholize and mount in DPX. Study under microscope in high magnification. Take microphotograph (Fig. 187).

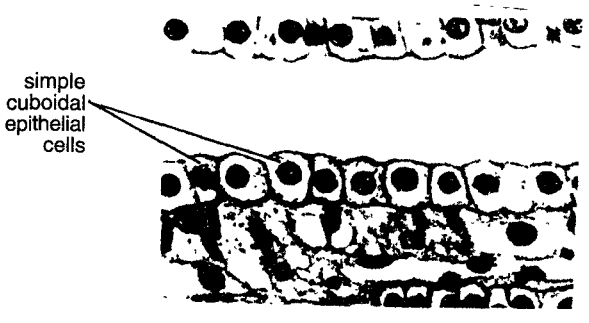


Fig. 186. Microphotograph. Rat. T.S. of kidney. Simple cuboidal epithelium.



Fig. 187. Microphotograph. Rat. T.S. of intestine Simple columnar epithelium.

Comments :

(1) Internal lining of the intestine is made up of tall **simple columnar epithelial cells.**
(2) These cells are **nucleated, ciliated** and are derived from **endoderm.**
(3) Columnar epithelial cells of intestine are absorptive cells through which **amino acids, monosaccharides** and **fatty acids** are **absorbed** by blood besides other nutrients.

[III] Goblet cells

Goblet cells are also studied from the T.S. intestine of frog or rabbit. Process microtomy sections as in case of columnar epithelial cells. Study under microscope. Take microphotograph.

Comments :

(1) Goblet cells are found towards lumen of the intestine along columnar epithelial cells.
(2) Goblet cells are rounded **nucleated** and **aggregated** together (Fig.188).
(3) Goblet cells secrete mucous.
(4) Nuclei of Goblet cells stain deep with haematoxylin.

[IV] Simple squamous epithelial cells

Simple squamous epithelial cells are studied in the **Bowman's capsule** from the T.S. kidney of frog. Prepare T.S. kidney slide by microtomy as described in case of T.S. intestine.

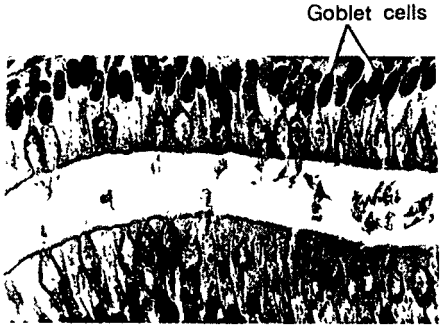


Fig. 188. Rat. Microphotograph. T.S. of intestine showing Goblet cells.

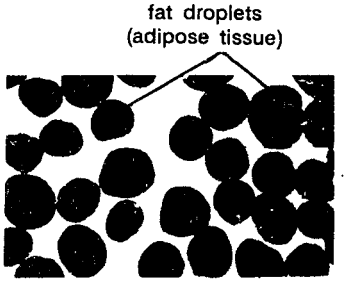


Fig. 189. Microphotograph. Frog. Adipose tissue.

Comments :

(1) Several flat **nucleated cells** can be seen in Bowman's capsule.
(2) Above cells compactly lie together.

[V] Adipose tissue

Take fat bodies from frog. Stain them in Sudan IV solution. Dissolve 0.1 gm of Sudan IV in 50 ml of acetone and add equal volume of 70% alcohol. Stains fat bodies in Sudan IV solution, dehydrate and mount in DPX. Take microphotographs. Study under microscope (Fig. 189).

Comments :

(1) Cells of adipose tissues are **rounded** and **polygonal.**
(2) Fat droplets aggregate and found fat bodies or **adipose tissues.**
(3) Cells of adipose tissues have thin layer of cytoplasm and nucleus is displaced towards one side.



Fig. 190. Microphotograph. Rat. Lymph vessels showing reticular tissue.

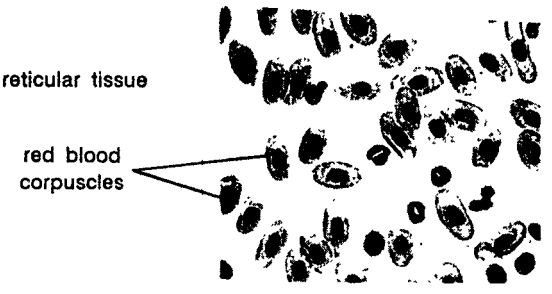


Fig. 191. Microphotograph. Frog. Blood smear showing blood corpuscles.

[VI] Reticular tissues

Reticular tissues can be studied by making a mount of **lymph vessels** or by making paraffin sections of spleen of frog. Take a frog, anaesthesize, dissect and take few lymph vessels. Fix in 10% formaline for 30 minutes, wash the tissues and stain in Borax-carmine, dehydrate and mount in DPX. Study under microscope. Take microphotograph. Reticular tissues can also be studied in a T.S. of spleen of frog. Take a frog dissect, take out spleen, fix in 10% formaline, wash, prepare paraffin section (T.S.) of spleen, stain with haematoxylin. Eosin and mount in DPX. Study under microscope. Take microphotograph.

Comments :

(1) Reticular tissue consists of a **network of cells** (Fig. 190).
(2) Cells contain stiff interconnected cytoplasmic fibrils.
(3) Spaces between reticular cells are filled with other kinds of cells, blood cells and nerve cells etc.

[VII] Blood smear of frog

Prepare a thin blood film. Take a freshly killed frog. Dissect frog and collect blood by cardiac puncture. Take a clean slide. Put a pin head size blood on a clean slide at a distance of about half an inch from its right edge. Hold another slide by right hand and apply over drop of blood at an angle of 45°, lower the angle to 30° and push the spreader slide forward till the blood is exhausted. Let the film dry. Keep the slide in 6" petridish. Flood the slide by Leishman stain for 30 seconds. Wash the slide and let the slide dry. Examine the slide under microscope.

Comments :

(1) Large number of nucleated biconvex **erythrocytes** are seen (Fig. 191).
(2) **Lymphocytes** with large nucleus rounded in shape present.
(3) Monocytes and **Polymorphonuclear leucocytes** are also present.

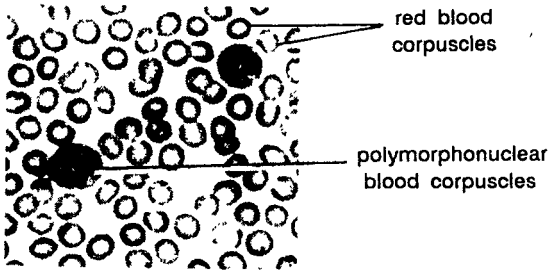


Fig. 192. Microphotograph. Rabbit blood smear showing blood corpuscles.

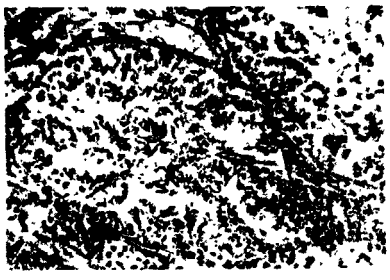


Fig. 193. Microphotograph. Frog. T.S. of testis.

[VIII] Blood smear of rabbit

Prepare thin blood film of Albino rat as in case of frog.

Comments :

(1) RBC or **erythrocytes** are rounded and non-nucleated (Fig.192).

(2) Other corpuscles are WBC (White Blood Corpuscles), **monocytes**, **lymphocytes**, and **polymorphonuclear leucocytes.**

[IX] Frog. T.S. passing through the testis

For studying different types of cells testis is also very suitable organ. Take a frog, anesthesize it by chloroform. Dissect and take the two testes. Fix them in 10% formaline solution for 24 hours. Wash them with distilled water for 4.6 hours to remove formaline. Make paraffin sections through the process of microtomy stain the section with haematoxylin and eosin. Dehydrate, dealcoholize and mount in DPX. Study under microscope and also take microphotography of a portion of T.S. testes.

Comments :

(1) T.S. through testes reveals that it is composed of outer **peritoneal layer**, **seminiferous tubules**, **interstial cells** and blood vessels. Section is more or less rounded in outline (Fig. 193).

(2) Each seminiferous tubule contains **germinal epithelium** or **sperm** mother cell, which gives rise to **primary spermatocytes**, **secondary spermatocytes**, **spermatids** and **sperms** or **spermatozoa**.

(3) Sertoli cells are absent.

(4) Blood vessels and interstitial cells are seen in the photograph.

[X] Frog. T.S. passing through the ovary

In transverse section of ovary, ova could be seen in various stages of development. Make a permanent slide of ovary of frog by cutting paraffin sections through microtomy. Take a frog, anaesthesize it. Cut open abdomen and take out ovaries. Fix ovary in 10% formaline for 24 hours. Wash the ovary with running tap water for 4 to 6 hours to completely remove the formalin. Process ovary for paraffin sections stain with haematoxylin and eosin. Mount in DPX study the sections under microscope and take microphotographs.

Comments :

(1) Various ova are seen in developing stage.

(2) Primary **oogonium** gives rise to primary oocyte.

(3) Primary oocyte changes into **secondary oocyte**.

(4) Each ovum has centrally placed **nucleus egg shell** and granular cytoplasm.

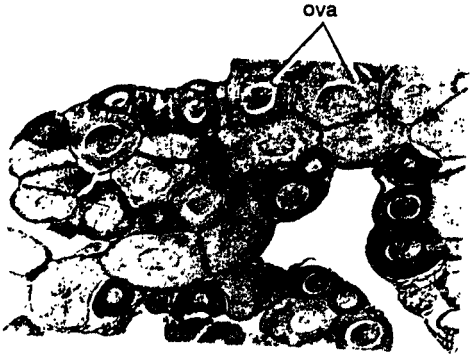


Fig. 194. Microphotograph. Frog. T.S. of ovary.

188. TMV : Tobacco Mosaic Virus

Virus can be best studied through **tobacco mosaic virus** (TMV).

Comments :

(1) Virus (TMV) has single stranded RNA as genetic material. RNA has helical configuration.

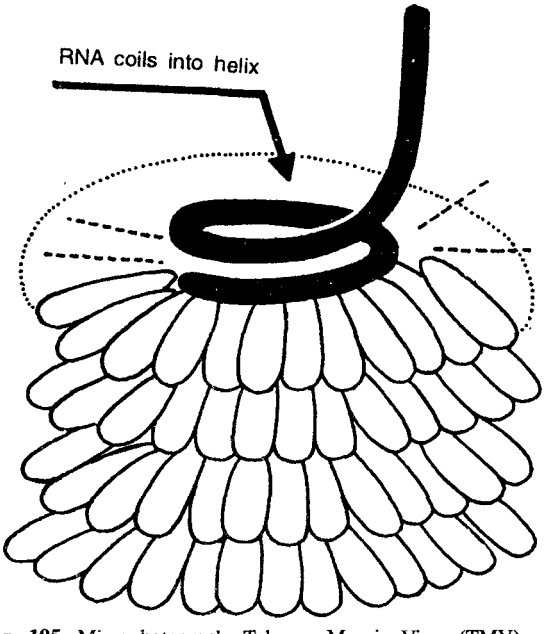


Fig. 195. Microphotograph. Tobacco Mosaic Virus (TMV).

(2) TMV contains **capsomeres**. Single helix contains 16 capsomera (Fig. 195).
(3) TMV is cylindrical measuring **3000** Å is length **180** Å in diameter.
(4) **Molecular weight** of TMV is 39×10^6.
(5) TMV is made up of TMV monomeres.
(6) Above virus contains 6400 nucleotides and about 2130 corresponding proteins.

189. Experiment : Demonstration of Haemolysis and Crenation in Red Blood Corpuscles

Principle : The above experiment is based on **permeability**, **osmosis** and **diffusion**. If RBC is kept in isotonic solution, then there is **absolutely no shrinkage** because osmotic concentration of the solution is similar to that of blood or crenate and this is retarded as **crenation**. If RBC are placed in a **hypotonic** solution, then since the osmotic concentration of RBC is less than that of solution, then they swell as water moves in RBC. The RBC burst and this process is called as **haemolysis**. Haemolysis of RBC also occurs by the effect of benzene, chloroform and venom of snake.

Requirements : Blood of frog, rat, sheep or goat, cavity block, sodium chloride salt, distilled water, reagent bottles and test tubes.

Preparation of reagents :

(1) **Isotonic solution :** Dissolve 0.85 gm of sodium chloride cystals in 100 cc of distilled water to make 0.85% NaCl **isotonic solution**.
(2) **Hypotonic solution :** (i) Dissolve 0.48 gm of NaCl crystals in 100 ml of distilled water to make 0.48% **hypotonic** solution, (ii) Also make 0.33% **hypotonic** solution.
(3) **Hypertonic solution :** Dissolve 1.5 gm of NaCl crystals in 100 ml of distilled water to make 1.5% **hypertonic** solution.

Procedure : Take four test tubes labelling then as A, B, C and D and keep them in a test tube stand. Keep equal volume of blood in all the four test tubes. To all the four test tubes add equal volume of different NaCl solution as under —

(1) Test tube A–Isotonic solution,
(2) Test tube B – Hypotonic solution (a),
(3) Test tube C–Hypotonic solution (b),
(4) Test tube D–Hypertonic solution.

Observation and result :

(1) Test tube A–No change in RBC.
(2) Test tube B – Haemolysis starts.
(3) Test tube C – Haemolysis is completed.
(4) Test tube D–Crenation occurs.

Dissections (Major and Minor)

8

Significance and Purpose of Dissection

Dissection constitutes very important practical work. The purpose of dissection is to learn the various internal structures and their co-relation with body. Such studies are very helpful in knowing the internal make up of man also. The **modern medicine** and surgery are dependent upon this kind of practical work. Human beings cannot be experimented and hence we have to depend upon other experimental animals. For example, the heart of ***Pila*** is a favourite organ for **pharmacologists** to study the relative effects of various drugs on heart beats. One must be trained to dissect the heart of ***Pila*** for such studies. Heart transplantations in human beings have been made possible after considerable studies of other animals, like dog, etc. The knowledge derived from regeneration and grafting studies in ***Hydra*** and ***Planaria*** has greatly helped **plastic surgery** to do repair in man as the cut nose and ear can be reformed. Therefore, dissection constitutes very significant and important practical work.

General Instructions for Dissection

While dissecting the animal keep in mind the following points.

(1) **Listen** and **follow** carefully the **instructions** given by the teacher in your practical class.
(2) Study well about the **internal structures** of the animal to be dissected.
(3) Keep all the **instruments** in your dissecting box **clean** and **sharp**.
(4) Always keep with you a **Zoology Practical Book** and also **hand-drawn diagram** of the dissection.
(5) Remember that all **invertebrates** are **dissected** from **dorsal side**.
(6) **Wash** the animal before dissection to remove excess of formaline or other fixing or killing chemical.
(7) Keep a **white sheet** below the animal in dissecting dish.
(8) **Fix** the animal in dissecting dish properly. **Insert** the **pins** obliquely.
(9) While opening the animal **never make deep incisions** as in earthworm, etc.
(10) **Remove** the body wall layers in such a manner that all the internal organs are fully exposed.
(11) Keep your dissection **submerged** in water.

(12) Remove **unwanted** tissue by cutting with scissors.
(13) **Blackpaper** your dissection. For example, keep small glazed black paper below the nerves and nerve cord in prawn.
(14) **Flag label** only when asked by the teacher. While doing it cut small flags, write the name of the organ or tissue and pin it with needle. Keep the flag near the blunt end of the needle and pin near the organ or tissue by pointed end of the needle obliquely.
(15) Always **leave** the dissection after **cleaning the tissues** in the dish.
(16) **Display** nicely the dissection.

1. *Ascaris* : Round Worm

[I] External features

Ascaris is commonly called as round worm. ***Ascaris lumbricoides*** is found in the intestine of man, ***A. suum*** in the intestine of pig, ***A. vitulorum*** in cow and ***A. megalocephala*** in the intestine of horse. For studying external features take preserved male and female specimens of ***Ascaris lumbricoides***. Study and draw their external features.

(1) **Mouth** and **lips** : **Mouth** is terminal, situated at the anterior end. Mouth opening is surrounded by one **dorsal** and **two ventro-lateral papillated** lips (Fig. 1).
(2) **Four longitudinal streaks** : Externally the building of hypodermis can be observed as 4 longitudinal dipressions called as **streaks on mid-dorsal, one mid-ventral** and **2 lateral**. The four streaks internally divide the muscles into 4 quadrants.
(3) **Male worm** : Male measures 15 to 30 cm in length. The tail end is **ventrally curved** and contains the **mid-ventral cloaca**. Sometimes a pair of small **copulatory spicules** are seen protruding through cloaca.
(4) **Female worm** : Female measures 20 to 35 cm in length. Its tail end is **bluntly pointed** and contains anus. The opening of **vulva** lies at a distance one third from the anterior end.
(5) **Excretory pore** : Anteriorly situated mid-ventrally.

[II] General anatomy

Procedure : *Take preserved male and female worms. As they are radio-bilaterally symmetrical hence can be dissected longitudinally. Make a fine longitudinal incision in any radius from anterior to posterior end. By forceps fix the flaps of skin in the dissecting dish. Digestive system and reproductive system are dominant structures. Study and draw the following :*

(1) **Digestive system** : Both in male and female the digestive system consists of **mouth**, **oesophagus** or **pharynx** and **intestine**. The intestine occupies major part of the body. The intestine leads into **rectum** which opens to outside by **anus** in female and into **cloaca** in male.
(2) **Excretory canals** : In both male and female worms the **excretory canals** are seen as thin thread like structures on both sides of digestive system.
(3) **Male reproductive system** : It contains the following :
   (a) ***Testis*** : **Monorchic** : A single thread-like **testis** found anteriorly coiled around the pharynx.
   (b) ***Vas deferens*** : Testis leads into a wider tube called **sperm duct** or vas deferens.
   (c) ***Ejaculatory duct*** : Vas deferens opens into a short muscular ejaculatory duct posteriorly.
   (d) ***Cloaca*** : Ejaculatory duct leads into cloacal chamber which opens to outside by cloacal opening.
   (e) ***Spicules*** : The cloacal chamber contains 2 **equal spicules** or pineal setae. They sometimes project out through cloacal opening. Spicules help in copulation.

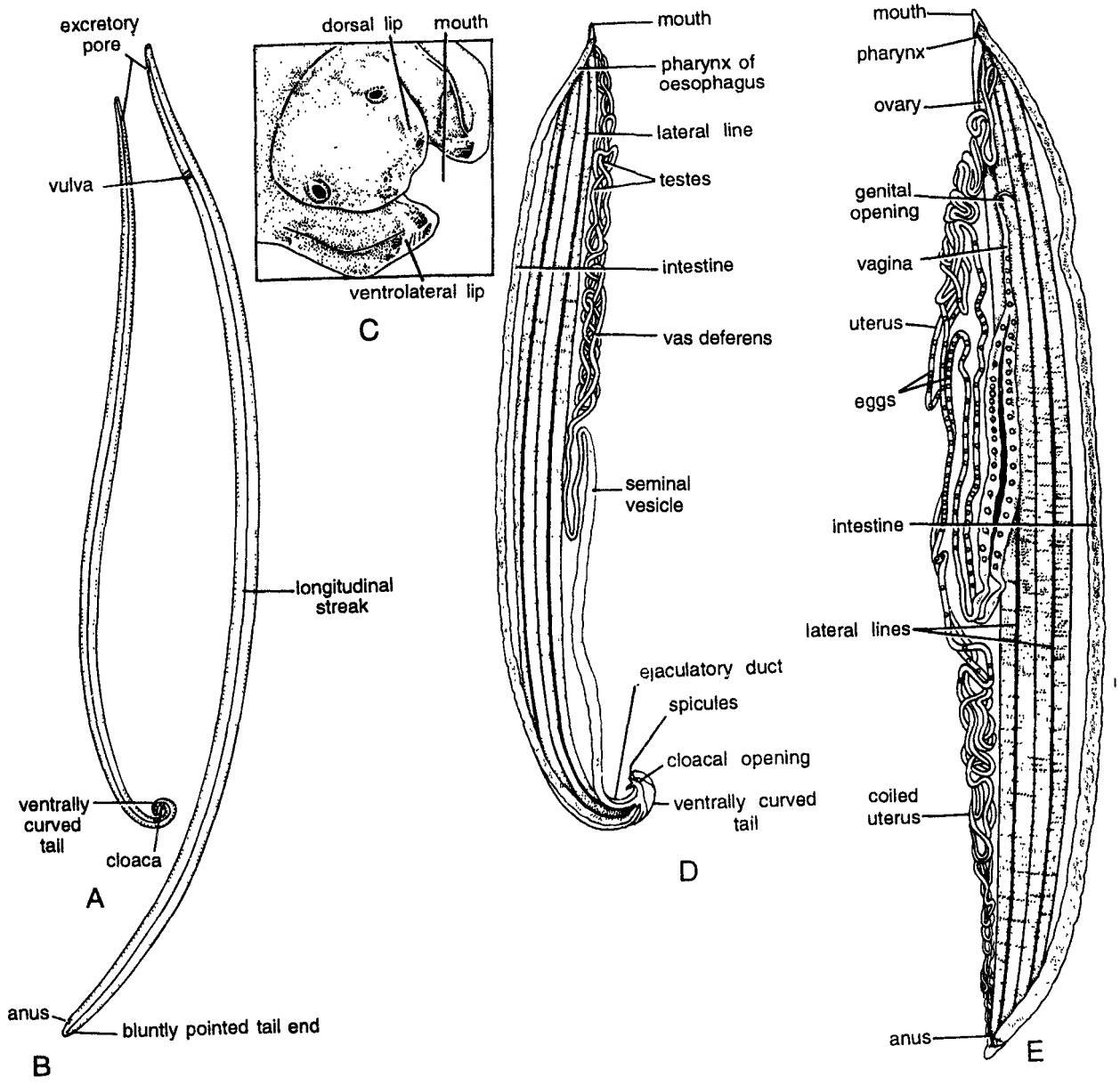


Fig. 1. *Ascaris lumbricoides.* External features of Male **A.** and Female **B. C.** lips, **D.** Male reproductive organs. **E.** General anatomy and female reproductive organs.

(4) **Female reproductive system :** It consists of following parts :

(a) ***Ovaries*** **: Two ovaries** coiled around pharynx.

(b) ***Oviducts*** **:** Each ovary leads into an opaque **oviduct.**

(c) ***Uterus*** **:** The oviduct leads into wide **uterus.** The uterii are very much coiled and occupy major part of the **interior.** Uterus contains eggs.

(d) ***Vagina*** **:** The two uterii open into a common chamber called **vagina,** which opens to outside by **vulva.**

2. *Nereis* : Clam Worm

[I] External features

Procedure : *For studying external feature take a formaline preserved animal. Fix it in a dissecting tray and study the following :*

(1) **Body form :** Worm like. Body divided into head and similar 200 segments.

(2) **Head :** It consits of **prostomium** or **pre-oral lobe** and **peristomium.** Prostomium is the first segment and contains **four eyes, two short prostomial tentacles** and 2 **large prostomial palps. Peristomium** carries at each **anterolateral position** 4 **pairs of peristomial cirri. Peristomium contains mouth.**

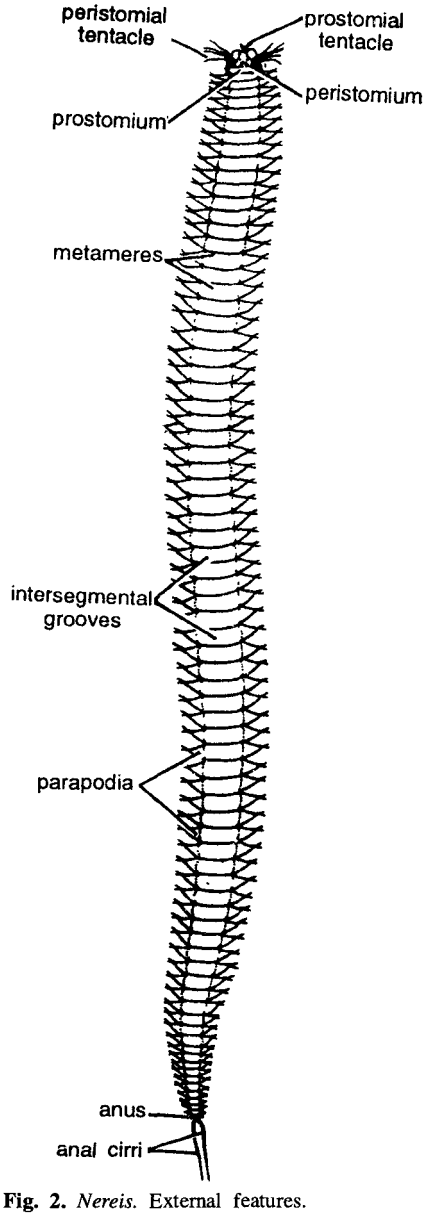


Fig. 2. *Nereis.* External features.

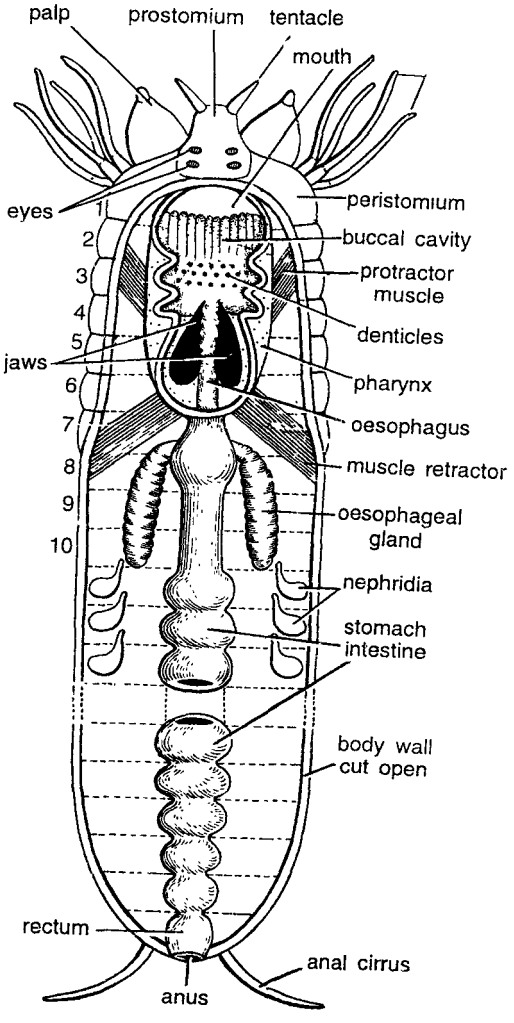


Fig. 3. *Nereis.* Digestive system.

(3) **Trunk :** The main body is trunk made up of similar segment. Each segment contains a pair of **parapodia.**

(4) **Anal segment :** The last segment is devoid of parapodia and is called as anal segment having anus and a pair of **anal cirri.**

[II] Digestive system

Procedure : *Take a preserved nereis wash it and fix in a dissecting tray. Make a superficial incision from anterior to posterior end, carefully remove the flap of skin and fix on side by pins. Study and draw the follwing parts :*

(1) **Mouth :** Transverse opening on the ventral side of prostomium. Mouth leads into **buccal cavity.**

(2) **Buccal cavity** and **pharynx :** Buccal cavity leads into a **muscular pharynx.** The pharynx is everted forming proboscis. Internally pharynx contains **jaws** and **denticles** (Fig. 3).

(3) **Oesophagus :** The pharynx narrows posteriorly into **oesophagus.** The oesophagus contains a pair of **oesophageal gland** on side. Oesophagus opens into the **stomach-intestine.**

(4) **Stomach-intestine :** It consists of segmentally constricted tube upto the last segment.

(5) **Rectum and anus :** The stomach-intestine opens into **rectum** in **pygidium.** The rectum opens to the exterior through a terminal anus. Which has a pair of anal cerci.

(6) **Parapodium :** Cut one or two parapodia of ***Nereis*** and ***Heteronereis*** from the side of the segment. Stain borax carmine, dehydrate, clear and mount in Canada balsam or D.P.X.

(7) Other structures seen are **protractor muscle, retractor muscle** and **nephridia meganephridia.**

3. *Pheretima posthuma* : Earthworm

[I] External features

Procedure : *It is common Indian earthworm. For external features, living narcotised or preserved specimens can be examined. Observe and draw the following parts. Draw separately dorsal and ventral surfaces. Distinguish the dorsal surface by median blood vessel.*

(1) **Shape :** Body is elongated, cylindrical with pointed anterior and blunt posterior end. Body shape is nicely adapted for burrowing life (Fig. 4).

(2) **Pigmentation :** Body is dark brown in colour.

(3) **Segmentation :** Entire body is divided by transverse furrows into **segments** or **metameres.**

(4) **Number of segments :** 100 to 120 *(Count in your specimen).*

(5) **Total length :** 150 mm.

(6) **Total breadth :** 3 to 5 mm *(Measure the size).*

(7) **Clitellum :** It is thick, girdle like, forwardly situated region, containing only three segments of the body (14 to 16). It forms a complete ring.

(8) **Setae :** Ventrally, middle of each segment contains a ring of small curved setae which can be observed by a hand lens. **Setae** are chitinous and locomotory. The first segment, last segment and the clitellar region are devoid of setae.

(9) **Mouth :** It is a crescentic opening, found in the first segment and shifted ventrally by fleshy prostomium. It overhangs the mouth opening dorsally and it also occupies a small portion of the dorsal surface of the segment.

(10) **Genital or copulatory papillae :** Two pairs. One pair each is found on the ventral surface of the 17th and 19th **segments** respectively.

(11) **Female genital opening :** It lies on the ventral side of the 14th **segment** in **clitellar** region.

(12) **Male genital pores : Two** in number. They are found on either side of ventral surface upon raised genital papillae.

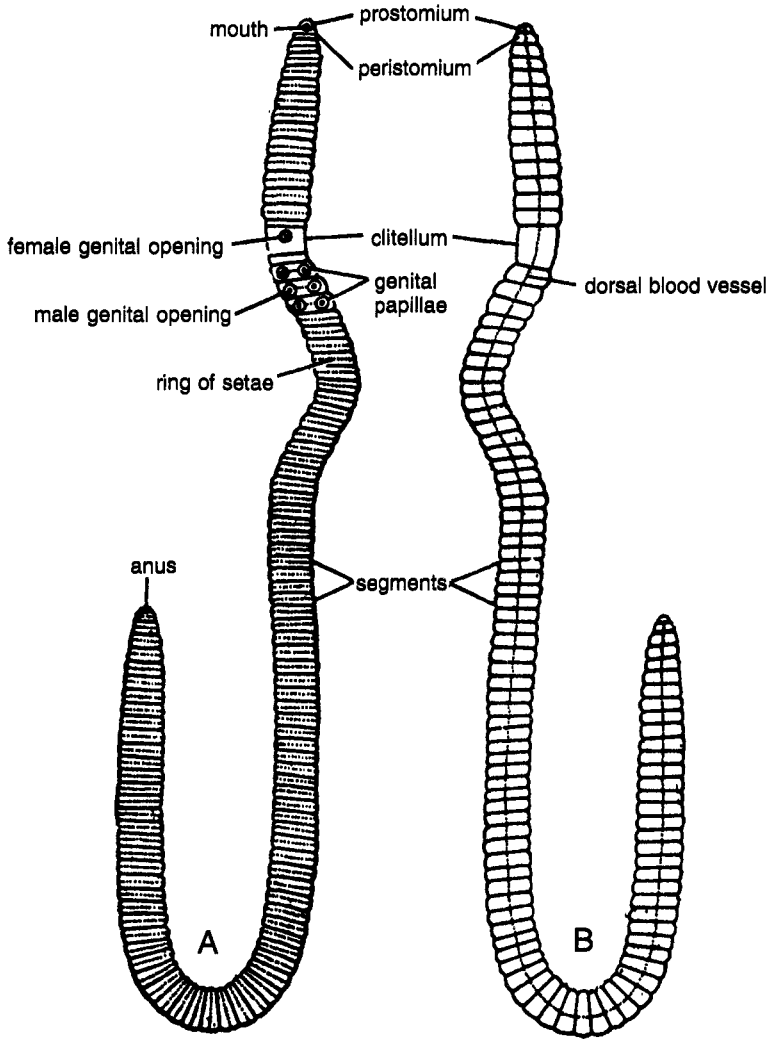


Fig. 4. *Pheretima* : Earthworm. External features. **A.** Ventral view, **B.** Dorsal view.

(13) **Spermathecal pores :** 4 pairs are located ventro-laterally in the inter-segmental **grooves of** 5/6, 6/7, 7/8 and 8/9 **segment.**

(14) **Anus lies** on the last anal segment.

(15) **Dorsal blood vessel** is seen on dorsal surface extending from anterior to posterior end.

Instructions : *Draw and label the diagram with the help* of figure. 4, A and B.

[II] General anatomy

Procedure : *Both freshly narcotised and killed specimens or preserved specimens can be used. Wash the worm and pindown the animal at its both ends in a dissecting dish with dorsal side upwards. Make a longitudinal mid-dorsal incision along the entire length of the worm with a very fine scissors and do not cut deep with the scissors to avoid injury to internal organs. In a bit deep incision alimentary canal is generally opened. After the longitudinal incision pin aside the flaps of the body wall. The inter-segmental septa often put resistance in opening the worm and for this, use pins to tear the septa and lossen the body wall.*

(Z–20)

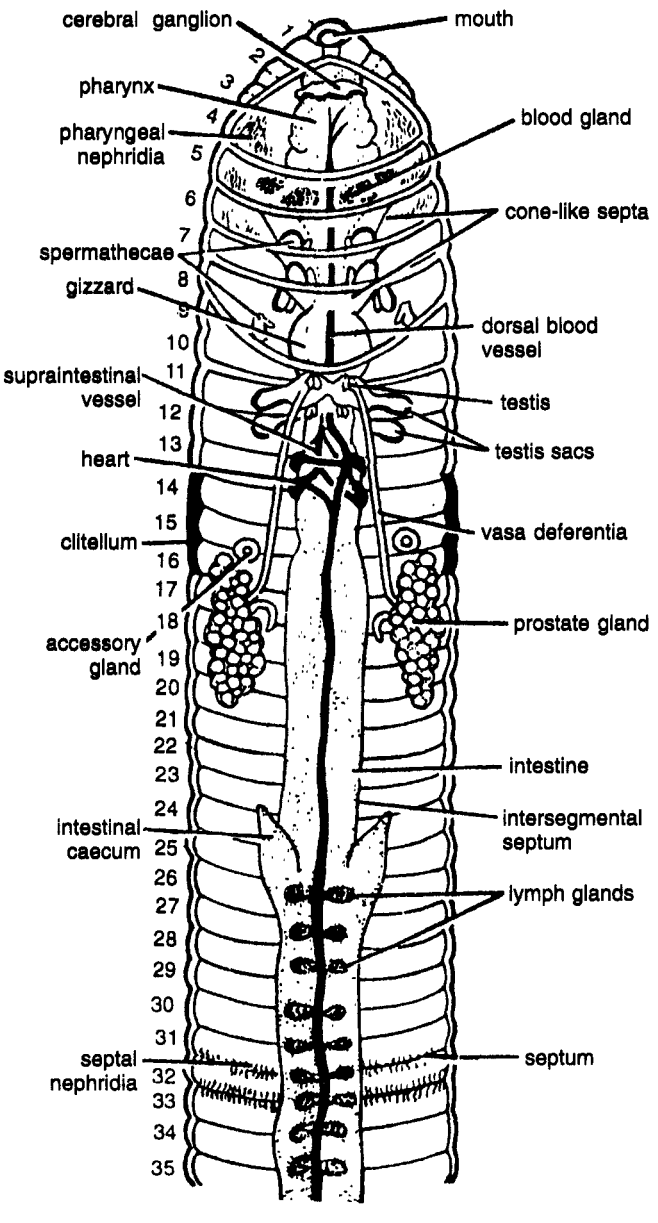


Fig. 5. *Pheretima* : Earthworm. General anatomy.

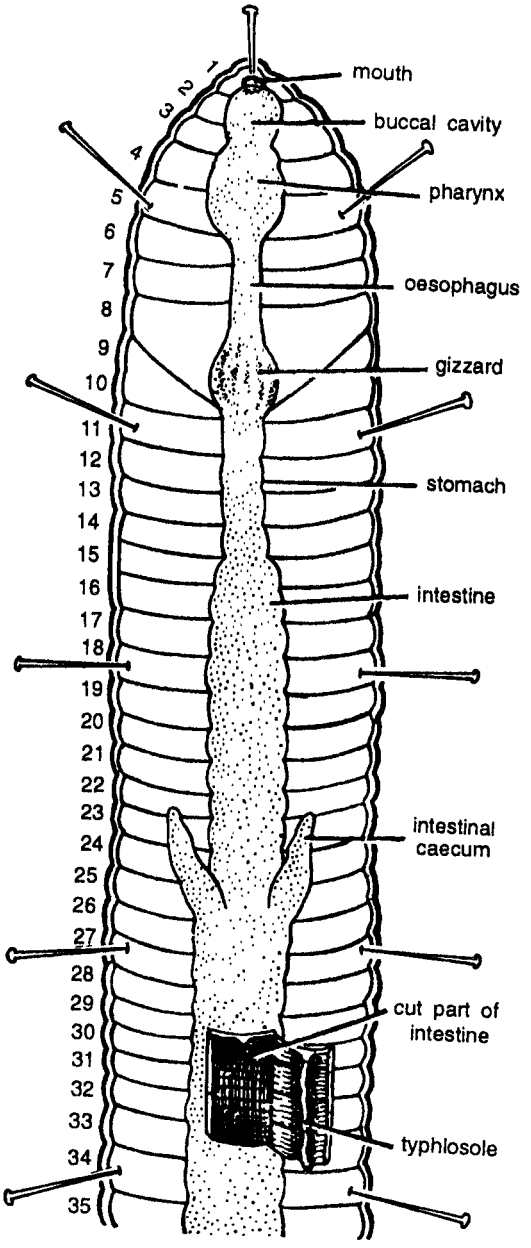


Fig. 6. *Pheretima* : Earthworm. Alimentary canal.

(1) **Circulatory system :** 4 pairs of so-called **hearts in the segments** 7, 9, 12 and 13 and blood vessels. Just after opening the animal, **dorsal blood vessel** is seen from anterior to **posterior end**. **Lateral oesophageal hearts** are very distinct in 12th and 13th **segments**. Various rounded and red coloured **blood glands** are found below the **pharynx**. **Lymph glands** are present below intestinal caeca associated with blood glands (Fig. 5).

(2) **Alimentary canal :** Discussed separately in dissection of **digestive system**. Various parts of alimentary canal consists of **buccal cavity**, **pharynx**, **oesophagus**, **gizzard**, **stomach** and **intestine**. Around **pharynx**

various **radial muscles** are seen attached from **pharnyx** to body wall layer. **Gizzard** is a very distinct structure. The **intestinal caeca** are present in 25th and 26th **segments** (Fig. 5).

(3) **Excretory system :** See different nephridia :
   (a) ***Integumentary nephridia*** **:** Several in each segment.
   (b) ***Pharyngeal nephridia*** **:** Found in three bunches in 4th, 5th and 6th segments.
   (c) ***Septal nephridia*** **:** From the 15th and 16th segments and onwards they are attached to inter-segmental septa.

(4) **Reproductive system :** Some of the male reproductive parts are clearly observed anteriorly. The **testes sacs** are in 11 to 13 **segments** and the **prostate glands** are 16 to 20 **segments**. For details, see dissection of reproductive system.

(5) **Nervous system :** Discussed separately in dissection of **nervous system**. Nerve ring and some part of the **ventral nerve cord** below the alimentary canal may be exposed and seen.

(6) Besides the above structures, **inter-segmental septum, spermathecae, accessory glands, clitellum, typhlosole**, etc. can also be observed for anatomy.

Instructions : *Draw and flag label various parts in general anatomy.*

[III] Alimentary canal

Procedure : *Dissect the worm as in the case of general anatomy. In the anterior region remove the inter-segmental septa and musculature to clear the parts of alimentary canal. See the following parts :*

(1) **Buccal cavity :** Between segments 1 and 2. It is a sac-like structure (Fig. 6).

(2) **Pharynx :** It is highly muscular and found in the segments 3 and 4. It is a pear-shaped structure and is demarcated from the buccal cavity by a transverse groove.

(3) **Oesophagus :** It lies behind pharynx and extends upto **the** 8th **segment**.

(4) **Gizzard :** It is hard, bulbous and thick-walled, situated in the 8th and 9th segment. It is highly muscular and it becomes very clear after removing the visceral layer over it.

(5) **Stomach :** It is narrow tube, found in the segments 9 to 14. The stomach is glandular and vascular structure.

(6) **Intestine :** It starts from the 15th **segment** and continues up to rectum. It is a thin-walled structure occupying major part of the body. In the 26th segment, intestine gives a pair of intestinal caeca. Often the wall of the intestine is cut and mud is seen in the lumen. Intestine is divided into 3 regions :
   (a) ***Pre-typhlosolar region*** **:** It extends from the 15th to 26th **segments**. No median fold.
   (b) ***Typhlosolar region*** **:** It continues from 26th segment to backwards leaving last 23 to 25 segments. It is characterised by having an internal mid-dorsal fold or typhlosole which can be exposed by cutting open the intestine from the side. It is meant for absorption of the food material. It is extra absorptive area.
   (c) ***Post-typhlosolar region*** **:** Found in last 23 to 25 segments. It is called as rectum and opens to the exterior by anus.

Instructions : *First expose buccal cavity, pharynx and gizzard and then draw the diagram of dissection with the help of the practical book.*

[IV] Reproductive system (Hermaphroditic)

Procedure : *Dissect the animal as in the case of general anatomy. First expose male reproductive system. For exposing the vasa deferentia, tease the body wall and insert black paper below sperm ducts.*

Male reproductive system

(1) **Testes : Two pairs**, one pair in the 10th **segment** and another in the 11th **segment**. Each testis is enclosed in a testis sac. Testes are generally degenerated in adult specimens. Each is associated with a spermiducal funnel, which communicates with sperm duct or vas deferens, which runs up to the 18th segment to join with prostatic duct (Fig. 7).

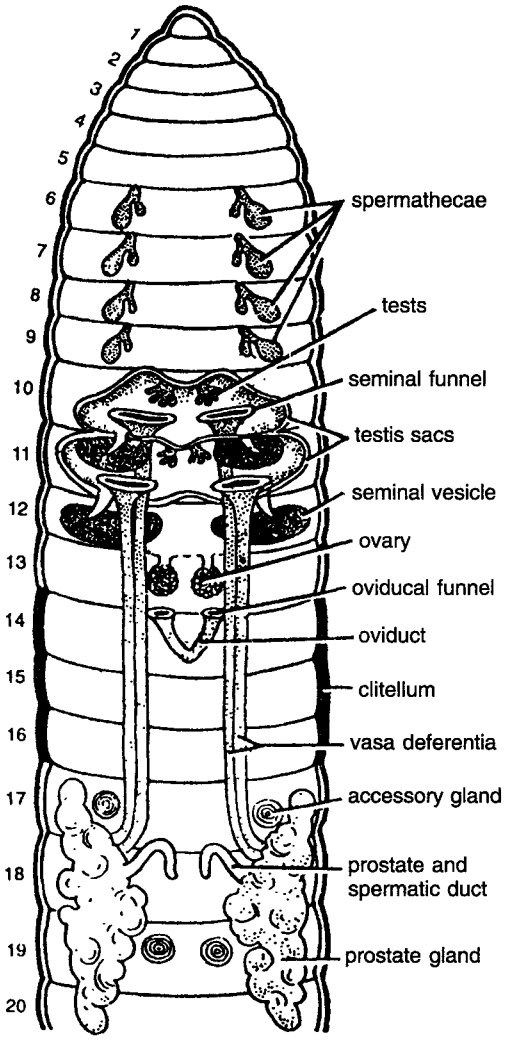


Fig. 7. *Pheretima* : Earthworm. Reproductive system.

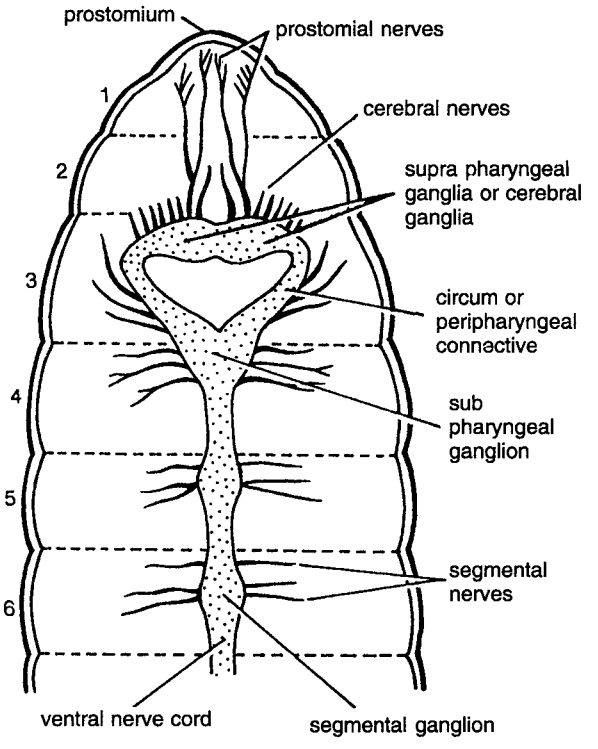


Fig. 8. *Pheretima* : Earthworm. Nerve ring.

(2) **Seminal vesicles : Two pairs**, lying in the 11th and 12th **segments**.

(3) **Prostate glands :** One pair of lobulated and irregularly-shaped prostate glands are found from 16-17 to 20-21 **segments**.

(4) **Accessory glands :** Two pairs are present. One pair in the 17th **segment** and another pair in the 19th **segment**. The glands look like rounded or coiled circles.

Female reproductive system

(1) **Ovaries :** 2 in number, in the form of whitish masses found attached to the posterior face of 13/14 **septum** below the gut on either side of the ventral nerve cord. *Locate the heart region, invert the intestine and ovaries will be seen as whitish dots* (Fig. 7).

(2) **Oviducts : 2 short ducts** with oviducal funnels. Oviducts converge to open on the ventral surface of the 14th segment.

(3) **Spermatheceae : 4 pairs found in** 6th, 7th, 8th and 9th **segment**. Each spermatheca consists of a pear-shaped ampulla and a narrow duct.

Instructions : *Draw the genital organs of the dissection with the help of the practical book.*

[V] Nerve ring

Procedure : *Dissect the animal as in the case of general anatomy. Try to expose the complete nerve cord from anterior to posterior end. Remove the intestine and nerve cord will be seen as whitish cord. Nerve ring is found encircling buccal chamber and cut the buccal chamber and remove it leaving nerve ring. Insert small pieces of the black paper under nerve cord and study the following parts.*

(1) **Supra-pharyngeal ganglia :** It forms a **bilobed mass** lying dorsal to the pharynx. It is also called as cerebral ganglia.
(2) **Sub-pharyngeal ganglia :** It is also a bilobed mass, found below the pharynx.
(3) **Circum-pharyngeal connective :** It connects the above two kinds of ganglia forming a complete ring around pharynx.
(4) **Ventral nerve cord :** Found ventral to digestive tube. It starts from the sub-pharyngeal ganglia and extends up to the last segment. In each segment it forms a swollen ganglion.
(5) Small nerves from ganglia and nerve cord supply to various organs.

Instructions : *Draw the nervous system with the help of your dissection and the practical book.*

4. *Hirudinaria granulosa* : Leech

It is the common Indian cattle leech. For studying external features, take freshly killed specimens with chloroform vapours.

[I] External features

(1) **Number of segments :** 33.
(2) **Number of annuli in a typical middle segment is** 5.
(3) **Total length :** 5 to 10 cm.
(4) **Parapodia and setae :** Completely absent.
(5) **Shape :** Body is dorso-ventrally flattened. It looks like ribbon-shaped when elongated and cylindrical when contracted.
(6) **Colour :** The body is greenish brown and paler below than above. The dorsal surface is characterised by having yellowish, longitudinal bands spotted with black pigments, while ventral surface is irregularly mottled.
(7) **External annulation :** Although the true segments are 33 only, but each segment is further divided, into generally 5 superficial rings or annuli.
(8) **Divisions of the body :** Body is divided into the following regions :
   (a) ***Cephalic region or head region*** **:** It comprises of first 5 anterior segments and includes anterior sucker, mouth, jaws and eyes.
   (b) ***Pre-clitellar region*** **:** It is formed by 3 complete metameres (6th, 7th and 8th).
   (c) ***Clitellar region*** **:** It is also made up of 3 segments (9th, 10th and 11th).
   (d) ***Middle region*** **:** It is composed of 11 segments from 12th to 22nd segments.

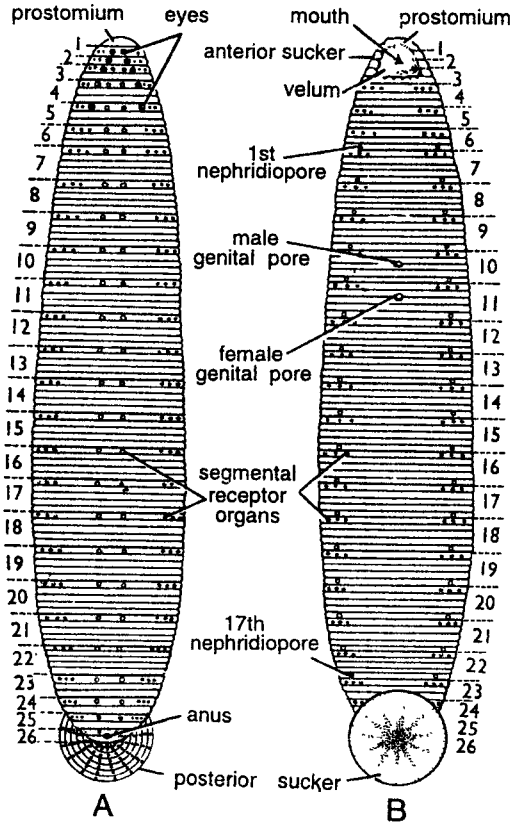


Fig. 9. *Hirudinaria* : Leech. External features. **A.** Dorsal view, **B.** Ventral view.

(e) Caudal region : It is made of 23rd, 24th, 25th and 26th and somites or segments.

(f) Posterior region : It contains 26 to 33rd segments.

(9) **Suckers** : Each end of the body contains suckers namely anterior and posterior suckers.

(10) **Apertures** :

(a) Nephridiopores : 17 pairs. One pair is found on the last annulus of each of the 6-22 segments.

(b) Male genital opening : Found on the midventral line of the annular groove between the 2nd and 3rd annuli of the 10th somite.

(c) Female genital opening : Lies mid-ventrally between the second and third annuali of the 11th segments.

(d) Anus : Lies mid-dorsally on the 26th segment at the base of the posterior sucker.

Instructions : *Draw well-labelled and proportionate diagrams of dorsal and ventral surface to show* external features of leech with the help of the practical book.

[II] General anatomy

Procedure : *Leaches are killed by chloroform or they may be (narcotised) in water by adding few crystals of magnesium sulphate or menthol. The wellfed leeches have swollen appearance, because crop is filled with blood. It is necessary to extract blood by pressing the body between thumb and first finger. The blood, in this way, comes out from the mouth. Stretch the leech and pin it on both the suckers to the dissecting dish with dorsal side upwards.*

Make a mid-longitudinal incision through the skin from anterior end. Care must be taken not to cut the alimentary canal. Remove carefully the connective tissue and botryoidal tissue between body wall and digestive tube. Pin the flaps on the sides. Study the following parts :

(1) **Alimentary canal** : See details in alimentary canal dissection.

(2) **Circulatory system** : It consists of 4 longitudinal haemocoelomic channels, which are reduced coelom, namely (i) **dorsal haemocoelomic sinus**, (ii) **ventral haemocoelomic sinus**, and (iii) 2 **lateral haemocoelomic sinuses** and their branches.

(3) **Excretory system** : 17 **pairs of nephridia**. First 6 **pairs are pre-testicular** lying in the 6 to 11 **segments**. These are devoid of **testis sacs**. Last eleven pairs are testicular lying in the 12 to 22 segments. Each nephridium is composed of **twisted glandular main lobe, spherical muscular bladder, nephridiopore** and **nephrostome**.

(4) **Nervous system** : For details refer to dissection of nervous system.

(5) **Reproductive system** : Leech is **hermaphroditic**. Male and female sex organs are found in the same animal. For details see dissection of reproductive system.

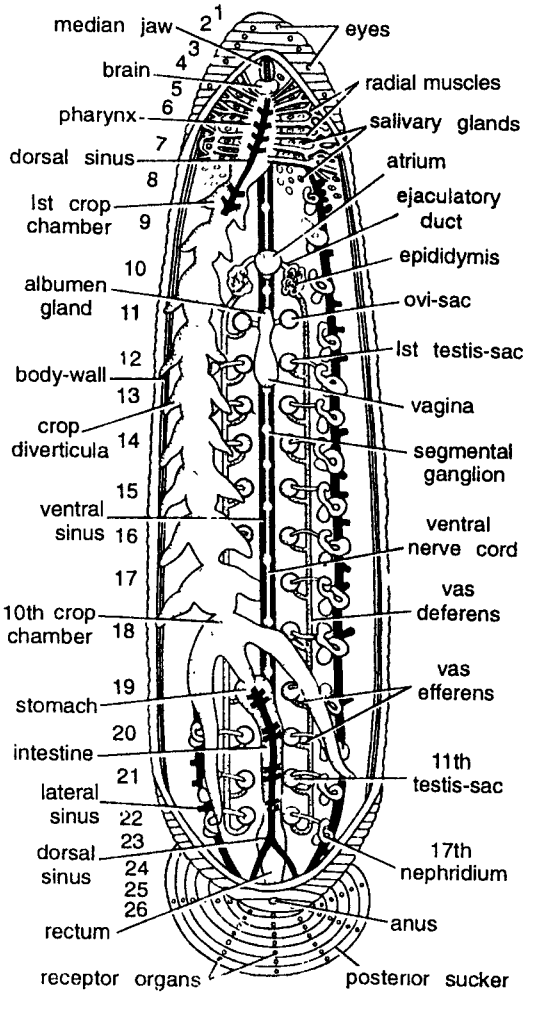


Fig. 10. *Hirudinaria* : Leech. General anatomy.

[III] Alimentary canal

It consists of the following parts :

(1) **Pre-oral chamber :** The concavity of the anterior sucker is called as pre-oral chamber containing mouth at its base.

(2) **Buccal cavity :** Mouth leads into **buccal cavity** having 3 serrated chitinous **jaws**, which mark a tri-radiate wound on the body of the host.

(3) **Pharynx :** Extends from the 5th to 7th segment. It is highly muscular and encircled by salivary glands.

(4) **Oesophagus :** Very short and leads into crop.

(5) **Crop :** Extends from the 9th to 18th segment. It consists of 10 **crop chambers** and each chamber has a pair of crop diverticula. The last diverticula are the largest and extend upto the 22nd segment.

(6) **Stomach :** It lies in the 19th **segment.**

(7) **Intestine :** Extends from the 20th to 22nd **segment.**

(8) **Rectum :** Extends from the 22nd to 26th **segment.**

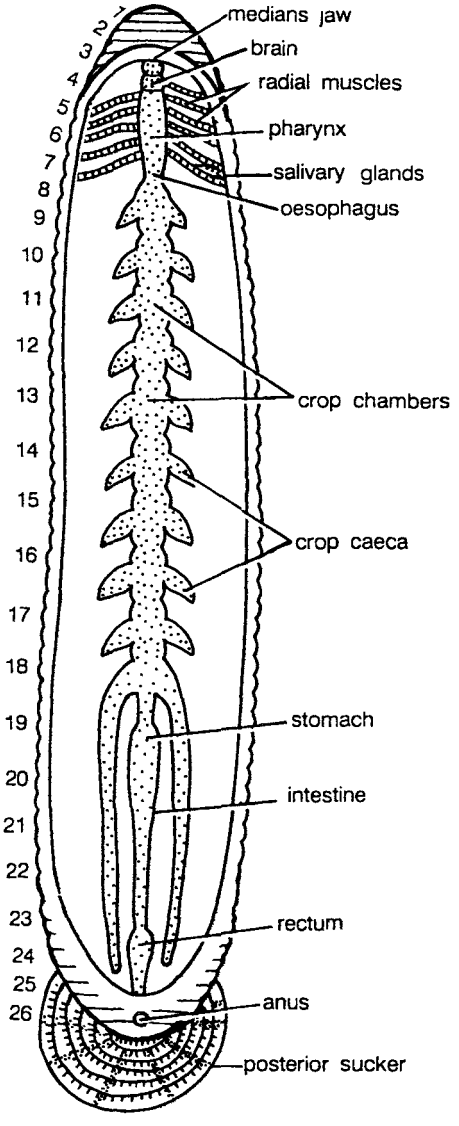


Fig. 11. *Hirudinaria* : Leech. Alimentary canal.

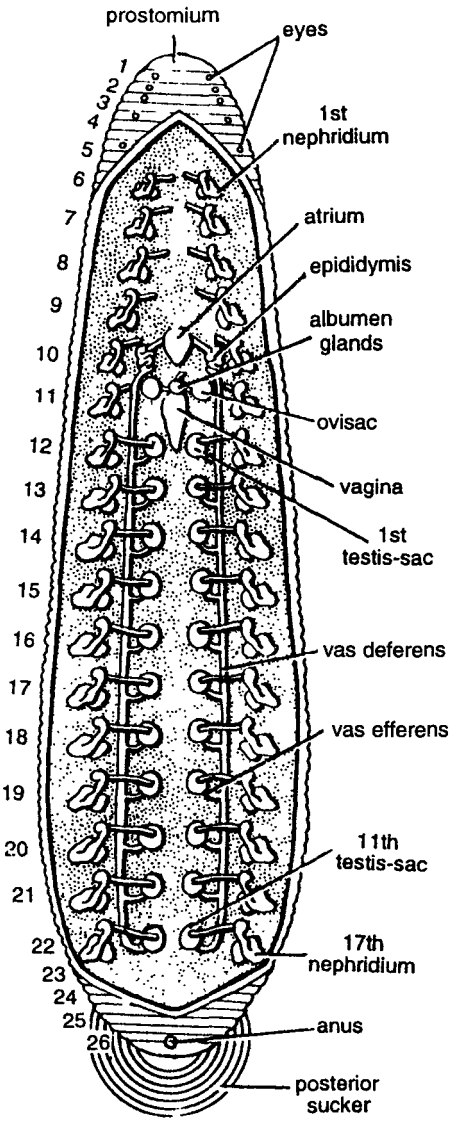


Fig. 12. *Hirudinaria* : Leech. Reproductive system.

Instructions : *After studying various parts, draw diagram of your dissection with the help of the practical book.*

[IV] Reproductive system (Fig. 12).

Procedure : *Leech is hermaphrodite. For details see dissection of reproductive system proceed as in case of general anatomy or alimentary canal.*

A. Male reproductive system

It is associated with excretory organs from 12 to 22 segments and consists of the following parts :

(1) **Testes sacs : 11 pairs**, one pair each in **segments** 12th to 22nd. Each testis sac is very distinct, whitish and rounded structure.
(2) **Vasa efferentia :** From posterior border of each testis sac arises a minute sperm ductule called as vas efferens, which joins with the sperm duct of its side.
(3) **Vasa deferentia :** There are 2 longitudinal sperm ducts, running from 22nd to 11th segment on either side of the nerve cord.
(4) **Epididymes :** Each sperm duct ends in a convoluted mass called as **epididymis in** the 10th **segment.**
(5) **Ejaculatory ducts** It arises from anterior end of each epididymis and opens into atrium.
(6) **Atrium :** It is a pyriform sac, found between 9th and 10th segments. It has anteriorly placed prostate gland backwardly directed penis sac.

B. Female reproductive system

It consists of the following parts :

(1) **Ovisacs :** A pair of rounded sacs, found in the llth segment.
(2) **Oviducts :** Each ovisac gives a slender, short tube called as oviduct. The two oviducts form a common oviduct in the llth segment.
(3) **Vagina :** It is an elongated sac-like structure in the llth segment. Note the presence of albumen glands anterior to vagina.

Instructions : *Draw the diagram of your dissection with the help of the practical book.*

[V] Nervous system

It consist of the following parts :

(1) **Supra-pharyngeal or cerebral ganglia :** Found above the pharynx.
(2) **Peripharyngeal connectives :** They arise from cerebral ganglia and make a ring of stout nerves around pharynx.
(3) **Sub-pharyngeal ganglion :** The connectives join a sub-pharyngeal ganglion.
(4) **Double-ventral nerve cord :** It arises from sub-pharyngeal ganglion and runs in successive segments within ventral haemocoelomic sinus from the 6th to 26th **segment.**

Instructions : *Draw the diagram of your dissection with the help of the practical book.*

5. *Unio* or *Lamellidens* : Fresh-water Mussel

[I] External features

Unio is the most familiar specimen amongst laboratory dissections. ***Unio*** is found abundantly in lime-rich water and in the bottom of lakes, ponds, rivers and streams. Generally they are found half-embedded in mud or sand at the bottom.

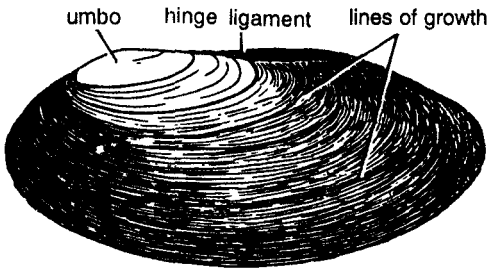


Fig. 13. *Unio.* External features with shell.

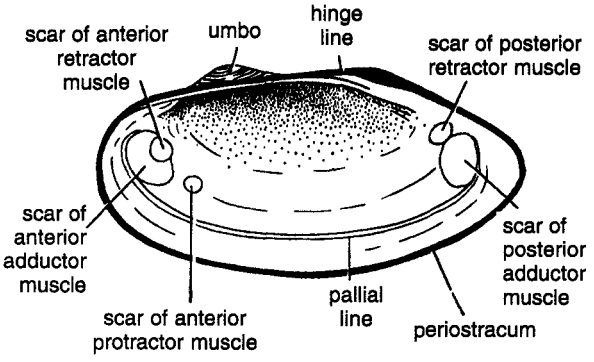


Fig. 14. *Unio.* Inner view of right shell valve.

Procedure : *For external features of the shell, use well-expanded specimens preserved in formalin. Remove one of the shells by raising it upwards by a scalpel and cut carefully the anterior and posterior adductor muscles. Pull the shell backwards till the hinge is broken. Note the following* :

(1) **Size :** 5 to 10 cm (Fig. 13).
(2) **Colour :** Outer surface is rough and reddish brown, while the inner surface white, smooth and lustrous.
(3) **Shape :** The body is unsegmented, bilaterally symmetrical and compressed.
(4) **Shell :** It consists of two equal lateral valves and hence it is called as bivalve.
(5) **Umbo :** It is a swollen, knob-like structure, which represents the oldest part of the shell. The concentric lines of growth are found around the umbo. The lines of growth are found all around the surface of the shell.
(6) **Hinge ligament :** It is a tough dark brown and elastic cord, situated on the dorsal edge by which the two valves are united and hinged together. Sometimes, hinge is toothed in some specimens.

[II] Inner view of shell

The places of muscle insertion appear as rough areas in comparison to the smooth surface. Note the following muscle scars (Fig. 14).

(1) At the anterior end three muscle scars are found.
  (a) Scar of the **anterior adductor muscle**, helps in closing the shell valve.
  (b) Scar of the **anterior retractor muscle**, helps in withdrawing the foot.
  (c) Scar of the **anterior protractor muscle**, extends the foot.
(2) At the posterior end 2 **scars** are found :
  (a) Scar of the **posterior adductor** muscle, closes the shell valves.
  (b) Scar of the **posterior retractor** muscle, withdraws the foot.
(3) **Hinge line** is found on dorsal position near the junction of the two valves.
(4) **Pallial line** or extends from the anterior adductor to the posterior adductor muscle. It indicates the insertion of muscle fibres, which arise on the mantle edge connecting it to the shell :

Instructions : *Draw the external features and inner view of the shell with the help of the practical book.*

[III] General anatomy

Procedure : *Take a large, nicely preserved specimen, wash it thoroughly to remove formalin smell. Lift the Unio by left hand and keep umbo towards the left side. Cut or scratch the portion of hinge ligament. Insert a scalpel through the inhalent siphon and cut the posterior adductor muscle. Similarly, cut the anterior adductor muscle and then lift the upper shell. Remove the mantle in order to expose the different soft parts and examine their disposition* (Fig. 15).

(1) **Body :** It is elongated and laterally compressed.

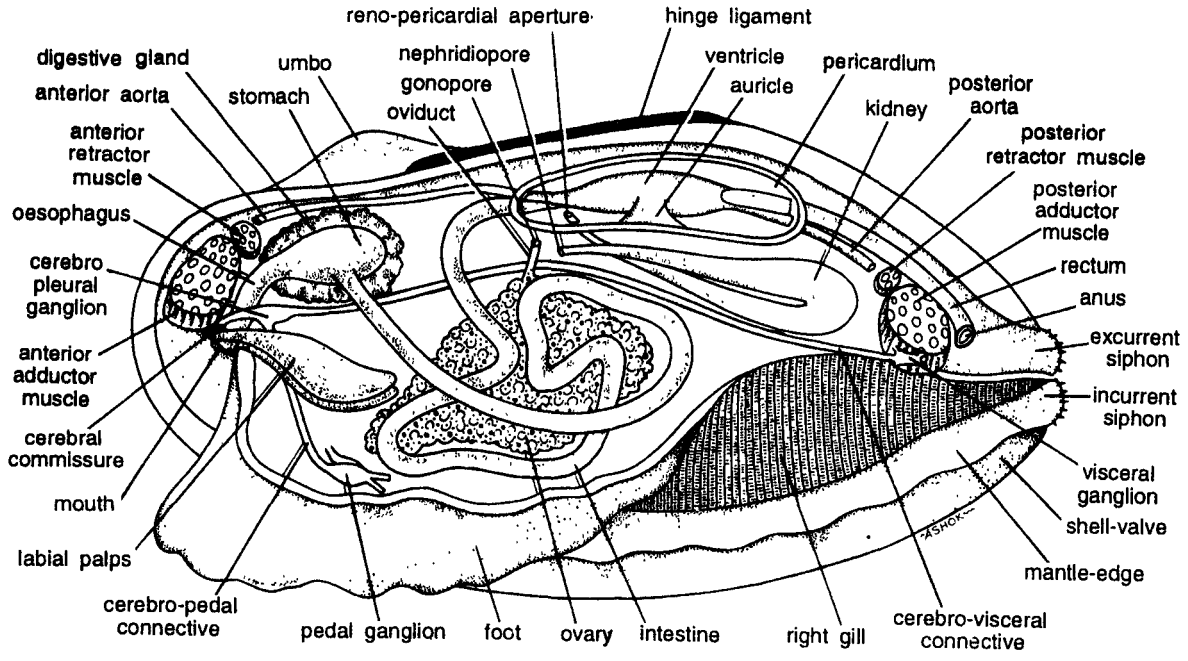


Fig. 15. *Unio.* General anatomy in lateral view.

(2) **Mantle :** It forms a thin covering for entire body and consists of two symmetrical **mantle lobes** which are united posteriorly except at two **places**, where they form a small, **smooth exhalent siphon** and **a large, papillated inhalent siphon**. Mantle encloses **mantle cavity**.

(3) **Muscles :** Note the large anterior and posterior **adductor muscles, small anterior retractor** and **protractor muscles** and the **posterior retractor muscle.**

(4) **Foot :** It is large, muscular and axe-shaped mass, protruding ventrally.

(5) **Labial palps : Two pairs are** found just below the anterior protractor muscle.

(6) **Gills or ctenidia : Two pairs** are situated in posterior half. Each gill consists of two **gill lamellae.**

(7) **Heart :** It lies mid-dorsally in the visceral hump within **pericardial cavity**. The **rectum passes** through the heart.

(8) **Kidneys : Two in number**, one on each side of **pericardium.**

(9) **Alimentary canal :** It consists of **mouth, oesophagus, stomach, intestine, rectum** and **anus** large and **greenish** digestive gland surrounds the stomach.

[IV] Nervous system

Procedure : *Take nicely preserved Unio and remove both the shell valves carefully by cutting the anterior and posterior adductor muscles. Now pin up the animal with the mantle fold with the foot facing upwards. Now, very carefully remove the gill lamellae of both the sides. Locate the posterior adductor muscle, at the base of which lies the X-shaped visceral ganglion. Remove the peritoneal covering and visceral ganglion will be clearly seen. While removing the covering 2 cerebro-visceral connectives become visible. Trace this connective. Just below the anterior retractor muscle, cerebro-pleural ganglion is found. Locate the ganglion of other side. The cerebral commissure passes over the upper rim of the mouth. For pedal ganglia, cut the muscular part of the foot and see those ganglia in anterior one-third foot. Now trace the cerebro-pedal connectives. Expose the following ganglia, connectives and commissures* (Fig. 16).

(1) **A visceral ganglion**, found at the base of posterior adductor muscle.

(2) A pair of **cerebro-pleural ganglia**, situated at the base of anterior retractor muscle.

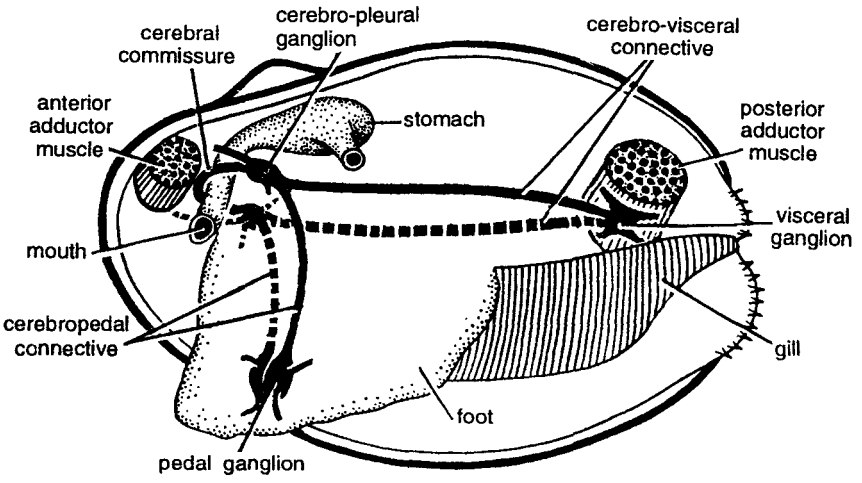


Fig. 16. *Unio.* Nervous system in lateral view.

(3) A pair of **pedal ganglia** inside the foot.
(4) **Cerebral commissure** connecting **cerebro-pleural ganglia.**
(5) **Cerebro-visceral connective**, which **connects cerebro-pleural** and **visceral ganglia.**
(6) **Cerebro-pedal connective**, which connects **cerebro-pleural** and **pedal ganglia.**

6. *Mytilus* : Sea Mussel

Nervous system

Procedure : *Take a nicely preserved Mytilus. Carefully remove shell by inserting the scalpel into the shell valves and not damaging the anterior and posterior adductor muscles. Remove the gills carefully. See for visceral ganglia at the base of the posterior adductor muscle. Remove the peritoneal covering, cerebral ganglia are found anteriorly and pedal ganglia in the foot. Expose the following ganglia, connectives and commissure* (Fig.17).

A. Ganglia

(1) ***Carebral ganglia*** : They lie anteriorly.
(2) ***Visceral ganglia*** : They are found at the base of the posterior adductor muscle.
(3) ***Pedal ganglia*** : In the foot.

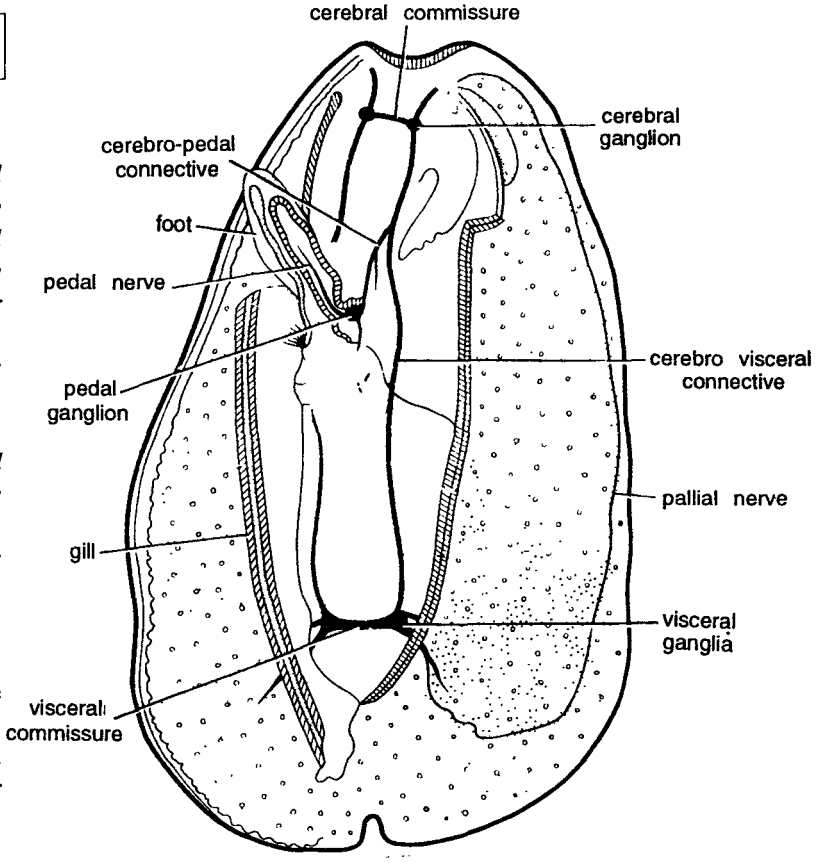


Fig. 17. *Mytilus.* Nervous system in ventral view.

B. Connectives

(1) ***Cerebro-visceral connective*** : It connects **cerebral** and **visceral ganglia.**
(2) ***Cerebro-pedal connective*** : It connects **pedal** and **cerebral ganglia.**
(3) ***Cerebral commissure*** : **The cerebral ganglia** are connected by it.
(4) ***Visceral commissure*** : It connects the **two visceral ganglia.**
Instructions : *Draw the dissection with the help of the practical book.*

7. *Pila globosa* : Apple Snail

Pila is the most common and abundant gastropod, inhabiting ponds, rivers, tanks and rice-fields. It is very familiar for dissection and is also famous for its very slow movement called as snail pace.

[I] External features with shell and operculum

Procedure : *For studying external features, take formalin-preserved specimens. Note the following :*
(1) **Shell** : It is a univalve globose type. It is **spirally coiled** around a **central axis** called as **columella.**
(2) **Apex** : It forms the first part of the shell, situated at the top of the spiral. It is also called as protoconch (Fig. 18).
(3) **Whorls** : The body coils of the shell are known as whorls and they are in open communication. The coils gradually increase from apex. Immediately after apex is penultimate whorl and then body whorl. The body whorl is the largest and successive whorls are demarcated by sutures.
(4) **Varices** : The surface of the shell is marked by numerous lines of growth, called as varices.
(5) **Columella** : It is the central axis around which shell is coiled.
(6) **Mouth or aperture** : The body whorl opens to outside by mouth or aperture.
(7) **Peristome** : The smooth and continuous margin of the aperture is called as **peristome.**
(8) **Outer lip** : It forms outer margin of the mouth.
(9) **Columellar lip** : It forms inner lip.
(10) **Umbilicus** : The hollow tube-like columella opens to outside by umbilicus.

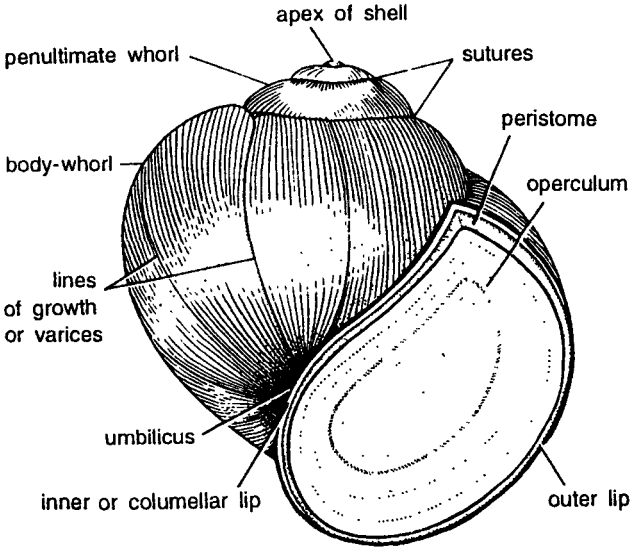


Fig. 18. *Pila.* External features with shell and operculum.

(11) **Dextral shell** : The shell of ***Pila*** shows clockwise spiralling, called as dextral shell.
(12) **Operculum** : The aperture of the shell is closed by operculum which is attached tightly to the hinder part of the foot.

[II] Soft parts

Procedure : *For studying soft parts, break the body whorl nearly up to first suture. Keep operculum on the lower side. To study external features of soft parts remove the shell completely.*
The body of the ***Pila***, After the shell is removed, is differentiated into 3 distinct regions (Fig. 19).

(1) **Head :** It is anterior fleshy part of the body overhanging foot. It is produced anteriorly into the contractile snout, which bears mouth and 2 pairs of tentacles. First pair is smaller, while second pair of tentacles is larger. At the base of each second pair tentacles is a stalked eye or ommatophore.

(2) **Foot :** It is large, **strongly muscular**, ventral part of the body. In fully expanded condition, foot shows triangular appearance. The part of the foot bearing **operculum** dorsally is called as operculiferous lobe. When foot is withdrawn, the operculum completely fits into the mouth.

(3) **Visceral mass :** It constitutes a **sort of hump** on the dorsal side called as visceral hump. It is spirally coiled according to the coiling of the shell.

(4) **Mantle :** The skin of the visceral mass forms a thin and delicate covering called as **mantle** or pallium. Mantle encloses a large cavity in dorso-lateral position called as mantle cavity or pallial cavity.

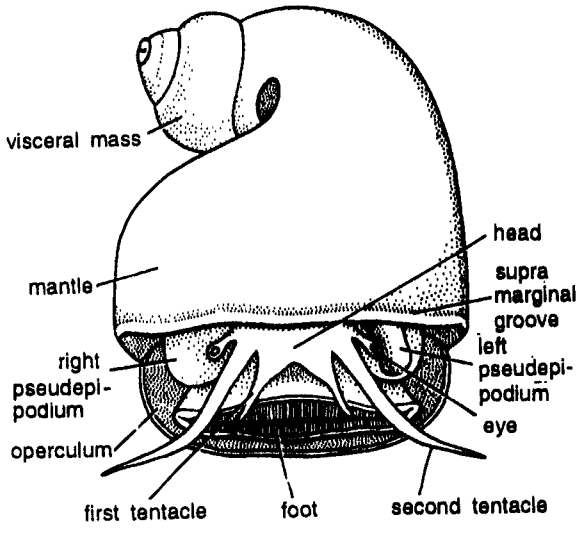


Fig. 19. *Pila.* External features after removal of the shell (the soft parts).

[III] General anatomy

Procedure : *For general anatomy, do not remove animal from the shell. Break the shell up to first suture. Keep the snail with visceral hump upwards. Make an oblique incision from the left side along the pigmented area of the mantle. Reflect the mantle flap and pin it up. Study the following parts :*

A. Mantle cavity and pallial complex

Mantle encloses a large dorso-lateral cavity, called as **mantle cavity** or **pallial cavity**. Animal retracts its head into this cavity. The pallial cavity encloses the following organs, collectively called as **pallial complex**.

(1) **Right and left nuchal lobes :** At the sides of the head and over the foot, the mantle is prolonged into highly contractile and fleshy nuchal lobes or **pseudepipodia** (Fig. 20).

(2) **Respiratory siphon :** The left nuchal lobe forms respiratory siphon.

(3) **Epitaenia :** From the anterior edge of right nuchal lobe a prominent ridge or raised area

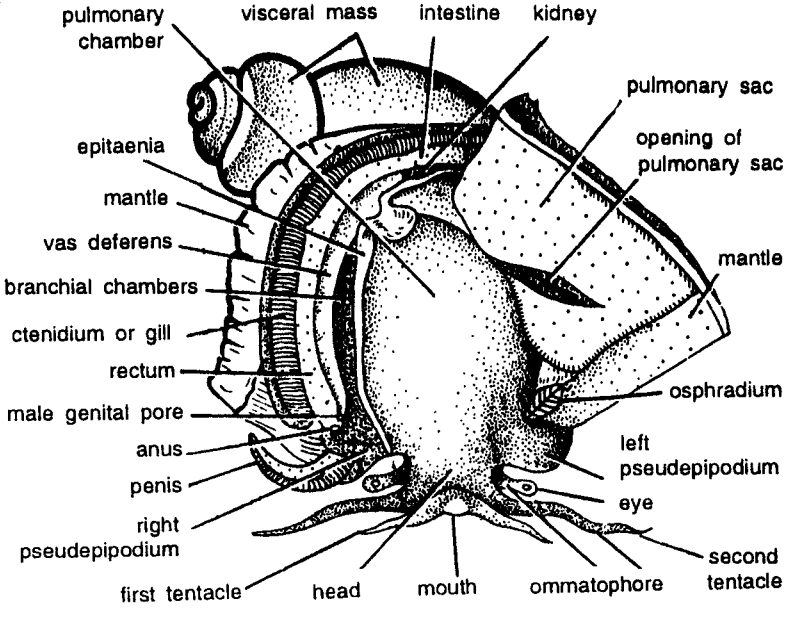


Fig. 20. *Pila.* Pallial complex i.e., organs of the mantle cavity in a male specimen.

extends up to extreme posterior end and is called as epitaenia. It divides mantle cavity into **right branchial chamber** and **left pulmonary chamber**.

B. Organs of the branchial chamber

(1) **Ctenidium** : ***Monopectinate***. Hangs freely vertically downwards from the dorso-lateral wall of the mantle cavity.
(2) **Rectum** : Rectum lies in front of the ctenidium.
(3) **Genital duct** : Male or female genital duct lies close to the rectum. In male, penis arises from the mantle edge.

C. Organs of pulmonary chamber

(1) **Pulmonary sac** : It is large bag-like structure, hanging down from the roof of the mantle cavity.
(2) **Osphradium** : It arises from the **mantle** and is found adjacent to left **nuchal lobe**.

Instructions : *Draw the diagram of dissection of general anatomy with the help of practical book.*

[IV] Nervous system

Procedure : *Take a nicely preserved animal. Break the body whorl up to suture. Cut the mantle fold obliquely and remove the fold by cutting it posteriorly carefully so as not to destroy the visceral ganglia. The pulmonary chamber is exposed and buccal mass can be easily seen. Remove the muscular covering over buccal mass very carefully and under the muscular coat thick cerebral commissure will be seen. On sides, cerebral ganglia are found Trace supra-intestinal ganglion posterior to left nuchal lobe. Visceral ganglia are found in posterior region. The supra-intestinal nerve is a very thin nerve passing over gut and going deep to join the right pleuropedal ganglionic mass. Cut the gut part and remove buccal mass carefully to expose complete nervous system. Expose the following ganglia, connectives and commissures* (Fig. 21).

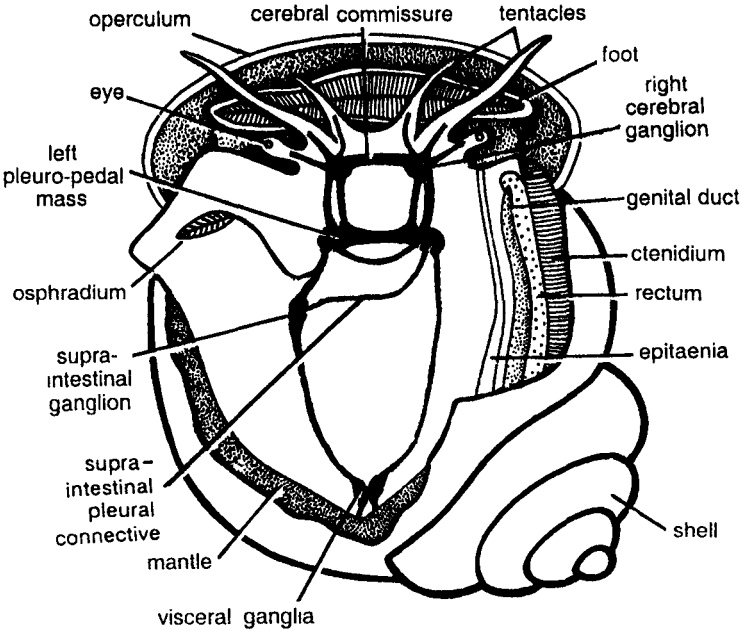


Fig. 21. *Pila.* Nervous system in dorsal view.

A. Ganglia

(1) **Cerebral ganglia :** A pair of these ganglia, situated on dorso-lateral sides of the buccal mass and triangular in shape.
(2) **Buccal ganglia :** A pair of small triangular ganglia dorso-laterally situated at the junction of buccal mass and oesophagus.
(3) **Pleuro-pedal ganglia :** A pair of ganglionic mass, lying on either ventro-lateral side of the buccal mass. Pleural outer one and pedal inner one are fused together to form pleuro-pedal ganglionic mass.
(4) **Supra-intestinal ganglion :** Unpaired fusiform ganglion lying in a sinus behind the left pleuro-pedal ganglionic mass.
(5) **Visceral ganglia :** Found in the lower end of the visceral mass.

B. Connectives

(1) **Two cerebro-pleural connectives :** They connect **cerebral** and **pleural ganglia** on either side.
(2) **Two cerebro-pedal connectives :** They connect **cerebral** and **pedal ganglia** on either side.
(3) **Two cerebro-buccal connectives :** They connect **cerebral** and **buccal ganglia.**
(4) **Infra-intestinal visceral connective :** It connects right **pleuro-pedal ganglia** to **visceral ganglia.**
(5) **Supra-intestinal pleural connective :** It connects **supra-intestinal ganglion** to **right pleuro-pedal ganglia.**
(6) **Infra-intestinal connective :** It connects left **pleuro-pedal ganglia** to **infra-intestinal ganglion** fused with right pleuro-pedal ganglionic mass.

C. Commissures

(1) **Cerebral commissure** connects the two **cerebral ganglia.**
(2) **Pedal commissure** connects the two **pedal ganglia.**
(3) **Buccal commissure** connects the **buccal ganglia.**

Instructions : *Draw the dissection of the nervous system with the help of the practical book.*

8. *Loligo* : Squid

[I] External features

Take a nicely preserved specimen. It can be easily differentiated from ***Sepia*** by having lateral fin in the posterior region of the trunk. Study various structures in head and trunk regions.

[II] Nervous system

Procedure : *Dissect the animal by making a mid dorsal sagittal incision. Pin the lateral flaps. Expose the cerebral ganglia, visceral ganglion, optic ganglia and stellate ganglia. Carefully trace out the following nerves. Keep black or blue paper below the exposed nerve* (Fig. 22).

A. Anterior nerves

(a) ***Cerebro-buccal connective*** **:** Small nerves from cerebral ganglia originate and connect with **superior buccal ganglion** just above the **brain.** These connectives are present under cerebral ganglia.
(b) ***Brachial nerves*** **:** Eight brachial nerves originate from the **pedal ganglionic** mass and **innervate** the **mantle.**
(c) ***Tentacular nerves*** **:** Two **tentacular nerves** originating from the **pedal ganglionic** mass **innervate** the **tentacles.**

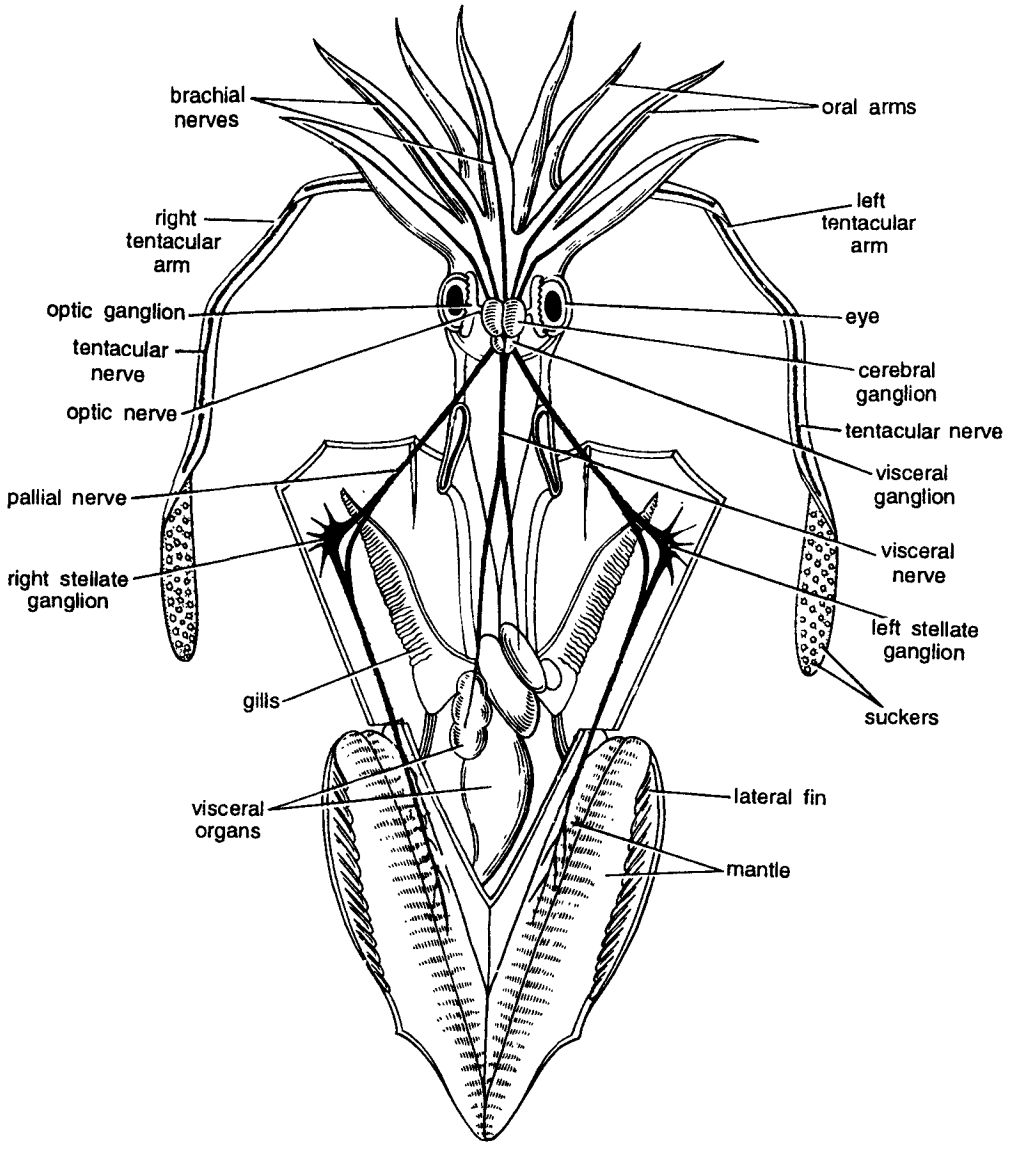


Fig. 22. *Loligo.* Nervous system.

(d) ***Optic nerves*** : A pair of **optic nerves** originating from the lateral side of **cerebral ganglia** from large optic ganglia on each side. From each optic ganglia small retinal nerves innervate **retinal cells.**

B. Posterior nerves

(a) ***A pair of pallial nerves*** : They originate from the posterior side of the **visceral ganglion** and after running posteriorly form **stellate ganglia** on each side. Fine nerves from **stellate ganglia** innervate mantle.

(b) ***Visceral nerve*** : Originate from the posterior portion of the **visceral ganglia**. After running posteriorly for some distance, divides into two branches. Small branches from each innervate various visceral organs.

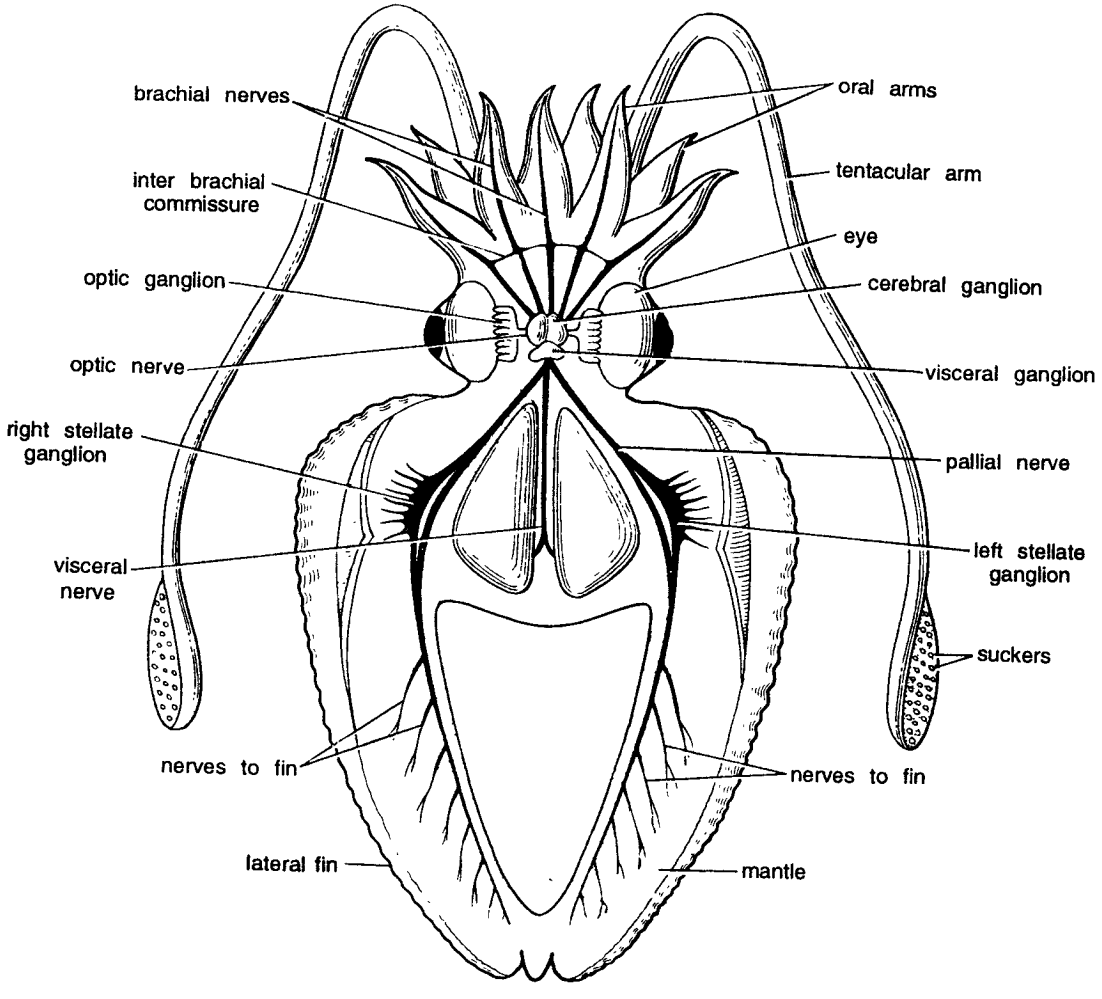


Fig. 23. *Sepia.* Nervous system (dorsal side).

9. *Sepia* : Cuttle Fish

[I] External features

Sepia is commonly found in sea in India. Very favourite class room specimen and very good animal to study the nervous system. The preserved specimen is brownish in colour bluish with leathery texture. The animal can atonce be recognized by the tentacles, majestic eyes and continuous lateral fin over the visceral hump or trunk. Head and trunk are joined by a narrow neck. The body is divided into head, neck and trunk. For detailed characters see under chapter Museum Specimen.

[II] Nervous system

Procedure : *Take a nicely preserved good specimen. It is always better to check the specimens. Pin down the animal with dorsal side upwards. Starting from the posterior end make a longitudinal incision upto cephalic end. Pin the lateral flaps of the body carefully by cutting the skin and muscles. First*

expose the cerebral ganglion in the head. Also expose visceral ganglia and pedal ganglionic mass. These stellate ganglion on mid lateral regions. After exposing these two ganglia proceed to trace the following nerves from anterior to posterior regions (Fig. 23). *If asked then black paper your dissection to show the nervous system.*

A. Anterior nerves (From the cerebral ganglia or brain)

(a) ***A pair of optic nerves*** **:** These nerves arise from the anterolateral portion of the **cerebral ganglia** on each side and after making in optic ganglia, they innervate **retinal cells** by the final **retinal nerves.**

(b) ***A pair of tentacular nerves*** **:** Originate from the **pedal ganglionic mass** just below the cerebral ganglia. They **innervate tentacles.**

(c) ***Eight brachial nerves*** **:** The **brachial nerves** also originate from the pedal ganglionic mass and they **innervate the oral arms.** The brachial nerves after running for a short distance from a **interbranchial commissure.**

(d) Other nerves and ganglia seen are olfactory ganglion, inferior anterior **ophthalmic nerve,** inferior posterior ophthalmic nerve.

B. Posterior nerves (From cerebral ganglia into trunk)

(a) ***A pair of pallial nerves*** **:** They originate from the postero-lateral position of the cerebral ganglia. They run obliquely in the posterior direction on each side and make a thick rounded stellate ganglia. Several outer branches from the stellate ganglia innervate **mantle** and various inner branches innervate the **fin.**

(b) ***A pair of sympathetic nerves*** **:** They originate from the mid posterior region of the brain, run posteriorly and form **gastric ganglion.** Fine nerves from gastric ganglion innervate **liver, stomach, intestine** and **caecum,** etc.

(c) ***A pair of visceral nerves*** **:** They originate from the posterior edge of visceral ganglia and run posteriorly. For sometime they run together, then separate and form a posterior **visceral commissure.** A pair of **brachial nerves** arise from the posterior visceral commissure and **innervate gills.** Various fine nerves arising from posterior visceral commissure innervate various visceral organs like cardiac nerves, etc.

10. *Periplaneta americana* : Cockroach

This is a common Indian cockroach. This insect is the most suited for laboratory study due to its manageable size, abundant occurrence and being least specialized insect. It is **Nocturnal** and **cursorial,** inhabiting drain pipes and backeries.

[I] External features

Procedure : *Take a fresh cockroach, which has been killed with chloroform vapour. Study the following features :*

(1) **Shape** : Body is elongated, bilaterally symmetrical and dorsoventrally flattened (Fig. 24, 25).

(2) **Size** : 28 to 45 mm in length and 8 to 10 mm in breadth.

(3) **Pigmentation** : The pigmentation or colouration is shining reddish brown with a yellowish area near pronotum and 2 dark patches over it.

(4) **Exoskeleton** : Entire body is covered by a **chitinous cuticle.** Cuticle consists of several sclerites. Cuticle is also found in **pharynx, foregut, trachea** and **genital ducts.** The skeletal plates of thorax and abdomen are dorsal **terga, ventral sterna** and **lateral pleura.**

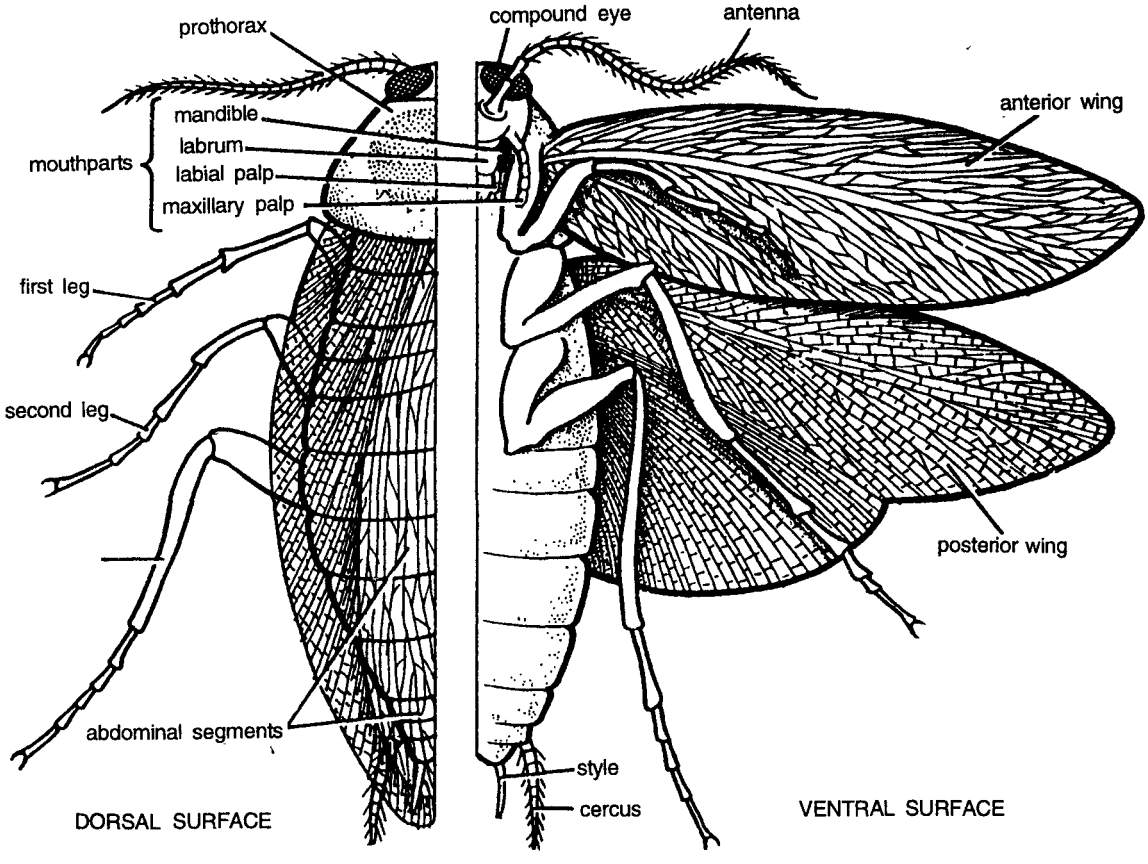


Fig. 24. *Periplaneta americana* : Cockroach. External features of male.

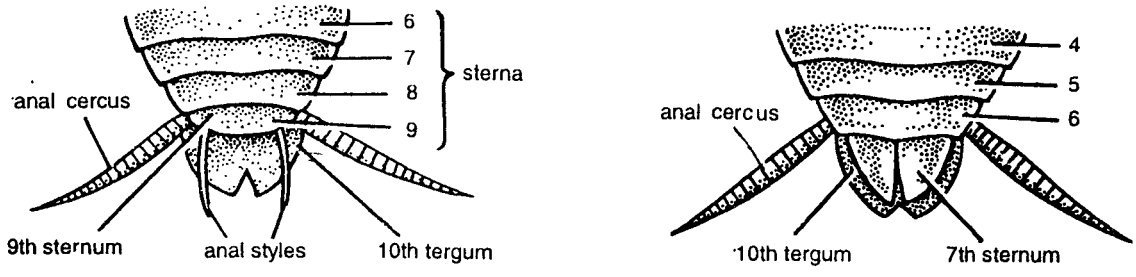


Fig. 25. *Periplaneta* : Cockroach. **A.** Tip of abdomen of male cockroach (ventral view), **B.** Tip of abdomen of female cockroach (ventral view).

(5) **Segmentation and divisions :** Body is metamerically segmented and divided into dorsal and ventral surfaces. It is regionated into (a) **head**, (b) **thorax** and (c) **abdomen**.

(a) Head **:** It is small, broader than long and is formed by several sclerites, such as epicranium, frons, clypeus and genae. Head contains appendages namely compound eyes, antennae and mouth parts.

(i) Compound eyes : Two large **rounded eyes** on sides. Eyes are large and sessile and made up of several visual units or ommatidia. It has mosaic vision.

(ii) Antennae : First pair of appendages are antennae, which are many jointed and filiform, attached in front of eyes.

(iii) Mouth parts : Composed of **labrum, mandibles, maxillae, labium** and **hypopharynx. Head** is connected to thorax by a short, slender **neck** and **cervix.**

(b) Thorax : It is composed of three segments namely prothorax, mesothorax and metathorax. The thorax contains :

(i) Wing : 2 kinds

Forewings : One pair. They originate from the tergum of mesothorax and are called as anterior wings or tegmina. They are flightless, dark, opaque, leathery and protective.

Hind wings : One pair. They originate from the tergum of metathorax. Hind wings are thin, membranous and used in flight.

(ii) Spiracles : 2 **pairs** in thorax.

(iii) Walking legs : Thoracic appendages are walking legs in 3 **pairs**. Each leg is made up of **coxa, trochanter, femur, tibia, tarsus, claws** and **pulvillus.**

(c) Abdomen : 10 **segments**. In both sexes the 10th tergum bears a pair of ventrolateral, many-jointed anal cerci. But in males, in addition to **anal cerci**, there is a pair of unjointed **anal styles** on the 9th sternal plate. There are 8 pairs of **spiracles** or **stigmata**, one pair each on soft cuticle of terga and sterna.

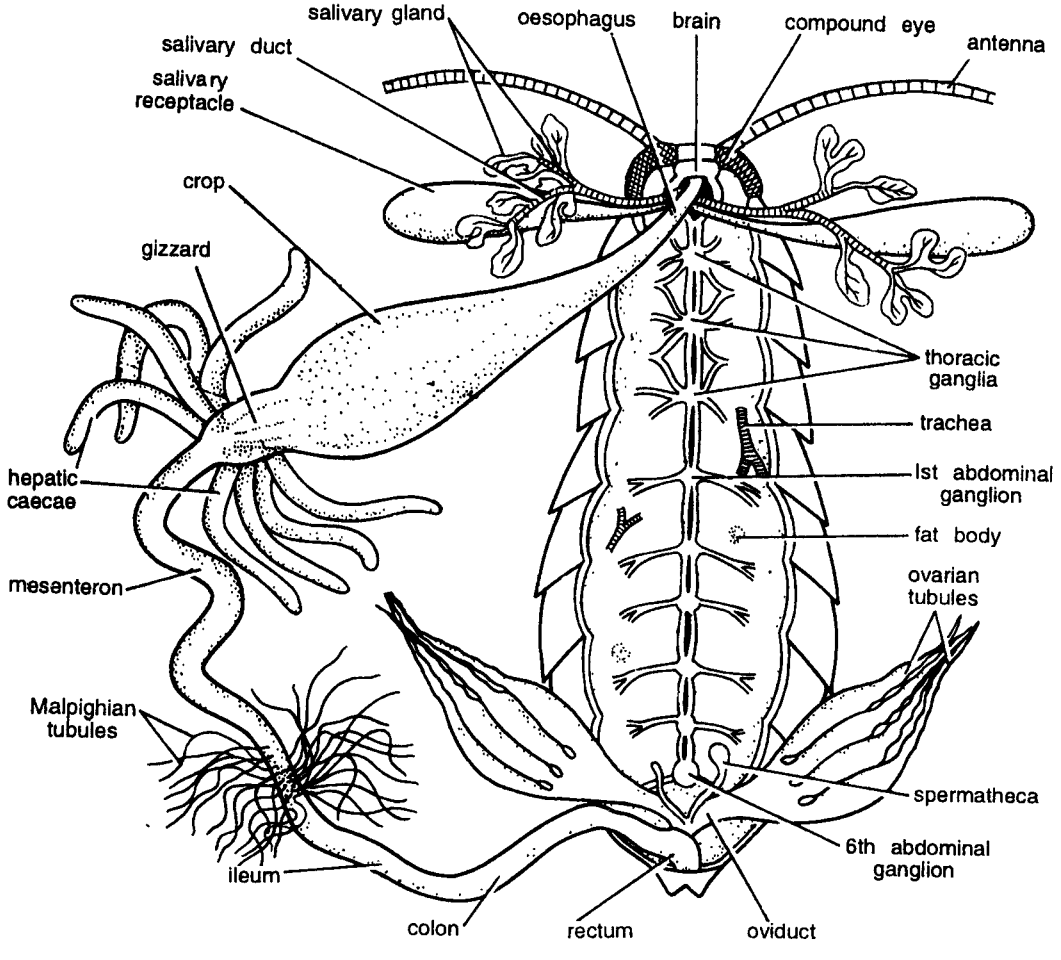


Fig. 26. *Periplaneta* : Cockroach. Alimentary canal, nervous and female reproductive systems.

Instructions : *Study and draw diagrams of the external features of cockroach from dorsal and ventral sides. Distinguish male and female specimens and make posterior ends with the help of the practical book.*

[II] General anatomy

Procedure : (i) *Take a freshly-killed cockroach for dissection, remove wings, cut off antennae and legs close to their bases* (Fig. 26).

(ii) *Hold cockroach in left hand and cut the lateral membranes between terga and sterna up to the anterior edge of pronotum.*

(iii) *Lay the insect in the dissecting dish with dorsal side uppermost and pin it in abdominal sterna and coxae of legs. (Another better procedure of fixing cockroach is to float it in petridish containing hot-melted wax. Allow it to cool and in due course the animal will be embedded and dissection may be done.) Fix the head by pinning between mandibles. By means of fine scissors make a rectangular cut in the head around clypeus and anterior epicranium to expose two cerebral ganglia.*

(iv) *Make a transverse cut along the posterior edge of the ninth segment (tergum) and gently remove other segments very carefully, so that the underlying organs and tissues are not disturbed.*

(v) *Uncoil intestine and stretch alimentary canal on one side. Remove fat bodies, tracheae and other muscles to expose internal organs. Study and draw the following parts :*

(1) **Heart :** 13 **chambers** in number (3 thoracic and 10 abdominal narrow chambers). Note inter-segmental alary muscles.

(2) **Alimentary canal :** It is divided into three parts :

(a) ***Foregut*** **:** It comprises of **mouth, buccal cavity, oesophagus, crop** and **gizzard**. The buccal cavity, receives the common salivary duct. Crop is meant for storing food. The gizzard has chitinous lining, which is internally produced into six teeth for masticating the food and setae for straining the food.

(b) ***Mesenteron*** or ***midgut*** **:** It is a narrow duct originating from gizzard. At the junction of gizzard and midgut there are 7 to 8 **hepatic** or **mesenteric caeca**. (Their function is to increase the absorptive area).

(c) ***Hindgut*** or ***proctodaeum*** **:** It includes ileum, colon and rectum. The beginning of ileum is marked by 60-70 fine and long **greenish yellow Malpighian tubules** (excretory in function).

Procedure : Note salivary glands, 2 in number, each present on the sides of oesophagus. Just invert the position of oesophagus and whitish glands along with reservoirs will be seen.

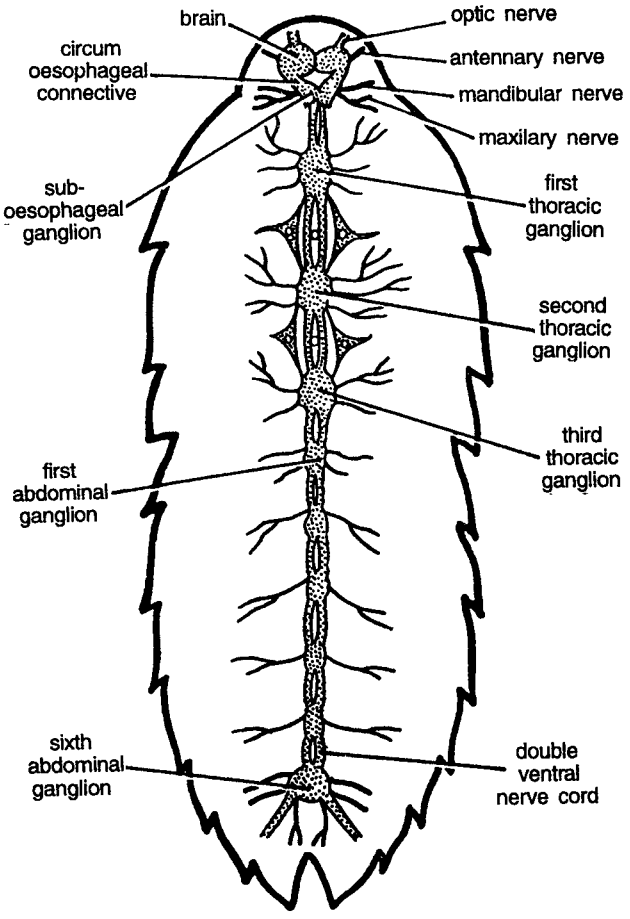


Fig. 27. *Periplaneta* : Cockroach. Nervous system.

(3) **Tracheae :** They are very much distinct by their striated and silvery appearance. Several tracheoles are present in the body tissues.

(4) **Reproductive system :** Sexes are separate. In case of males, mushroom glands are very distinct while in female ovarian lobes are clear.

(a) ***Male reproductive system*** consists of a pair of 3 **or 4-lobed** and **rounded testes**, 2 **sperm ducts**, **mushroom gland made up of utriculi breviores** and **utriculi majores, ejaculatory duct, genital pouch, phallomeres** and **conglobate gland.**

(b) ***Female reproductive system*** consists of 2 **ovaries**, 2 **oviducts, vagina, collaterial glands and spermathecae.**

(5) **Nervous system :** It has the following parts (Fig. 27) :

(a) Two **cerebral ganglia** or brain lies dorsally on head.

(b) Single **sub-oesophageal ganglion** lies on lower or ventral side of head.

(c) Two **circum-oesophageal connective**, which connect **cerebral ganglia** and **sub-oesophageal ganglia.**

(d) ***Double ventral*** **nerve cord** starts from sub-oesophageal ganglion and extends up to posterior end. It consists of 9 **pairs of fused ganglia** (3 thoracic and 6 abdominal).

Instructions : *Draw the dissection of the general anatomy including nervous system with the help of the practical book.*

[III] Reproductive system

Procedure : *Unisexual. Sexes are separate. The procedure* of dissection *is same as in the case of general anatomy.*

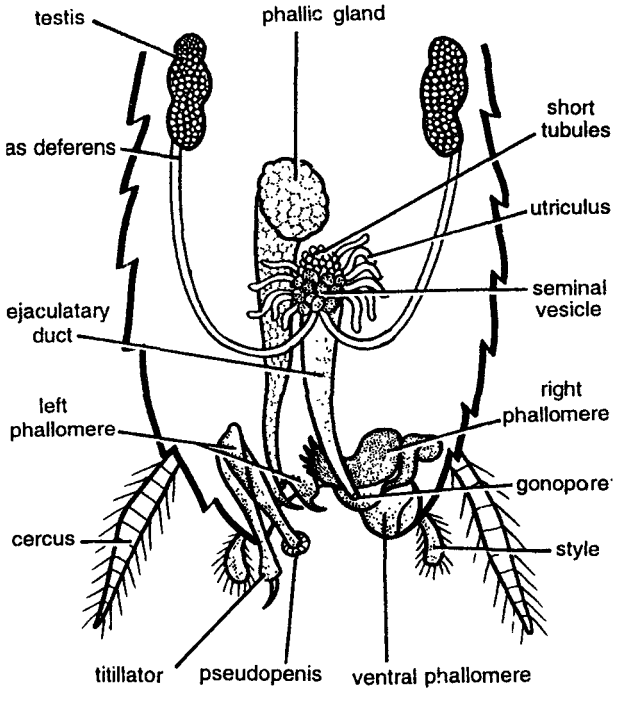


Fig. 28. *Periplaneta* : Cockroach. Male reproductive system.

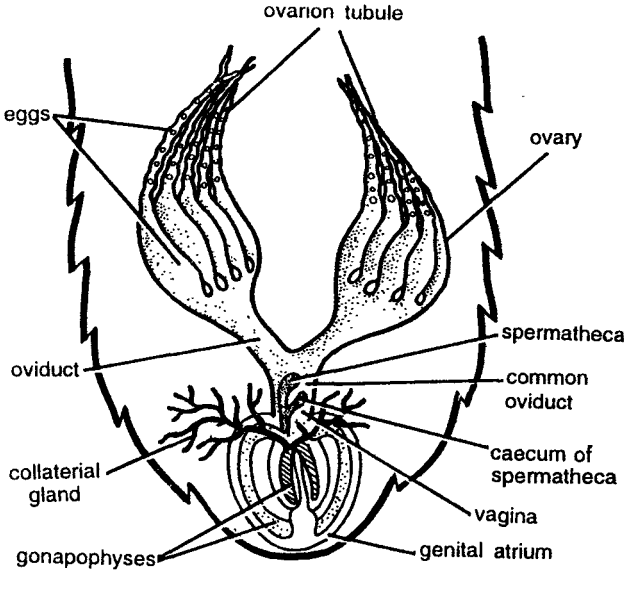


Fig. 29. *Periplaneta* : Cockroach. Female reproductive system.

A. Male reproductive system

Males are recognised by additional pair of unsegmented **small anal styles**, present ventrally in the 9th sternum. The male system comprises of testes, vasa deferentia, seminal vesicles, ejaculatory duct, phallic gland and mushroom-shaped gland (Fig. 28).

Testes are lobular or small follicular structures generally difficult to recognise easily. Remove very carefully the fat bodies in the 5th and 6th segments. Testes are in form of rounded follicular, somewhat transparent structures. The specific gravity is higher than fat body and testes lobes sink in water in watch glass, while fat bodies float. The **mushroom-shaped gland** is very distinct and whitish in appearance. The sperms are said to be manufactured and stored in the utriculi of the mushroom-shaped gland, while cockroach remains in nymphal stage, after which the testes partially degenerate. Due to this, it may be explained why the testes are not seen in adult specimens.

B. Female reproductive system

It consists of **two ovaries**. Each ovary contains 8 **ovarioles** or **egg tubes**. Each ovarian lobe consists of upper **filiform germarium** producing ova and lower wider vitellaria producing yolk cells. Each lobe gives an **oviduct** and all the **oviducts** combine to form **common oviduct**, which opens into **vagina**. Vagina leads into **genital chamber**, containing **collaterial gland**, **gonapophyses** and **spermatheca** (Fig. 29).

Instructions : *Draw the diagrams of your dissection with the help of the practical book.*

11. *Poecilocerus* or *Schistocerca* : Grasshopper or Locust

[I] General anatomy

Procedure : *Take either preserved or freshly chloroformed grasshopper. Fix it in the dissecting dish. Cut the lateral membranes between terga and sterna. Remove carefully the cut tergal plates over thorax and head region to study the following systems.*

[II] Digestive system

Consists of following parts :

(1) **Mouth :** Lies in pre-oral cavity and is bounded by **labrum**, **clypeus**, **mandibles** and **maxillao**. **Hypopharynx** lies in pre-oral cavity (Fig. 30).
(2) **Pharynx :** Mouth leads into a **short pharynx**.
(3) **Oesophagus :** Pharynx is followed by a short **oesophagus**.
(4) **Crop :** Oesophagus enlarges into a crop which extends upto thorax. Behind crop is branched **salivary gland**. Its duct opens into mouth.
(5) **Gizzard :** Behind the crop is a small muscular gizzard.
(6) **Midgut :** Midgut starts after gizzard and it includes **ventriculus** or **stomach**. Anterior end of stomach contains cone-shaped **pouches** or **gastric caeces**.
(7) **Hindgut** or **intestine :** Stomach leads into an **intestine**. At the function of stomach and intestine there are **yellowish thread-like Malpighian tubules**. Intestine leads into colon. Colon leads to rectum which opens to outsides by anus.

[III] Reproductive system

Procedure : *Dissect the grasshopper in same manner as for general anatomy. Carefully examine the male and female reproductive systems. Females are distinguished from the males by the presence of ovipositor at the posterior end of abdomen. Dissect separately male and female insects.*

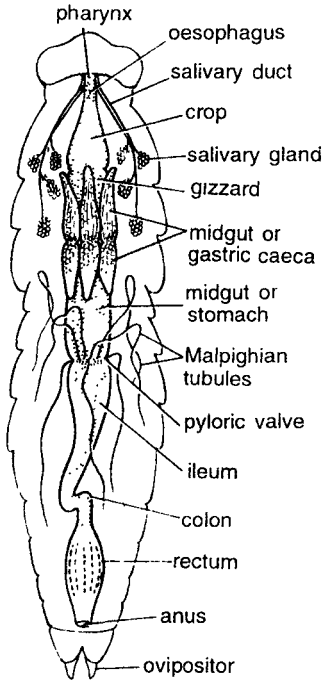


Fig. 30. Grasshopper. Digestive system.

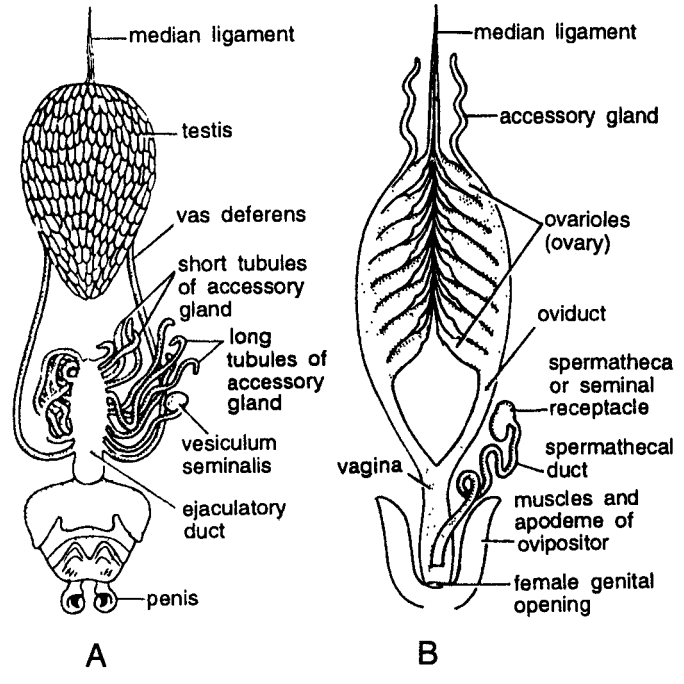


Fig. 31. A. Grasshopper. Male reproductive system. **B.** Grasshopper. Female reproductive system.

A. Male reproductive system

It consists of following parts (Fig. 31) :

(1) **Testes : Two testes** lie in **fourth, fifth** and **sixth abdominal segments**. Each testis consists of a series of slender tubules or follicles.

(2) **Vasa deferentia :** Each testis leads into **vasa efferentia**. The vasa efferentia unite to form two **sperm ducts** or vasa deferentia.

(3) **Ejaculatory duct :** The sperm ducts open into a wide duct, called as **ejaculatory duct**.

(4) **Penis :** The ejaculatory duct opens to the exterior through **penis**.

(5) **Accessory glands** and **seminal vesicle :** On both sides of ejaculatory duct are a number of **accessory glands**. Associated with accessory glands is a much longer and wider tube called as **seminal vesicle** for storage of spermatozoa.

B. Female reproductive system

Consists of the following parts :

(1) **Ovaries : Two ovaries** are located over the intestine and connected to dorsal body wall by an **ovarian ligament**. Each ovary contains 8 **ovarioles**. Each ovariole contains developing ova arranged in a linear row.

(2) **Oviduct :** Each ovary leads into an oviduct.

(3) **Vagina :** The two oviducts open into a wide muscular **vagina**. **Vagina** opens to outside through the genital opening between the plates of the ovipositor.

(4) **Seminal receptacle** or **spermatheca :** From vaginal pore arises a small tube which communicates with a storage chamber called seminal receptacle.

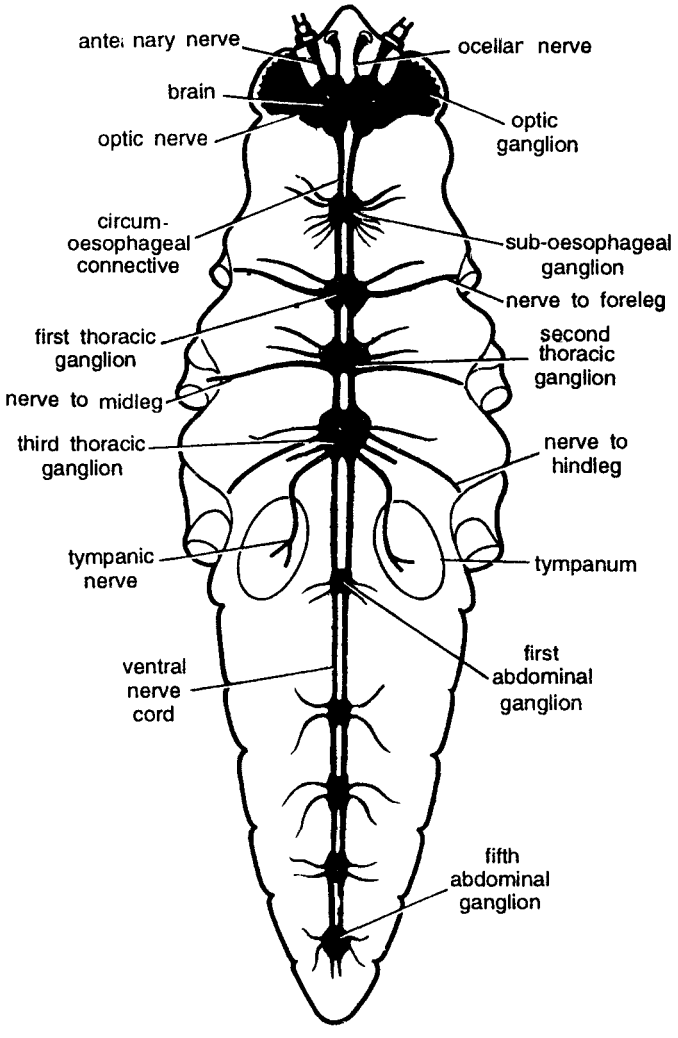


Fig. 32. Grasshopper. Nervous system.

(5) **Accessory** or **collateral glands** : Lying in front of each **oviduct** is elongated and curved accessory glands. They secrete a cement like substance that holds the eggs together when laid.

[IV] Nervous system

Procedure : *Take a freshly chloroformed or preserved grasshopper, cut the wings and fix the animal with dorsal side upwards. Make incision in pleura and remove the tergal sclerites. Remove terga in head region. Now carefully remove the viscera and expose as clearly as possible the entire nervous system. Start from posterior side and gradually trace the nerve cord up to brain. Observe the following parts*: Entire nervous system is divided into 3 parts :

1. The central nervous system : It consists of a dorsal brain or supra-oesophageal ganglia situated above oesophagus between eyes and connected to ventral sub-oesophageal ganglion by circum-oesophageal connectives (Fig. 32).

Sub-oesophageal ganglion is formed by the fusion of mandibular, maxillary and labial ganglia. It gives rise to double ventral nerve cord which extends upto posterior region and shows the following thickenings or ganglia :

(1) **First thoracic ganglion.**
(2) **Second thoracic ganglion.**
(3) **Third thoracic ganglion,** and
(4) **Five pairs of abdominal ganglia.**

2. Peripheral nervous system : The following nerves arise from central nervous system :

(1) A pair of **optic nerves** originates from optic lobes and supplies to **large compound eyes.**
(2) **Ocellary nerves :** They innervate ocelli.
(3) A pair of **antennary nerves** originates from brain and supplies to **antennules.**
(4) **Walking leg nerves.** They originate from thoracic ganglia.
(5) **Abdominal nerves** arise from abdominal ganglia and supply to various organs.

3. Sympathetic nervous system : It includes occipital ganglion, frontal ganglion and ingluvial ganglion, which are associated with brain and control involuntary actions of alimentation, heart ganglion, frontal aorta and genital organs.

Instructions : *Draw the diagram of your dissection with the help of the practical book.*

12. *Palaemon malcolmsonii* : Prawn

[I] External features

It is common. Indian fresh-water prawn, which forms a highly palatable dish. Prawn is the most favourite and well-liked animal by the students.

(1) **Total length :** 25 to 35 cm.
(2) **Shape :** Spindle-shaped, elongated and bilaterally symmetrical.
(3) **Colour : Pale blue** or greenish it becomes orange-pink on preservation in formalin or on boiling.
(4) **Exoskeleton :** It forms a ring around the segment. On dorsal side, the exoskeleton is in the form of a convex shield, called as **tergum**; the downward projection of tergum is called as **pleuron** and ventral shield is called as **sternum.** The hardened pieces or **sclerites** and segments of the appendages are joined together by soft articulating membranes, called as arthrodial membranes.
(5) **Divisions of the body :** The body of the animal is composed of nineteen appendage-bearing segments. It is regionated into anterior (i) **cephalothorax** and **posterior** (ii) **abdomen.** Abdomen is slightly flexed.
   (a) Cephalothorax : It is large, rigid, unjointed and cylindrical in shape and is formed by 5 **appendage-bearing head segments** and 8-**appendage-bearing thoracic segments.** Exoskeleton of cephalothorax is formed by carapace, which is dorsally and anteriorly produced into a serrated rostrum. On the sides, carapace hangs freely and covers gills and is called as **branchiostegite plate.** At the base of rostrum, there is a pair of pedicellate large **compound eyes.** Cephalothorax has 13 **pairs of appendages.**
   (b) Abdomen : It is jointed and consists of 6 **movable segments** and a terminal conical tail plate or **telson.** Abdominal segments are dorsally rounded, laterally compressed and flexed or bent under cephalothorax. Each abdominal segment bears a pair of **pleopods** or **swimmerets.**

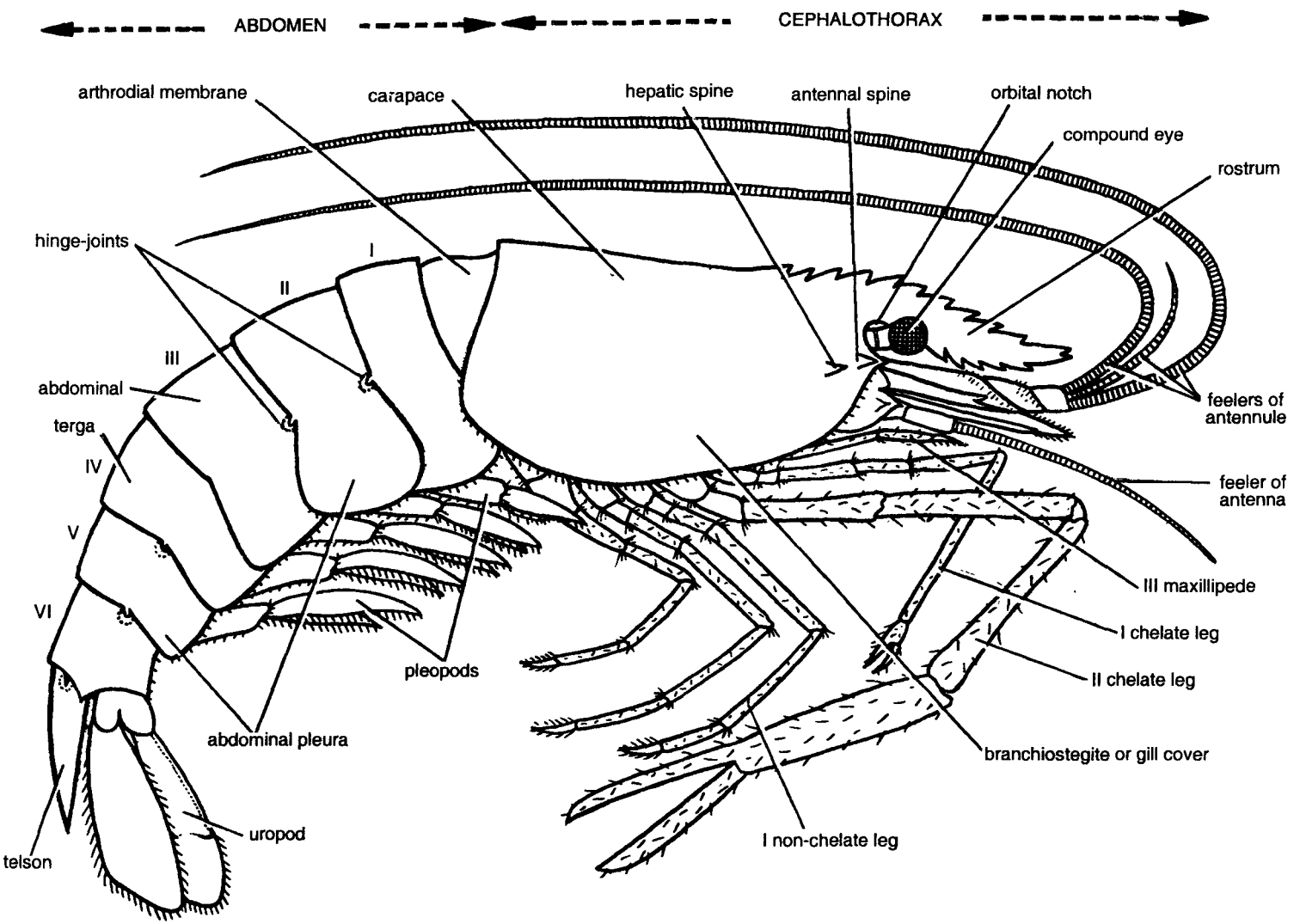


Fig. 33. *Palaemon* : Prawn. External features in lateral view.

[II] Appendages

Instructions : *Study and draw the following appendage (19 pairs) as shown serially in* figure 34.

A. Cephalic appendages (Fig. 35).

(1) **Antennule :** It is sensory and tactile in function and contains inner and outer feelers, **basis, coxa, precoxa** and **stylocerite**. Precoxa contains statocyst and is large. The basis is longer than coxa and carries 2 long sensory feelers. Outer feeler is divided into 2 unequal branches.

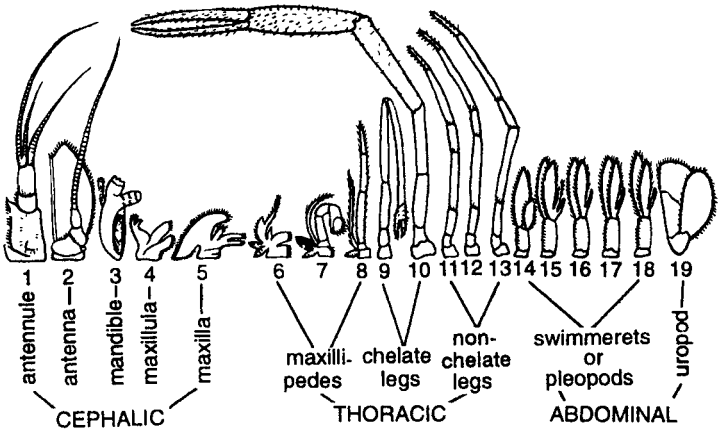


Fig. 34. *Palaemon* : Prawn. Serial arrangement of appendages (19 pairs).

(2) **Antenna :** It is sensory, excretory and balancing, and it consists of **coxa** and **basis** which bears an expanded leaf-like exopodite, called as **squama**, and a long narrow feeler.

(3) **Mandible :** Mandibles are short and stout, lying one on each side of the mouth. It is masticatory in function and consists of coxa. The coxa is densely calcified to form powerful jaws. Its proximal part is spoon-shaped, having cavity for muscle insertion and is called as apophysis, while the distal part is called as head. Head contains stout molar process and a flat plate-like incisor process. Its outer border also contains a 3-jointed **mandibular palp**.

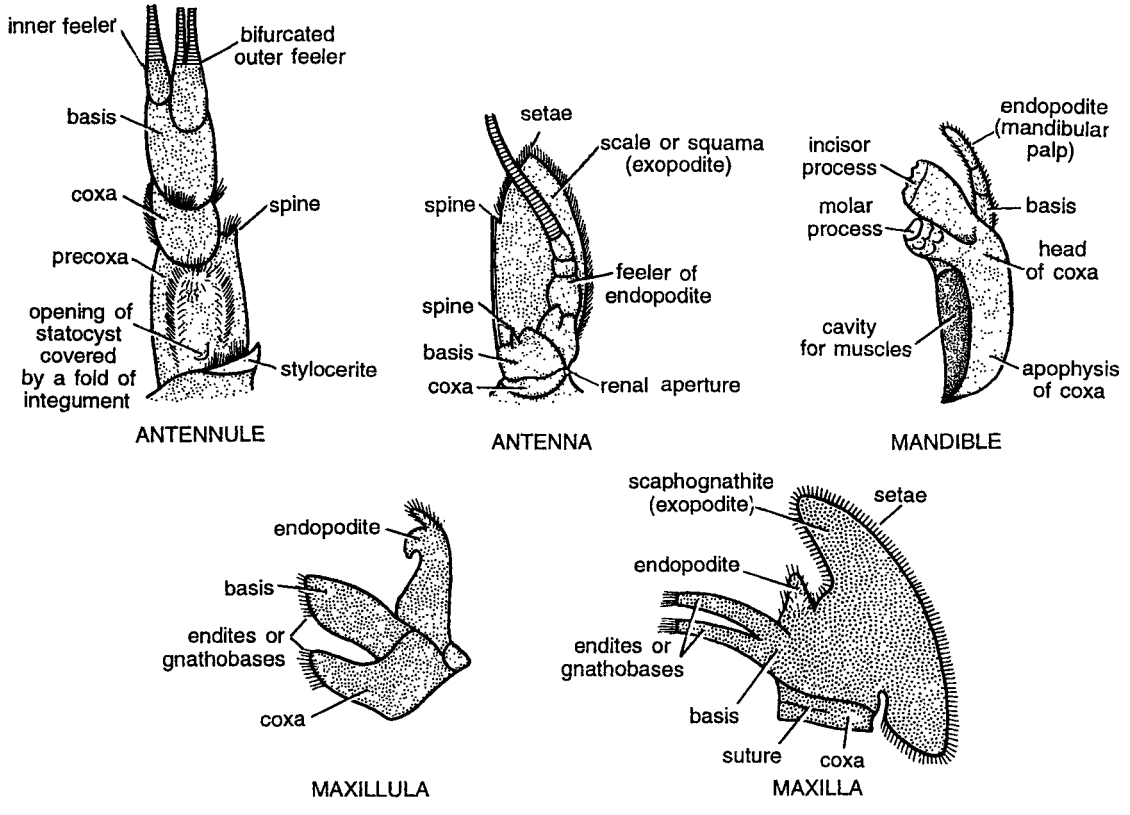


Fig. 35. *Palaemon* : Prawn. Cephalic appendages.

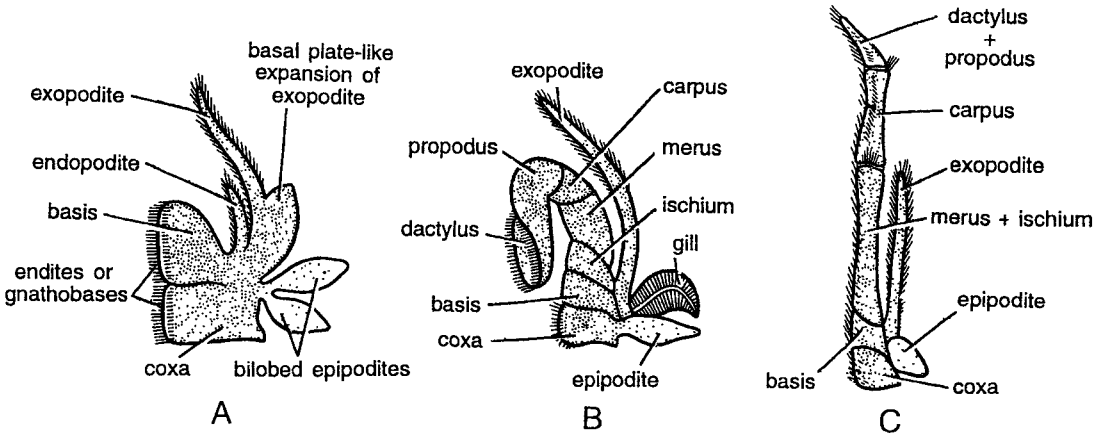


Fig. 36. *Palaemon* : Prawn. Maxillipedes.

(4) **Maxillula :** It also helps in **manipulation of food** and consists of **coxa, basis, gnathobases** and **endopodite.**

(5) **Maxilla :** This manipulates food and is composed of **coxa, basis, gnathobases** and **endopodite.** The exopodite is large and forms a fan-shaped structure, called scaphognathite. It is also respiratory in function.

B. Thoracic appendages

It comprises of anterior 3 pairs of **maxillipedes** and **posterior 5 pairs of walking legs** (Fig. 36).

(1) **First maxillipede :** (i) It is formed by flattened, leaf-like **coxa** and **basis,** (ii) Coxa contains a bilobed leaf-like **epipodite** (iii) **Endopodite** is small and unsegmented. (iv) The **exopodite** is also unsegmented but is elongated, with a basal plate-like expansion.

(2) **Second maxillipede :** (i) It comprises of **coxa** and **basis.** It is not so flattened, (ii) Coxa is short and contains a small **epipodite** and **gill** on outer side and setae on inner side, (iii) Basis is jointed to ischium of endopodite. (iv) Endopodite comprises of 5 **segments** namely **ischium, merus, carpus, propodus** and **dactylus.** (v) **Exopodite** is elongated and contains setae.

(3) **Third maxillipede :** (i) It is leg-like and comprises of **coxa and basis,** (ii) Coxa has a small epipodite on its outer side and basis bears a slender unjointed **exopodite** and an elongated **endopodite.** (iii) The endopodite is composed of 3 podomeres, proximal podomere fused with merus, middle carpus and terminal one fused with dactylus. (iv) Setae are found all along exopodite and on inner margin of **endopodite.**

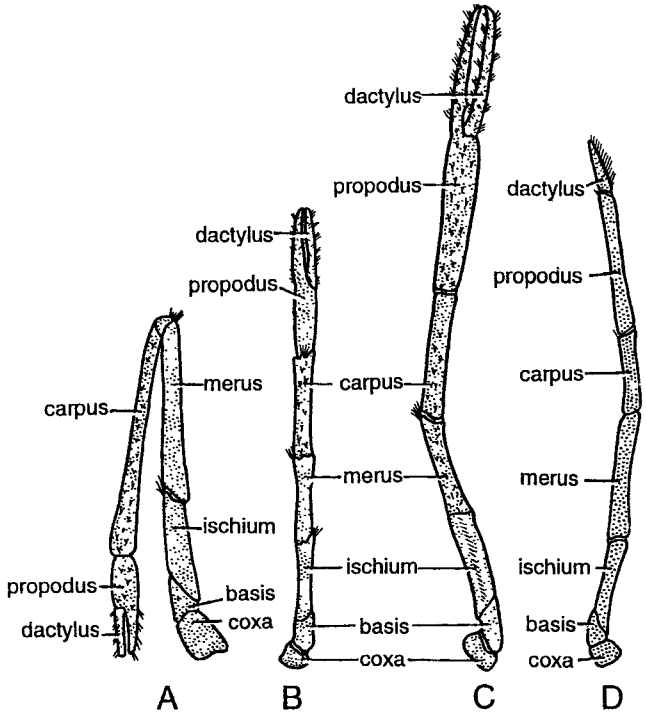


Fig. 37. *Palaemon* : Prawn. Walking legs. **A.** Typical (4th) non-chelate legs, **B.** Ist chelate leg, **C.** 2nd chelate leg of female, **D.** 2nd chelate leg of male.

(4) **Typical leg :** (i) There are 5 pairs of walking legs differing from maxillipedes in the absence of exopodite and endopodite and also greater in size, (ii) A typical leg or 4th leg consists of 2-jointed **protopodite and a 5-jointed endopodite**. (iii) All the seven podomeres namely **coxa, basis, ischium, merus, carpus, propodus and dactylus,** are arranged in linear series and hinged together (Fig. 38).

(5) **First chelate leg :** (i) In this, the propodus is prolonged beyond its articulation with the dactylus, so that 2 podomeres work one against the other like forceps blades forming chela or pincer. These legs are called as cheliped or chelate legs, (ii) **Setae** cover the entire surface.

(6) **Second chelate leg :** (i) All podomeres are considerable elongated, (ii) In males, it is more powerful than in female. Third, fourth, and fifth pairs of legs are **non-chelate** and typical. In males, each fifth leg bears a male genital aperture on the arthrodial membrane between leg and thorax. In females, the genital aperture is found on the inner side of the coxa of third leg.

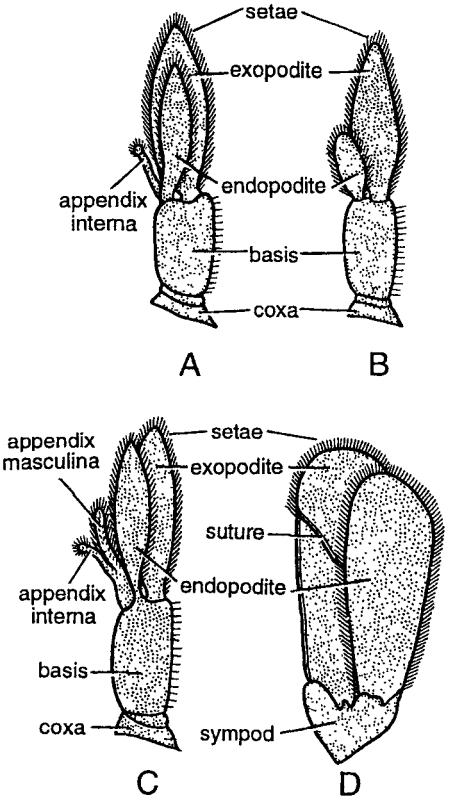


Fig. 38. *Palaemon* : Prawn. Abdominal appendages (pleopods), **A.** Typical, **B.** First, **C.** 2nd of male, **D.** Uropod.

C. Abdominal appendages

There are **six pairs of abdominal appendage**. These are typical **biramous appendages**, one pair in each abdominal segment. They help in **swimming** and hence called as swimmerets or **pleopods** (Fig. 38).

(1) **Typical abdominal appendages** (3rd appendages) **:** (i) The **protopodite** has ring-like coxa and a **cylindrical basis**, (ii) The basis bears flattened leaf-like smaller **endopodite** and a larger **exopodite**. (iii) From inner basal margin of endopodite, a small knob-headed rod-like structure arises, called as **appendix interna**. (iv) In female, the appendix interna of opposite appendages articulate with each other forming bridges to carry the eggs, (v) The outer surface of basis and margins of exopodite and endopodite contain several setae, (vi) Remaining appendages slightly differ from typical ones.

(2) **First abdominal appendage :** Appendix interna absent and endopodite greatly reduced.

(3) **Second abdominal appendage :** In males only, in addition to appendix interna, there is additional **rod-like** and **setae-bearing process called as appendix masculina**, found between appendix interna and endopodite.

(4) **Uropods :** Sixth pair of appendages are called **uropods** lying one on either side of telson. In each uropod, coxa and basis are fused together to form a triangular sympod. **Endo** and **exopodites are oar-like** and their margins bear setae. Exopodite is bigger than endopodite and incompletely divided in the middle by a transverse suture.

Instructions : *Draw the diagrams of the appendages with the help of the practical book.*

[III] General anatomy

Procedure : *Take the specimen in hand or dish and lift carapace from lateral side. Cut loose the carapace at its anterior margin to remove it completely. Remove all the abdominal terga and pleura with scalpel and forceps and expose the abdominal muscles. Pin the specimen in dissecting dish and study the various organs* (Fig. 39 and 40). *Figure 39 shows general anatomy (various organs) in lateral view while figure 40 depicts the general anatomy dissected in dorsal view.*

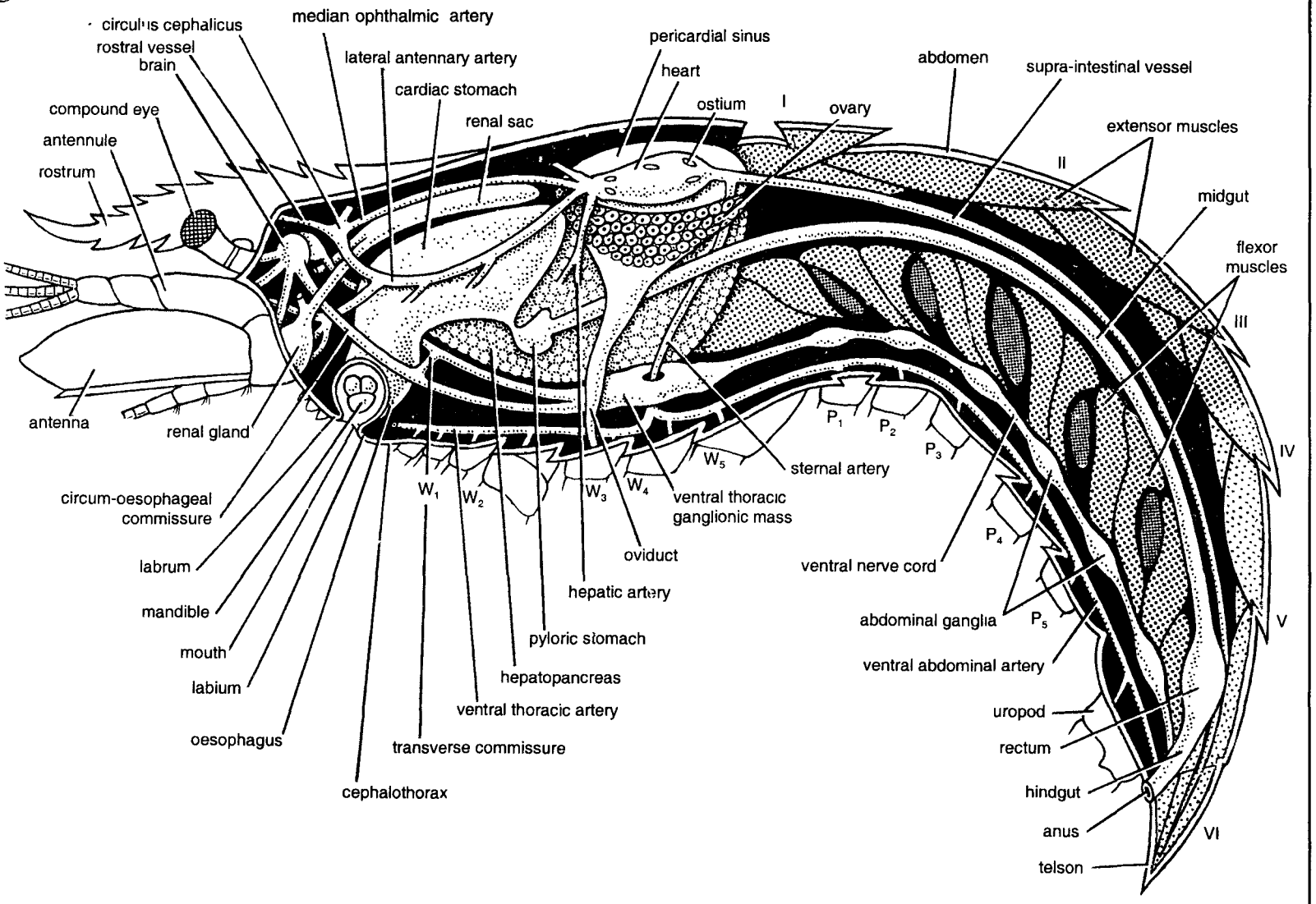


Fig. 39. *Palaemon* : Female Prawn. Dissection of general anatomy in lateral view.

Procedure : Reproductive organs : *To expose the gonads fully, remove the heart and two narrow longitudinal extensor muscles.*

Procedure : Digestive system : *Remove completely the gonads to expose digestive system. The stomach is found just beneath carapace, embedded in large digestive gland. The intestine is a narrow tube present in the groove of abdominal muscles. For* **hastate plate** or **gastric mill**, *cut the stomach at both ends and make a dorsal incision on the dorsal side. Spread it flat, clean, wash and then see its teeth and comb etc. with the lens.*

Procedure : Nervous system : *For nervous system first expose the nerve cord in the abdominal region. For this, cut medianly with the scalpel between the large flexor muscles. Press these muscles and pin them in the dissecting tray. As the muscles are stretched, the nerve cord is very clearly seen with ganglionic swellings. Proceed from posterior side, cutting the middle line with the scissors through the chitinous endophragmal skeletal plates found on the ventral side of the thorax and exposing underlying nerves till brain is exposed. Study the various parts.*

Musculature : It occupies greater part of the body segmentally arranged and inserted on the inner surface of the cuticle and its internal foldings called apodemes. The cut muscles of the abdomen are very clear, (i) **Extensor muscles** for straightening abdomen, (ii) **Flexor muscles** for bending abdomen, (iii) Muscles for **moving appendages** and for alimentation are also found.

Digestive system : It is well developed with associated glands and is divided into three regions : Foregut, midgut and hindgut.

The **foregut** consists of the following parts :

(a) ***Mouth*** **:** It is a large aperture on the ventral side of the head bounded by **labrum**, **mandible** and **labium**.

(b) ***Buccal cavity*** **:** Mouth leads into a short **buccal cavity**.

(c) ***Oesophagus*** **:** It is a short duct arising from buccal cavity and it communicates with stomach. It extends upwards.

(d) ***Stomach*** **:** It is a wide chamber consisting of cardiac and pyloric parts. Ventrally stomach is surrounded by orange-red hepatopancreas. Internally cardiac stomach shows cuticular thickening called as hastate plate.

The midgut is a very short and slender duct, which ascends between hepato-pancreas to extend backwards.

The hind gut extends from midgut up to anus. The terminal part is modified as rectum.

Circulatory or vascular system : If consists of pericardium heart and blood vessels. Arteries are **ophthalmic**, **antennary**, **hepatic**, **sternal**, **supra-intestinal**, **thoracic** and **ventro-abdominal**.

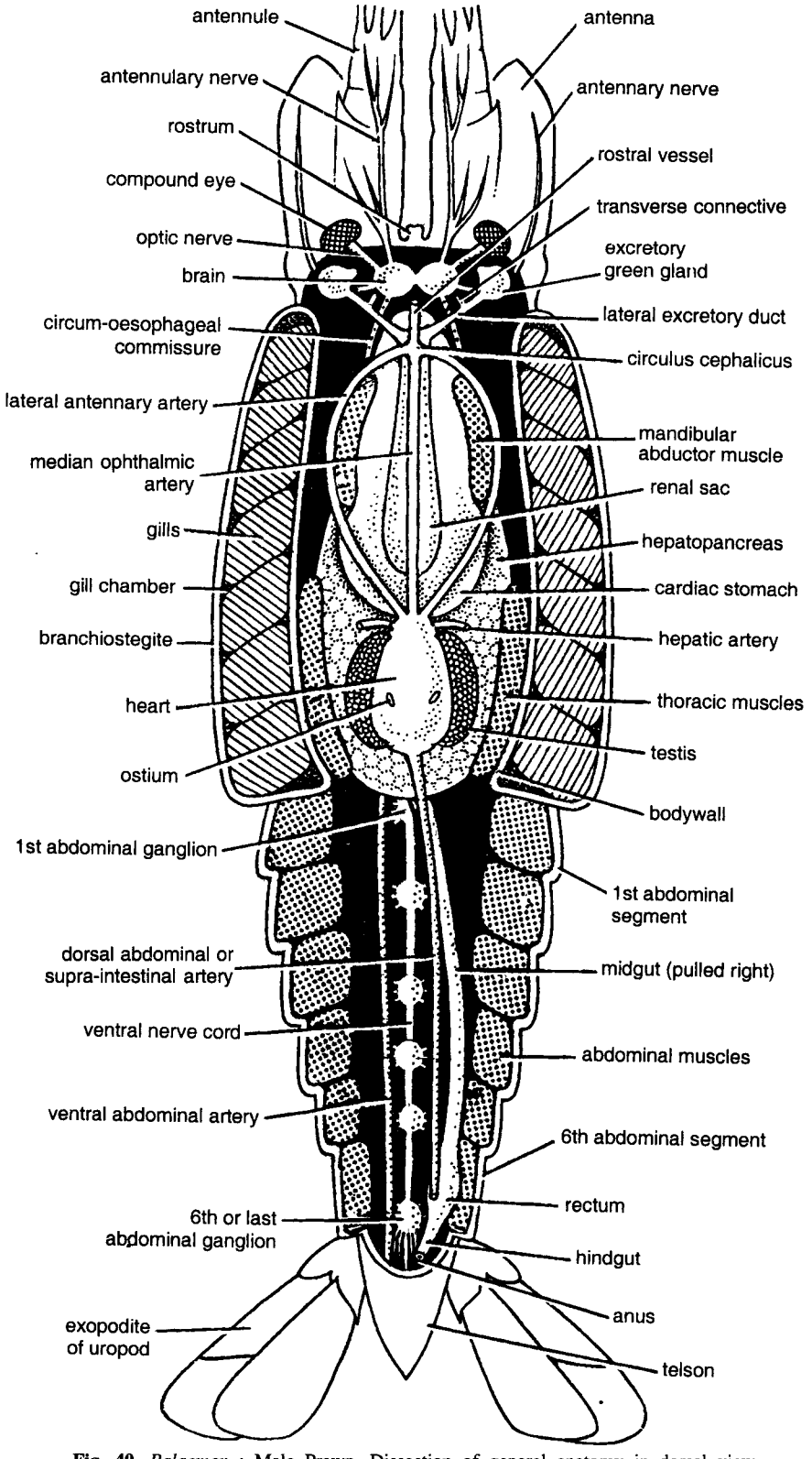
Excretory organs : Renal glands.

Nervous system : It consists of well-developed nerve cord and brain.

Other structures : (1) Parts of **appendages**, **uropods**, **telson**, eyes, **gills** (pleurobranchial), arthrobranchial and podobranchial) and gonads.

(2) Various structures seen in section of lateral view are rostrum, antennule, compound eye, brain, rostral vessel, circulus cephalicus, median ophthalmic artery, lateral antennary artery, cardiac stomach, renal sac, pericardial nerve, heart, ostium, ovary, abdomen, supra-intestinal vessel, extensor muscle, midgut, flexor muscle, telson, anus, hind gut, rectum, uropod, ventral abdominal artery, abdominal ganglia, ventral nerve cord, sternal artery, ventral thoracic ganglionic mass, oviduct, hepatic artery, pyloric stomach, hepatopancreas, ventral thoracic artery, transverse commissure, cephalothorax, oesophagus, labium, mouth, mandible, labruus, circum-oesophageal commissure, renal gland and antenna.

(3) Various structures seen in dissection of general anatomy in dorsal view are antenna, antennary nerve, rostral vessel, transverse connective excretory duct, circulus cephalicus, mandibular adductor muscle, renal sac, hepatopancreas, cardiac stomach, hepatic artery, thoracic muscles, testis, body wall, 1st abdominal segment, midgut, abdominal muscle, 6th terminal segment, rectum, hind gut, anus, telson, exopodite of uropod, last abdominal ganglia, ventral abdominal artery, dorsal supra-intestinal artery, 1st abdominal ganglia, ostium, heart, branchiostegite, gill chamber, gills, median ophthalmic artery, lateral antennary artery, circum-oesophageal commissure, brain, optic nerve, compound, eye, rostrum antennary nerve and antennule.



(Z–20)

Fig. 40. *Palaemon* : Male Prawn. Dissection of general anatomy in dorsal view.

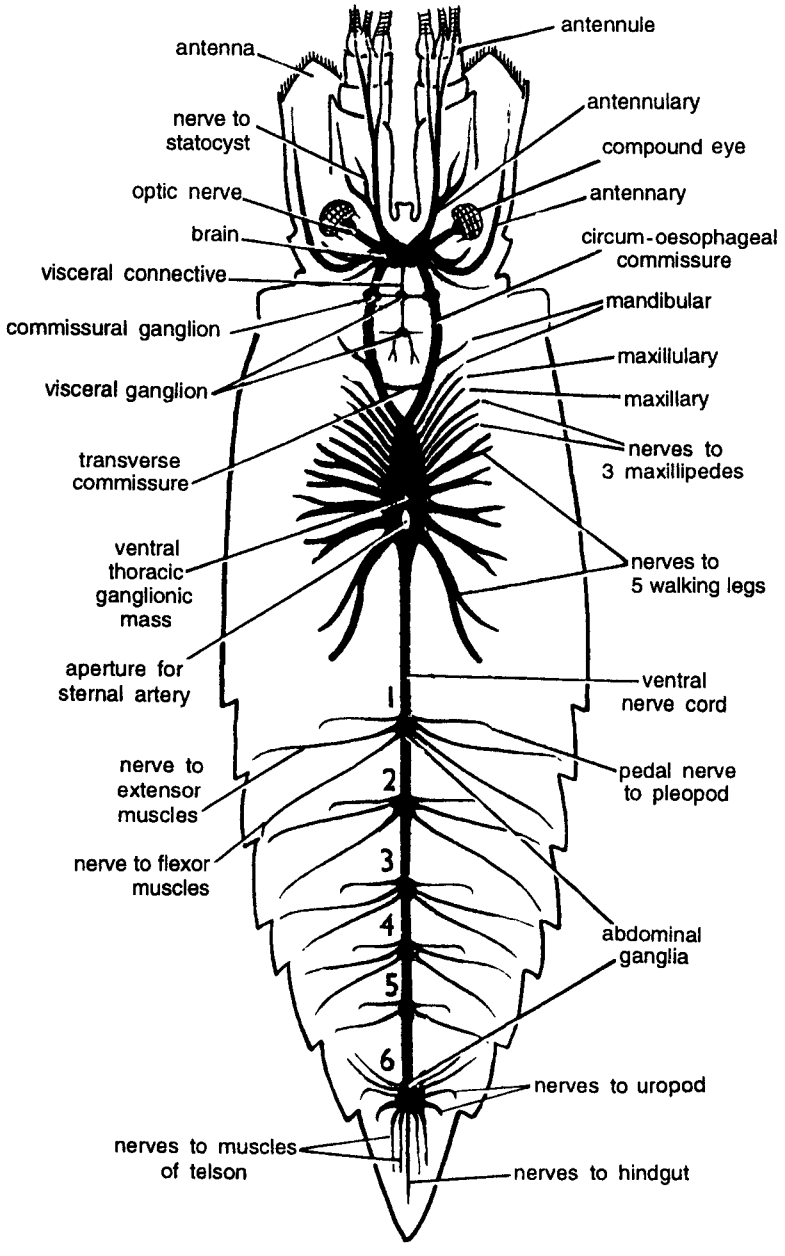


Fig. 41. *Palaemon* : Prawn. Nervous system.

Instructions : *Draw the diagram of the general anatomy with the help of the practical book.*

[IV] Nervous system

The nervous system of ***Palaemon*** **is the most favourite dissection of the students.** It comprises of :

(1) **Brain** or **supra-oesophageal ganglia :** It is a bilobed ganglion, situated at the base of rostrum. On each side, brain gives **antennulary nerve** to antennule, **optic nerve** to **compound eye**, **statocystic nerve** to statocyst, **antennary nerve** to antenna and **tegumental nerve** to **labrum** (Fig. 41).

(2) **Circum-oesophageal commissures :** Brain gives rise to a pair of thick posterior **circum-oesophageal commissures**, which surround oesophagus and unite together ventrally with **sub-oesophageal ganglion. A transverse connective** connects the two **commissures**. The sub-oesophageal ganglion is fused with anterior part of ventral thoracic ganglionic mass.

(3) **The ventral thoracic ganglionic mass :** It is formed by the fusion of eleven **segment a cephalothoracic ganglia**, which consequently gives 11 **'pairs of nerves'**. The first three pairs **innervate** the **mandibles**, maxillulae and maxillae; the next 3 pairs supply to 3 pairs of maxillipedes and the remaining 5 pairs of nerves **supply to walking legs**.

(4) **The ventral nerve cord :** It runs in the abdomen, forming 6 ganglionic masses, from where nerves are given out to **pleopods**, **musculature** and **uropods**.

Instructions : *Draw the diagram of dissection of nervous system with the help of practical book.*

13. *Squilla*

[I] External features

Squilla is a marine crustacean found in burrows of sandy bottom. It is found in India. Take a preserved specimen and study the external features, draw both dorsal and ventral surfaces. Disarticulate appendages, study and draw.

Body is whitish, semi-transparent and differentiated into cephalothorax, and abdomen. Carapace is small and flattened structure. Rostrum is movable. Last four thoracic segments are free. Head appendages are bilobed antennae, antennules and eyes. Abdomen consists of 6 segments. First five pairs of thoracic appendages are maxillipedes. The second maxillipede is sub-chelate and raptorial. Last three thoracic segments beat walking legs. Abdomen has pleopods. Telson is broad and flattened.

[II] Nervous system

Procedure : *Take as nicely preserved specimen and pin it on the dissection dish. Make two incisions dorsally over the tergum on each side. Remove the middle portion of tergum. Remove muscles and fat bodies and expose a portion of the nerve cord in the abdomen and trace backwards and in the anterior region. The cephalothorax should be completely removed. Proceed gradually anteriorly upto ventral thoracic ganglionic mass then circum-oesophageal commissure leading upto brain. Expose the brain carefully. After tracing complete nerve cord trace various branches. Expose and study the following ganglia and nerves :*

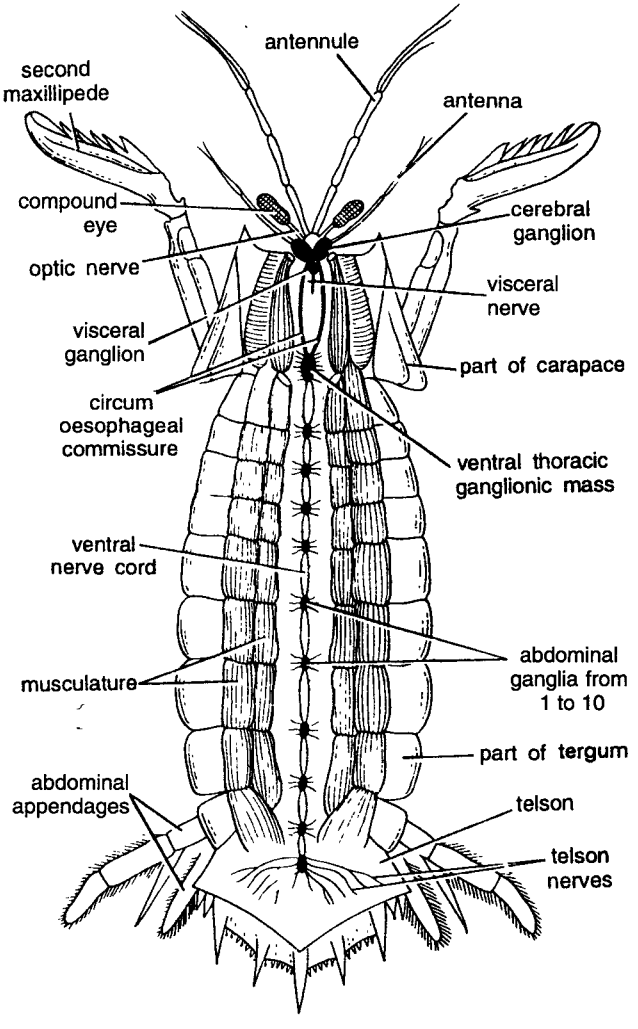


Fig. 42. *Squilla.* Nervous system.

(1) **Brain** or **supra-oesophageal ganglion** : From, brain following nerves originate :
   (a) A pair of antennulary nerves : They originate from brain and innervate antennules.
   (b) A pair of optic nerves : They originate from brain innervating eyes.
   (c) A pair of antennary nerves : Originating from the ventral surface of brain and innervating **antennae**.

(2) **Circum-oesophageal commissures** : Originating separately from the hind end of the brain descend along the side of the oesophagus to meet as ventral thoracic ganglionic mass.

(3) **Ventral thoracic ganglionic mass** : From this mass nerves innervate to **maxillipede**, **chellipede** and other **cephalic appendages**.

(4) **Free thoracic ganglia** : Just behind ventral thoracic ganglia are three thoracic ganglia which innervate to each **walking leg**.

(5) **Ventral nerve cord** : The first five abdominal ganglia innervate **swimming appendages** and **muscles** while sixth abdominal appendage gives three pairs of **nerves to telson**.

Instructions : Insert black or blue glazed paper below the nerves and place a white sheet below the animal.

14. *Paratelphusa* : Fresh-water Crab

[I] External features

Body dorsoventrally compressed and divisible into broad **cephalothorax** and stumpy **abdomen. Antennules** and eyes stalkes. Antennules and antennae small. Five **pairs of walking legs** well developed. First leg **chelate. Abdomen reduced** and fixed under **cephalothorax. Pleopods** reduced and uropods absent.

[II] Nervous system

Procedure : *Take a formalin preserved crab keeping dorsal surface facing you. Pin up all the thoracic legs. Make a mid dorsal incision in carapace from anterior to posterior end. Carefully remove carapace. Look for ventral nerve cord. Trace the brain just below oesophagus. Trace the following ganglia and nerves to various parts* (Fig. 43).

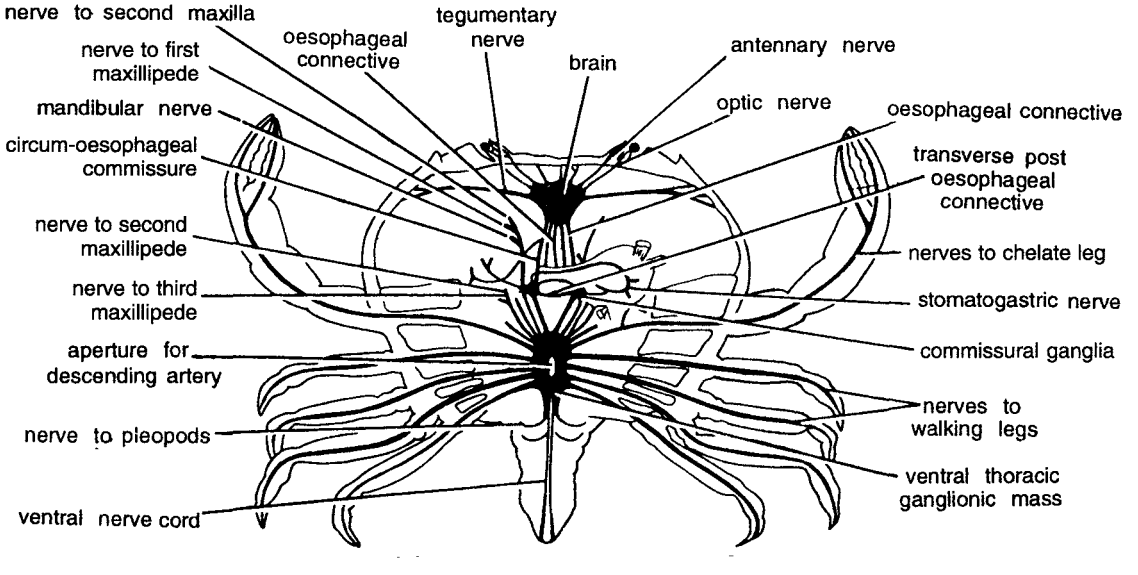


Fig. 43. Crab. Nervous system.

(1) **Brain (Supra oesophageal ganglia) :** Just below oesophagus. Trace following nerves from **brain.**
   (a) Antennulary nerves : From brain to **antennules.**
   (b) Antennary nerves : From brain to **antennae.**
   (c) Optic nerves : From brain to **optic nerves.**

(2) **Circum-oesophageal commissure :** Two nerves originate from brain, run downwards forming circum-oesophageal commissure on each side. Each commissure forms a **commissural ganglion.** Two commissured ganglia are connected by transverse nerve.

(3) **Ventral thoracic ganglionic mass :** Large oval mass in mid ventral region. It gives following nerves
   (a) Paired first maxillary nerves : To **first maxillae.**
   (b) Paired second maxillary nerves : To **second maxillae.**
   (c) Three pairs of maxillipede nerves : To respective **first, second** and **third maxillipedes.**
   (d) Gonadial nerves : To gonads.
   (e) Five pairs of walking leg nerves : One each **to leg** of respective side (Trace these nerves upto end of each leg).

[III] Ventral nerve cord

From ventral thoracic ganglia, nerve cord continues in stumpy abdomen as ventral nerve cord. Two pleopod nerve are seen. *Leave a neat dissection after black papering the each nerve.*

15. *Palamnaeus* : Scorpion

Procedure : It is a nocturnal and dangerous animal, found in the tropical and temperate regions. It is harmful to mankind. For external features, take freshly-killed specimen with chloroform vapour and observe the following :

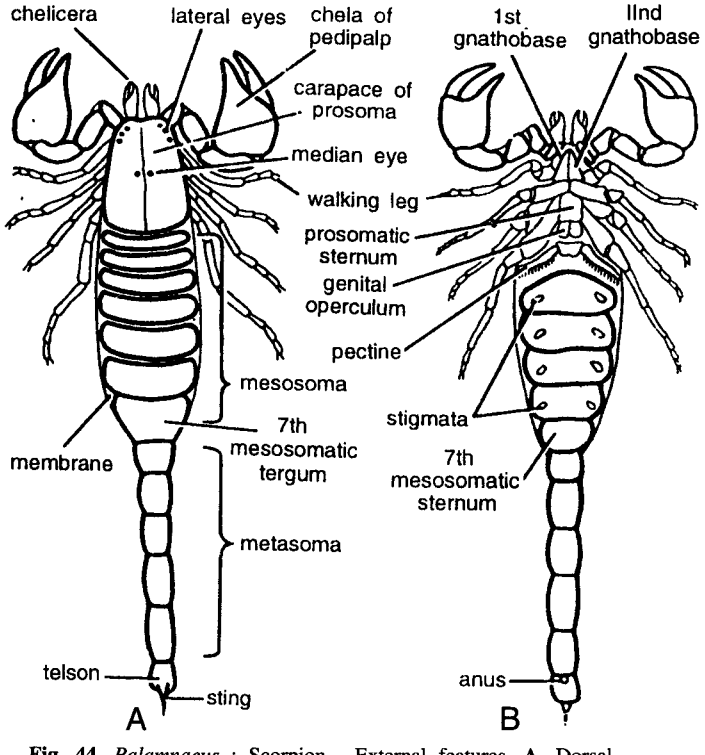


Fig. 44. *Palamnaeus* : Scorpion. External features. **A.** Dorsal view, **B.** Ventral view.

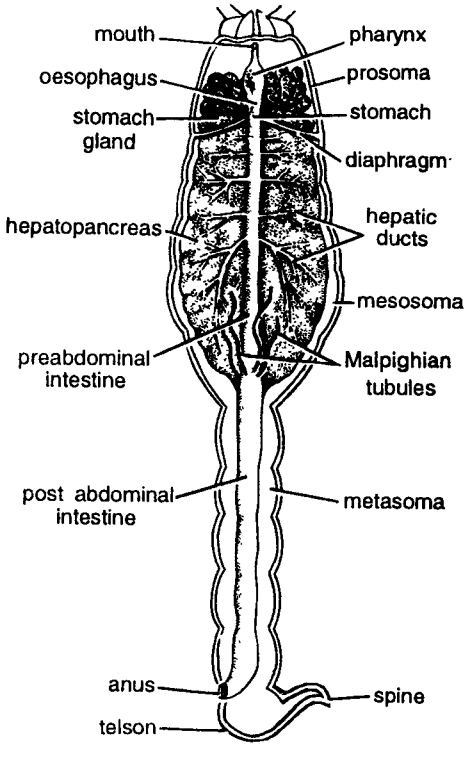


Fig. 45. *Palamnaeus* : Scorpion. Alimentary canal.

[I] External features

(1) **Size :** Approximately 7 to 9 cms.
(2) **Shape :** The body is elongated and dorso-ventrally flattened.
(3) **Pigmentation :** It varies according to environment. It may be black, dark brown or pale.
(4) **Division :** The body is divided into anterior prosoma and posterior opisthosoma; the latter is again divided into broad mesosoma and a narrow metasoma, which ends in a sting.
   (a) ***Prosoma or cephalothorax*** **:** It is covered by a dorsal shield or carapace, bearing two large median eyes and 2 to 5 pairs of lateral eyes. Mouth is small and ventral (Fig. 44).
   (b) ***Mesosoma*** **:** It consists of 6 broad segments or pre-abdomen. Exoskeleton consists of dorsal **tergum**, **ventral sternum** and **lateral pleuron**. The first segment contains genital aperture on its sternum. The second segment sternum contains a pair of pectens, longer in males than in females. The sterna of 3rd, 4th, 5th and 6th segments contain a pair of **spiracles** in each, which lead into **book-lungs**.
   (c) ***Metasoma*** **:** It comprises of 5 **limbless segments**. The last segment has a telson, which contains curved and pointed sting, the **aculeus**.
(5) **Appendages :** Six pairs are borne by **cephalothorax**.
   (a) ***A pair of chelicerae*** **:** Three-segmented; two distal segments form **chela**.
   (b) ***A pair of pedipalps*** **:** They are carried horizontally and act partly as feelers and partly as raptorial organs. Each consists of six joints, namely coxa, trochanter, humerus, branchium manus and movable finger.
   (c) ***Four pairs of walking legs*** **:** Pedipalps are followed by four pairs of walking legs. Each leg is composed of coxa, trochanter, femur, tibia and 3 tarsi, terminating with two curved claws and a third median small claw.

Instructions : *Draw labelled drawings of the scorpion as seen from dorsal and ventral aspects with the help of the practical book.*

[II] General anatomy

Procedure : *For dissection, use fresh specimens, killed with chloroform vapour. Make two longitudinal cuts with fine scissors alongwith the pleural membranes of the mesosomatic segments and proceed forward on both sides of the prosoma upto the carapace. Take the scorpion in hand and cut the terga of all segments and also remove the carapace. Fix the scorpion in dissecting dish with dorsal side upwards and pin it on legs and sterma. Remove carefully the digestive glands for genital ducts.* Study and draw the following parts :

(1) **Digestive system :** It consists of **mouth**, **pharynx** and a narrow **oesophagus**. **Oesophagus** leads into **mesenteron**, which is differentiated into the **anterior stomach** in **prosoma** and a **posterior intestine** in mesosoma. Intestine is surrounded by digestive gland (Fig. 45).
(2) **Excretory system :** It consists of (i) a pair of **coxal glands**, lying in posterior part of prosoma and open to outside on the coxa of one of the third **walking legs**, and (ii) **Malpighian tubules** consisting of two pairs of delicate and branched excretory tubules, opening into the intestine at the posterior end of the mesosoma.

Instructions : *Draw the dissection of the general anatomy with the help of the practical book.*

[III] Reproductive system

Sexes are separate. Gonads lie in the mesosoma, more or less embedded in the digestive gland.

(1) **Male reproductive system :** It consists of a pair of **testes**, lying in 3 to 6 segments in the form of tubes connected by cross branches, forming 3 chambers each. Each testis ends into sperm duct or **vas deferens**, which forms **terminal ampulla** before opening into **genital chamber** of its side. The genital chamber contains **accessory glands**, **vesicula seminalis** and is produced into **paraxial organ** containing **flagellum**. The two genital chambers open into the common genital chamber (Fig. 47).

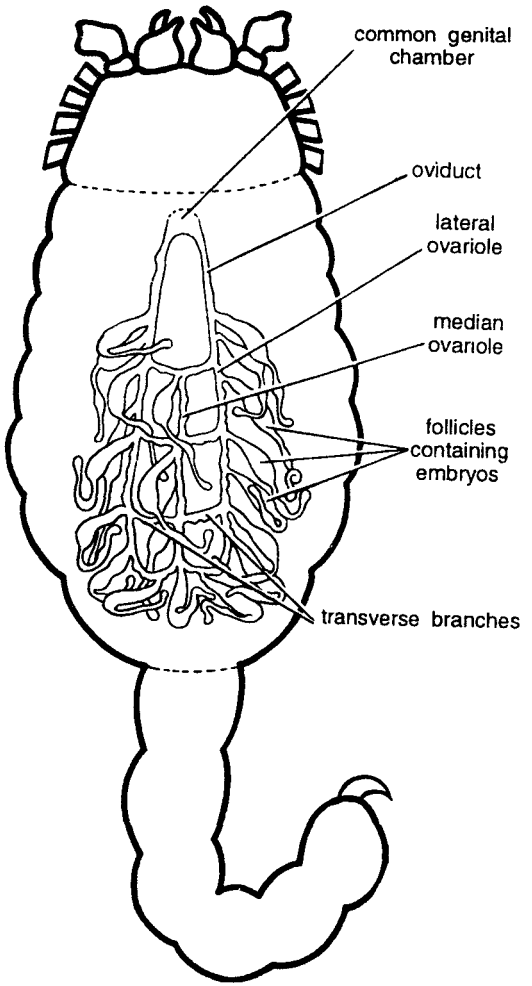


Fig. 46. Scorpion. Female reproductive system.

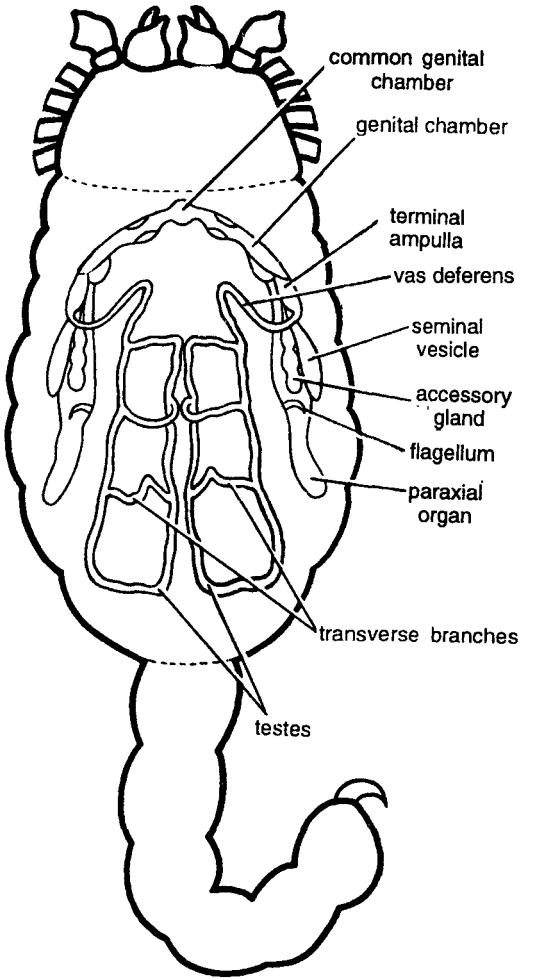


Fig. 47. Scorpion. Male reproductive system.

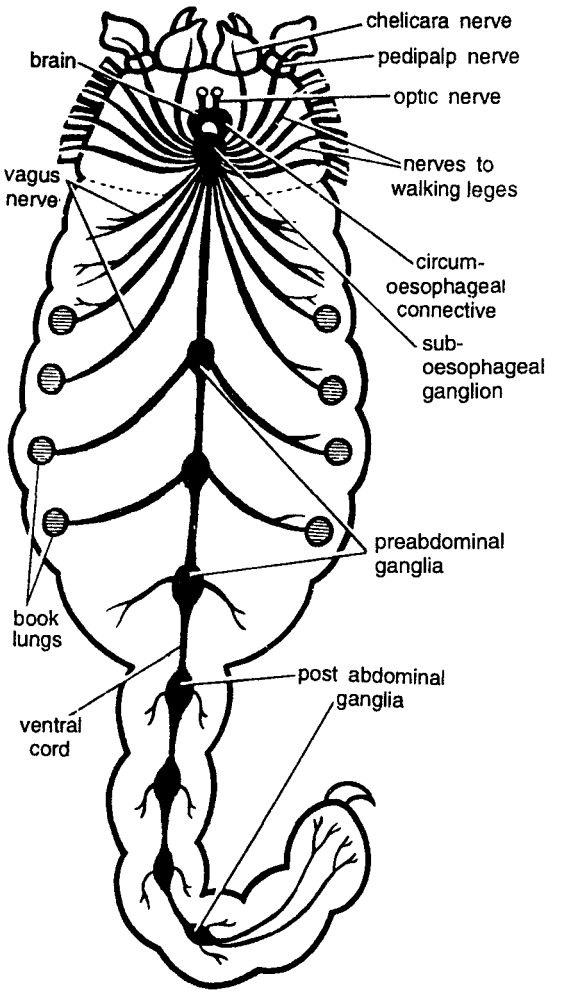


Fig. 48. Scorpion. Nervous system.

(2) **Female reproductive system :** It consists of a single **ovary** in the term of **one median** and **two lateral, longitudinal ovarioles**. The median ovariole is connected with lateral ones by **cross bars**. Ovarioles contain **several follicles**. The lateral ovarioles extend forward as oviduct, which open into common **genital chamber** (Fig. 48).

Instructions : *Draw the dissection of the reproductive system with the help of the practical book.*

[IV] Nervous system

For nervous system, remove all the glands, alimentation and genital tubes. Nervous system consists of brain, which gives two circum-oesophageal connectives which unite to form sub-oesophageal ganglion. The ventral nerve cord arises from sub-oesophageal ganglion and extends backwards, forming 3 pre-abdominal and 4 post-abdominal ganglia. The brain and nerve cord give various nerves namely cheliceral, pedipalps and optic, nerves to walking legs, vagus nerves to book-lungs.

Instructions : *Draw the dissection of nervous system with the help of the practical book.*

16. *Pentaceros* : Starfish

[I] External features

Procedure : Take a preserved specimen of starfish. Study and draw both its oral and aboral surfaces.

(1) **Aboral surface :** The body is star-shaped consisting of a central disk and 5 radially symmetrical arms. The aboral surface contains madreporite in one of the inter-radius. The arms contain definitely arranged distinct **marginal plates**. Each arm contains median row of **spines** (Fig. 49).

(2) **Oral surface :** The oral surface can be easily recognized by the mouth or actinostome and 5 **ambulacral grooves**. The **tube feet** are present in ambulacral grooves.

[II] General anatomy

Procedure : *Take a well preserved specimen. First make a circular incision around the central disk on aboral surface. Carefully remove the ossicles. Also make incision over the arms on dorsolateral sides. Don't cut near lateral margins because the marginal plates may be broken. Observe and draw the following. Care should be taken not to cut the madreporite plate.*

(1) **Digestive system : Mouth** is central which leads into a short **oesophagus**. Oesophagus leads into **stomach**. Stomach occupies much of the space of the **central disk**. Stomach contains **cardiac** and **pyloric** portions. Each angle of the pyloric chamber is prolonged into two long sacculated **pyloric caeca**. The pyloric caecae extend upto the tip of the arm (Fig. 50).

(2) **Reproductive system :** Gonads are 5 **pairs**, one pair at the base of **each arm**. The gonads (testes or ovaries) are whitish lobulated structures.The gonads open on aboral surface by 10 simple ciliated gonoducts.

[III] Water vascular system

Observe and draw the following parts :

(1) **Water ring or ring canal :** This is found around the mouth and oesophagus (Fig. 51).

(2) **Madreporite and stone canal :** The **stone canal** arises from the ring canal and communicates with madreporite. Single stone canal and single madreporite.

(3) **Polian vesicles :** In each **inter radius**, there is a sac-like polian vesicle. There are 5 **polian** vesicles arising from outer side of the water ring.

(4) **Tiedemann's bodies :** There are 5 **pairs of small glandular bodies** on the inner side of the water ring. Their function is to **produce coelomic corpuscles**.

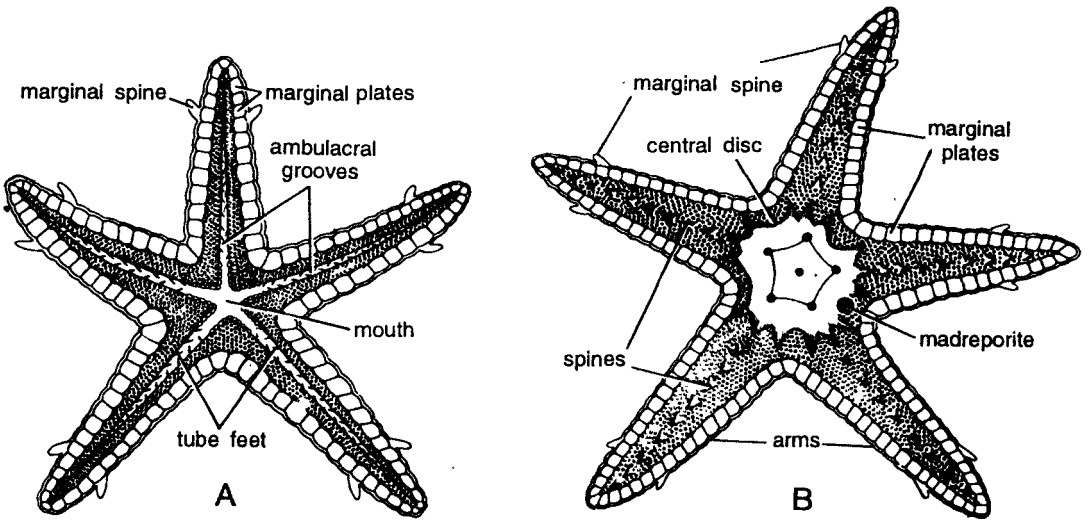


Fig. 49. Starfish. External features. **A.** Oral view, **B.** Aboral view.

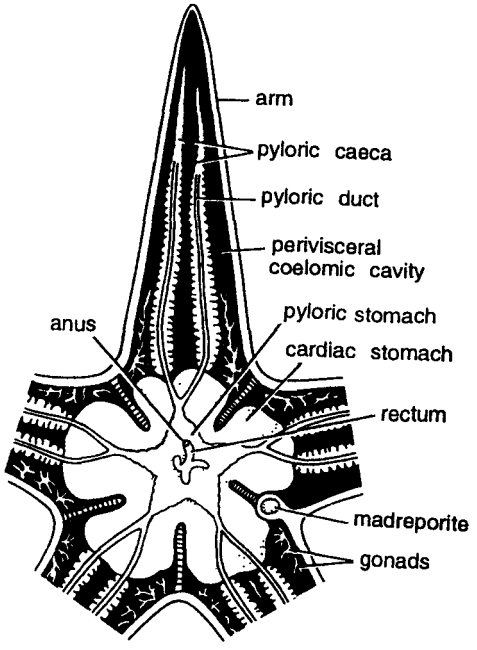


Fig. 50. Starfish. Digestive system.

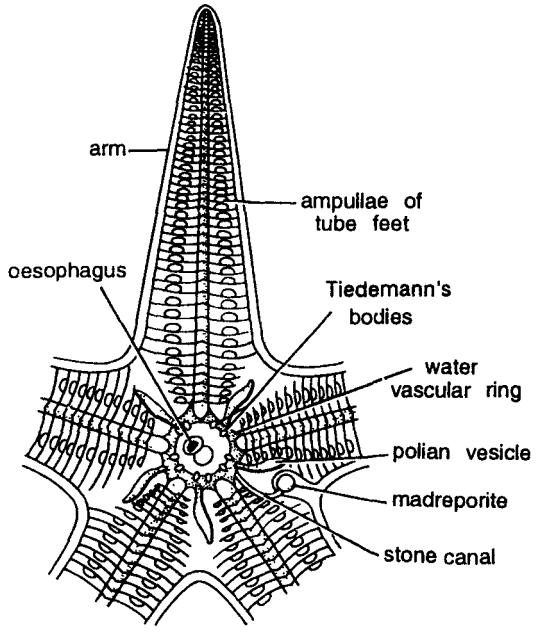


Fig. 51. Starfish. Water vascular system.

(5) **Radial canals :** From the water ring 5 **radial canals** originate which run in each arm giving podial canal to tube foot or podia.

(6) **Tube feet or podia :** In each ambulacral groove podia are seen in a row. Small and large podia alternate. Each tube foot consists of an internal swollen **ampulla** and an external **tube** which ends in a **sucker**.

17. *Echinus* : Sea Urchin

[I] Dissection of Aristotle's lantern

Aristotle's lantern is a **favourite minor dissection for post-graduate students**. Aristotle compared the masticatory apparatus of Echinus to lantern hence the name Aristotle's lantern (Fig. 52).

Procedure : *Take a well preserved Echinus. Handle it carefully because a slight pressure may break the test of the animal. With very gentle stroke on the shell by scalpel, break the shell at as shown in the diagram. The shell should be broken from aboral side. The masticatory apparatus is found around the oesophagus. If the lantern is to be taken out then carefully cut around peristonial membrane and take out the apparatus intact with teeth and muscles. Observe and draw the following parts :*

(1) **Pyramids** : A pair of large **V-shaped structures** fused together.
(2) **Teeth** : One tooth to each pyramid. **Teeth** protrude during feeding.
(3) **Rotulae** : Beam-like resting on the aboral surfaces of two adjacent pyramids.
(4) **Compasses** : Y-shaped on top of **rotulas**.
(5) **Muscles** : Five pairs of each of the following kinds :
   (a) ***Protractors*** : Between **pyramids** and **apophyses**.
   (b) ***Cumminators*** : Between adjacent pyramids for moving the teeth.
   (c) ***Posturals*** : Alongwith **protractors**.
   (d) ***Circumferential compass muscles*** : They join adjacent compasses and forming a pentagonal. Pattern on the aboral face of the lantern.
   (e) ***Radial compass*** : Joining each compass to apophyses.

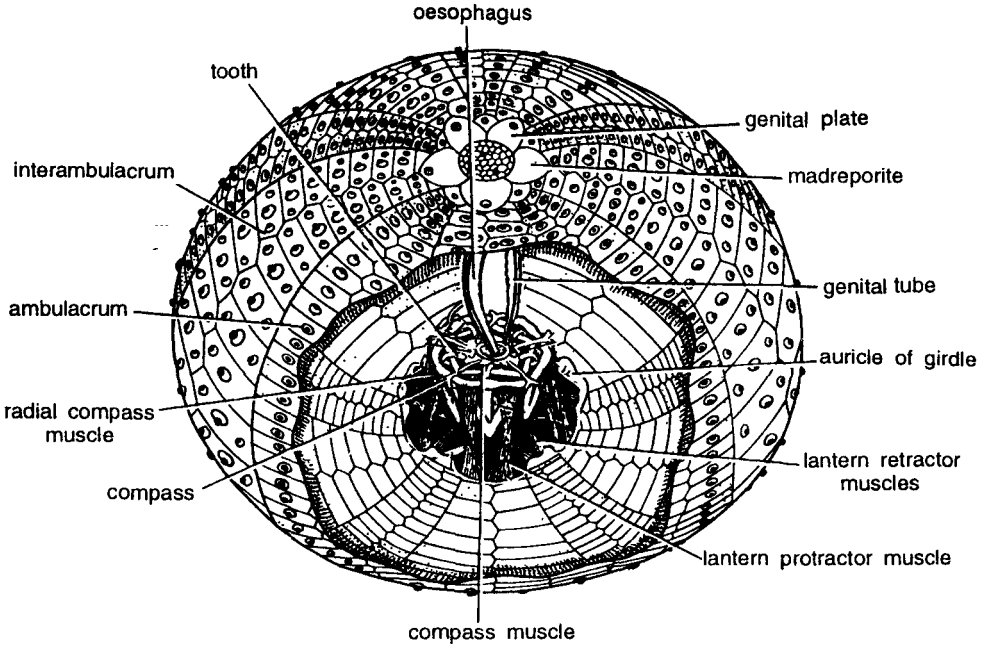


Fig. 52. *Echinus.* Dissection of Aristotle's lantern.

18. *Holothuria* : Sea Cucumber

[I] External features

Body dark brownish slippery. Body orally aborally elongated. Oral end contains buccal club-shaped bunches of tentacles. Body surface divided into ambulacral and interambulacral zones. In ambulacral zone tube feet present. Ossicles embedded in body wall.

[II] General anatomy

Most favourable dissection for post-graduate students and easiest dissection.

Procedure : *In a dissecting dish keep the animal in oral-aboral axis. Very carefully make a longitudinal incision from anterior to posterior end. Fix the two flaps by pins on each side after spreading them. Be very careful in shifting the alimentary canal to one side. It is very fragile and in easily broken. After spreading body wall flaps, various organs are seen as under.*

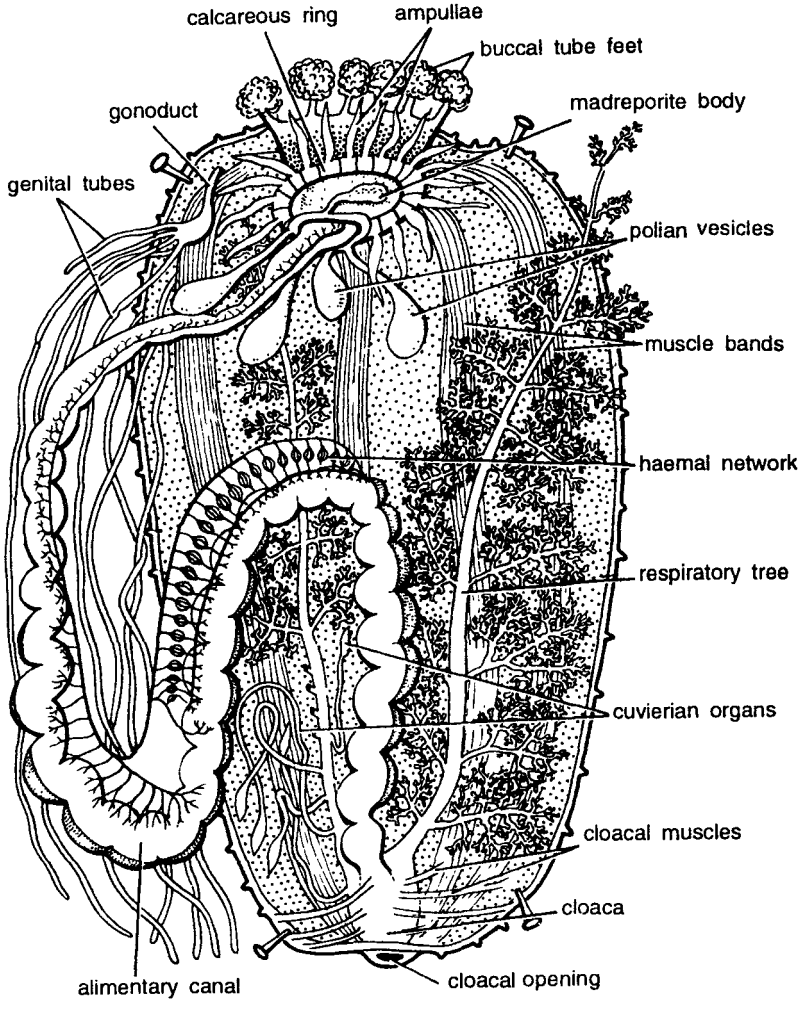


Fig. 53. *Holothuria.* General anatomy.

(1) **Digestive system :** Consists of **mouth, oesophagus, stomach, intestine, cloaca** and **cloacal opening** (In certain sea cucumbers sometimes evisceration occurs and alimentary canal is not seen).

(2) **Water vascular system**

(a) ***Ring canal*** **:** Around circum **oesophageal calcarious ring.**

(b) ***Madreporite*** **:** Internal and leads into **stone canal** which opens into ring canal.

(c) ***Polian vesicles*** **:** 4 or 5 large **polian vesicles** hanging from ring canal.

(d) ***Radial canals*** **:** Indistinct embedded in body wall and giving branches to each tube feet.

(3) **Respiratory tree :** Paired structures having branched structures like tree. Very prominent structures. Each duct of the tree originates from cloaca and extends upwards giving several side branches.

(4) **Cuverian organs :** Filamentous tubular structures around **cloaca.**

(5) **Gonads :** Consists of gonopore outside, gonadial duct and long tubular gonads inside. Sexes separate. Look for ova in females. Take a portion of the tube and make temporary glycerine. Mount to observe ova or sperms.

(6) **Other structures : Longitudinal muscle bands, buccal tentacles** and **ampullae of tentacles.**

9 Wonder Invertebrates

The invertebrates present vast gallaxy of diversified animals. Some are largest, some smallest, some heaviest and some deep sea forms. The present account deals with some of those wonders from Protozoa to Echinodermata.

Protozoa

Largest : The largest Protozoa which are known to have existed are now extinct forms called as Nummulites which had a diameter of 0.95 of an inch. The largest existing protozoan is ***Pelomyxa palustris***, 0.6 inch in diameter.

Smallest : The smallest form is ***Mycoplasma*** having diameter of 0.000004 of an inch.

Longest lived : ***Euglena gracilis*** has been kept alive in culture for more than 20 years in King's College, London.

Fastest moving : ***Monas stigmatica*** has been measured to move a distance equivalent to 40 times its own length in a second. Whereas no man can cover even seven times his own length in a second.

Fastest reproducing : ***Glaucoma*** reproduces by binary fission as frequently as every three hours. In a day it reproduces six great grand parents and producing 510 descendants.

Densest : The densest Protozoa is a dinoflagellate ***Gymnodinium breve***. It occurs at a density of 240,000,000 per gallon of sea water.

Porifera

Largest : ***Spheciospongia vesparium***, the barrel-shaped loggerhead, measures 3.5 inches in length.

Tallest : ***Poterion patere*** stands upto 4 feet.

Smallest : ***Leucosolenia blanca*** is the smallest sponge measuring 0.11 of an inch.

Deepest : Sponges are found upto a depth of 18,500 feet.

Coelenterata

Largest : The largest and longest jellyfish collected was ***Cyanea arctica***, which had a bell 7.5 feet in diameter and tentacles measuring 120 feet.

Most venomous : The box jellies ***Chiropsalmus*** and ***Chironex*** are most venomous. Their neurotoxic venom is similar in strength as that of Asiatic cobra and they have been accounted to cause the death of at least 60 persons along the coast (Indopacific region). The victims die within 1 to 3 minutes.

Platyhelminthes

Largest : ***Taenia solium*** measures about 13 to 14 feet in length.

Annelida

Largest : The largest annelid is earthworm ***Microchaetus rappi*** of South Africa which measures 4 feet 6 inches in length.

Smallest : The smallest or shortest segmented worm is ***Chaetogaster annandale*** measuring 0.019 of an inch.

Mollusca

Largest mollusc : ***(a) Squid*** **:** The largest and heaviest among invertebrates is the giant Atlantic Squid (***Architeuthis*** sp.) measuring 55 feet in length (head and body 20 feet and tentacles 35 feet).

(b) Octopus **:** ***Octopus apollyon*** is the largest known octopus (U.S.A.) which measures 25 feet 7 inches in length and 118 lbs in weight.

(c) Shell **:** The largest shell is that of bivalve giant clam ***Tridacna derasa*** which measures 43 inches by 29 inches and weighing 275 kg. The shell is now preserved in the American Museum of Natural History.

(d) Snail **:** Largest snail is ***Tethys*** weighing 3 to 7 kg.

Smallest : The smallest mollusc is a bivalve shell ***Ammonicera rota*** found in British waters which measures 0.02 of an inch in diameter.

Longest lived : The longest lived mollusc is ***Margaritifera margaritifera*** which lived for 100 years.

Slowest : The slowest moving animal is snail-snail's pace. The common garden slug (***Helix aspersa***) moves 0.00036 to 0.0313 m.p.h. or 23 inches to 55 yards per hour.

Arthropoda

Crustacea

Largest : The largest of all crustaceans is the giant spider crab called as ***Macrocheira kaempferi***. Its body is 12 to 14 inches wide. Claws measure 8 to 9 feet.

Heaviest : Heaviest crab is ***Pseudocarcinus gigas*** weighing 30 lbs.

Smallest : Smallest crustaceans are water fleas ***Alonella*** measuring less than 1/100th of an inch.

Longest lived : ***Homarus americanus*** may live upto 50 years.

Deepest : Amphipods have been collected 32,110 feet deep.

Insecta

Largest : ***(a) Ant*** **:** The driver ant ***Dinoponera grandis*** of Africa measures 1.31 inches in length.

(b) Grasshopper **:** It is the New Guinea grasshopper ***Siliquoferg grandis***. Its females have wings upto 100 inches.

(c) Dragonfly **:** ***Tetracanthagyne plagiata*** of Borneo now preserved in British Museum of Natural History has a wing span of 7.63 inches and measures 4.25 inches in length.

(d) Flea **:** It is the ***Hystricopsylla*** which measures 0.31 inches in length.

(e) Tick **:** The largest tick is ***Amblyomma varium***, recorded from a Venezuelan sloth.

(f) Butterfly **:** The giant birdwing ***Troides victoriae*** of Pacific measuring 12 inches in length.

Longest : It is the tropical stick-insect ***Pharmacia serratipes***. Its female measures 12.99 inches in body length.

Heaviest : The Goliath beetle ***Goliathus goliathus*** weighing 3.52 ounces.

Smallest : The hairy winged beetles of family Trichopterygidae and the battledore wing fairy flies (parasitic wasps) of the family Mymaridae which measure only 0.008 of an inch in length.

Fastest flying : The deer Bot fly ***Cephenemyia pratti*** could attain a speed of 818 m.p.h.

Longest lived : The queen termites (Isoptera) have been recorded to lay eggs for 50 years.

Loudest : The male cicada's sound can be heard from a quarter of a mile.

Largest locust swarm : Recorded in 1889, that of desert locust ***Schistocera gregaria***, crossing Red Sea and contained an estimated number 250,000,000,000 weighing about 500,000 tons.

Fastest wing beat : The fastest with beat is that of ***Forcipomyia*** 62,760 per minutes.

Arachnida (Spiders)

Largest : The South American 'bird eating' spider-***Theraphosa leblondi***. Its male measures

32 inches in length and its legs fully stretched extend upto 10 inches.

The *largest* and *heaviest* ever recorded was female 'Tarantula' of the genus ***Iasiodora*** which measured 92 inches in length and weighed 3 ounces.

Smallest : It is ***Patu marplesi*** measuring 0.017 inches long.

Largest web : The largest web spun by tropical weaver. ***Nephila*** measured 18 feet and 10 inches in circumference.

Most venomous : ***Lactodectus mactans*** can bite a man leading to death. It is most venomous and is called as 'black widow'.

Centipedes

Longest : ***Scolopendra marsitans*** found in Bay of Bengal. It measures 13 inches in length and $1\frac{1}{2}$ inches in breadth.

Fastest : ***Scutiger coleoptrata*** travels 19.68 inches a second.

Most legs : ***Himantarum gabrielis*** of Southern Europe has 171 to 177 pairs of legs.

Millipedes

Largest : ***Graphidostreptus gigas*** of Africa measures 11.02 inches length.

Shortest : It is ***Polyxenus lagurus*** -The shortest 2 millipede (0.082 to 0.15 of an inch).

Echinodermeta

Largest : The Asteroid ***Midgardia xandaros*** measuring 54.33 inches from tip to tip.

Most massive : North Pacific five armed starfish ***Evasterian echinosoma***. It measures 37.79 inches in length and weighs more than 11 lbs.

Smallest : The starfish ***Marginaster caprensis*** which measures 0.78 inches in length.

Deepest : ***Porcellanaster*** sp., a starfish was collected from a depth of 24,880 feet.

Preparation of Fixatives, Stains and Other Reagents

10

Fixatives

The following fixative agents are in use for fixing various kinds of tissues :

1. Bouins fluid (alcoholic) : Dissolve 1 gm of picric acid in 250 cc of 90% alcohol. The bouins fluid or alcoholic picric acid is used to fix the tissues for microtomic sections.

2. Bouins fluid (aqueous) : It is prepared by adding excess of picric acid in a measured distilled water. Decant the saturated picric acid fluid. The aqueous bouins fluid is used to fix the tissue with the elements *in situ.* Picric acid may be washed with 70% alcohol.

3. Corrosive sublimate : It is prepared by adding 10 gm of corrosive sublimate to 3 cc of glacial acetic acid and 300 cc of distilled water. This fixative is removed from tissues by washing with 70% alcohol. Tissues are fixed within few seconds to 10 minutes.

4. Formalin solution : 0.5-0.1% or 5% solution of formalin is prepared. Formalin acts both as fixative as well as preservative.

5. Trichlore acetic acid :

Sublimate solution	6%
Trichlor-acetic acid	1%
Acetic acid	1%

This fixative is one of the best decalcifying fluid.

6. Formol-picric-trichlor-acetic acid :

Formalin (40%)	15 cc
Trichlor-acetic acid	0.5 gm
Alcoholic picric acid solution (2% picric acid in 50% alcohol)	85 cc

7. Chromo-aceto-osmic acid :

(a) Weak formula

Chromic acid	0.25% in
Osmic acid	0.1% water
Glacial acetic acid	0.1%

This fluid is good for smaller animals.

(b) Strong formula

Chromic acid	15 parts
Osmic acid (2%)	4 parts
Glacial acetic acid	1 part

The stock solution is prepared and is mixed at the time of use. This fluid is good for large objects.

8. Formol-acetic-alcohol (F.A.A.)

Formalin (40%)	10 cc
Glacial acetic acid	5 cc
Ethyl alcohol (70%)	85 cc

F.A.A. fluid is good for fixing the nematodes and plant material.

9. Henking fluid

Water	80 cc
Glycerine	16 cc
Formic acid	3 cc
Osmic acid 1%	1 cc
Dahlia	0.04 gm

10. Acetic sublimate

Corrosive sublimate	6 gm
Distilled water	100 cc
Glacial acetic acid	2 cc

11. Chromo-acetic acid (Flemming solution)

Chromic acid in distilled water	0.2% to 0.25%
Acetic acid	0.1 %

12. Picro-formol

Picric acid saturated aqueous solution	75 parts
Formol	25 parts
Acetic acid	5 parts

13. Zenker's fluid

Water distillate	10 cc
Potassium dichromate	2.5 gm
Mercuric chloride	5 gm
Sodium sulphate	1 gm
Glacial acetic acid	5 cc

This fixative is good for delicate objects.

14. Mayer's albumen

White of egg	20 gm
Glycerine	50 cc
Sodium salicylate	1 gm

Mix the reagents, stir and filter. This is used to stick microtomy ribbons and small micro-organisms, protozoans, etc. over slide.

Cytological reagents

For cytological studies animals are first dissected in physiological salines.

(a) For cold-blooded animals

(i) NaCl solution

NaCl (A.R.)	0.64 gm
Distilled water	100 cc

(ii) Ringer's solution

NaCl	0.65 gm
KCl	0.025 gm
$CaCl_2$	0.03 gm
$NaHCO_3$	0.02 gm
Distilled water	100 cc

(b) For warm-blooded animals

(i) NaCl solution

NaCl solution	0.9 %
(Normal saline)	0.78 %

(ii) Ringer's solution

NaCl	0.85 gm
KCl	0.025 gm
$CaCl_2$	0.03 gm
Distilled water	100 cc

Cytological fixatives

1. Carnoy's fluid I

Glacial acetic acid	1 cc
Absolute alcohol	3 cc

This fluid is good for animals as well as plant material.

2. Carnoy's fluid II

Glacial acetic acid	1 cc or 1 : 3 : 4
Chloroform	3 cc or 1 : 1 : 1
Absolute ethyl alcohol	6 cc or 1 : 1 : 3

This fixative is recommended for animal tissues and flower buds. The alternative proportions given are also tried and instead of acetic acid propionic acid may also be taken.

Stains (Dyes)

The following stains are in use in a biological laboratory :

Borax carmine, eosin and haematoxylin are commonly employed for single and double staining, which can be prepared by the following methods :

1. Borax carmine :

Borax	4 gm
Carmine	3 gm
Distilled water	100 cc
70% alcohol	100 cc

First dissolve 4 gm of borax in 100 cc of distilled water. Add 3 gm of carmine to borax solution. Boil this solution for 30 minutes. Allow to stand for 2 to 3 days and stir occasionally. Measure the prepared solution and mix with equal volume of 70% alcohol. Allow to stand for 1 hour and then filter.

Borax carmine is mainly cytoplasmic stain and it is always better to overstain the tissues and then de-stain to rose petal colour or bright red colour.

2. Eosin : Dissolve 0.5 gm of eosin in 100 cc of either 70% or 90% alcohol. It is also a cytoplasmic stain and is used in double staining along with haematoxylin.

3. Ehrlich's acid haematoxylin :

Haematoxylin	2 gm
Absolute alcohol	100 cc
Glycerine	100 cc
Glacial acetic acid	10 cc
Alum	in excess

Dissolve 2 gm of haematoxylin in 100 cc of absolute alcohol. Add 10 cc of glacial acetic acid. Add 100 cc of glycerine. Add 100 cc of water.

Allow the mixture to stand in the light for maturation for about 5 to 10 days until it assumes dark red colour. Keep the mouth of the bottle closed with cotton plug and occasionally stir the solution. Haematoxylin is a nuclear stain.

4. Delafield's haematoxylin :

Haematoxylin	4 gm
Absolute alcohol	25 cc
Alum	in excess
(Saturated solution)	400 cc
Glycerine	100 cc
Methyl alcohol	100 cc

Mix 4 gm of haematoxylin with 25 cc of absolute alcohol and then add it to 400 cc of saturated solution of ammonium alum. Leave the mixture in an open bottle for 3 or 4 days after which filter and add 100 cc of glycerine and 100 cc of methylated alcohol. Allow the solution to stand until the solution becomes dark coloured. Filter and use.

5. Picro-indigo carmine :

Alcoholic picric acid saturated sol. in 90% alcohol	1 part
Indigo carmine saturated sol. in 70% alcohol	2 parts

This stain is good for staining hard and chitinous structures.

6. Safranin :

Safranin	1 gm
Distilled water	100 cc

This dye or stain is used to colour the plant tissues.

7. Acid fuchsin :

Acid fuchsin	0.5 gm
Distilled water	100 cc

This stain is good for chitinous tissues.

8. Leishman stain :

Leishman stain	0.15 gm
Absolute alcohol	100 cc

This dye is good for protozoans.

9. Mallory's triple stain :

Solution A.

Acid fuchsin	1.0 gm
Distilled water	100 cc

Solution B.

Aniline blue	0.5 gm
Orange G	2.0 gm
Phosphomolybdic acid	2.0 gm
Distilled water	100 cc

Solution C.

Phosphomolybdic acid	1.0 gm
Distilled water	100 cc

This stain is good for microtomy section. Stain the section in solution A for 30 seconds, then wash in distilled water for 2 minutes, and again stain in solution B for 1 to 5 minutes, wash in distilled water for 1 to 2 minutes, by dehydrate and mount.

10. Light green :

Light green stain	0.82 gm
90% alcohol	100 cc

This is a good plasma stain.

11. Fast green :

Fast green stain	1 gm.
90% alcohol	100 cc.

This is a cytoplasmic stain.

12. Aceto-carmine stain or Propionic carmine :

Glacial acetic acid or porpionic acid	45 cc
Distilled water	55 cc
Carmine powder	0.5 to 1.0 gm

Mix 45 cc of glacial acetic acid or pure propionic acid with 55 cc of distilled water. Heat to boiling and add 0.5 to 1.0 gm of carmine. Shake well, cool and filter.

This is one of the most commonly used stain for chromosomal studies.

13. Aceto-orecin :

Glacial acetic acid	45 cc
Distilled water	55 cc
Orecin stain	1 gm

Because of deterioration in dilute acid, the stain is best kept as 2.2% stock solution in glacial acetic acid which can then be diluted to 45% when required. This is also a cytological stain good for chromosome studies.

Other Reagents

Besides fixatives and stains, the following reagents are needed for preparing slides.

1. Normal saline : Dissolve 0.78% of sodium chloride (Analytical) in 100 cc of distilled water.

2. Acid alcohol : Add 1 drop of concentrated hydrochloric acid (HCL) in 100 cc of 70% alcohol.

3. Acid water : Add 1 drop of concentrated HCL to 100 cc of distilled water.

4. Grades of alcohol : 30, 50 and 70% alcohols are prepared from 90% or absolute alcohol by adding desired quantity of distilled water.

30% alcohol :	Add 206.22 cc of distilled water to 100 cc of 90% alcohol.
50% alcohol :	Add 84.71 cc of distilled water to 100 cc of 90% alcohol.
70% alcohol :	Add 31.05 cc of distilled water to 100 cc of 90% alcohol.

Experimental Cytology

11

This chapter includes the study of :

(1) **Prokaryotic** and **Eukaryotic cells.**
(2) Preparation of chromosomes in **mitosis** and **meiosis** from plant and animal materials.
(3) Study of mitosis from prepared slides.
(4) Study of meiosis from prepared slides.
(5) Demonstration of mitochondria by supra-vital stains.
(6) Study of ultrastructure of different cell organelles (Mitochondria, Endoplasmic reticulum, Golgi body, Chloroplast and Nucleus) by their microphotographs.

1. Prokaryotic and Eukaryotic Cells

Prokaryotic cells are primitive while Eukaryotic are advanced cells.

Differences between Prokaryotic and Eukaryotic cells alongwith examples are given in Table 1.

[I] *Mycoplasma* cells

Comments : (1) ***Mycoplasma gallisepticum*** is the smallest living cell found in sewage and soil.
(2) Cells rounded measuring 0.1 to 0.5 μm.
(3) Cell wall thick and made up of phospholipid protein layer.

Table 1.

Characters	Prokaryotic cell	Eukaryotic cell
1. **Cell wall**	Present and composed of amino sugars and muramic acid	Absent in animal cells. Present in plant cell and contains celiulose.
2. **Plasma membrane**	Present	Present
3. **Nucleus and nuclear membrane**	Absent	Present
4. **Endoplasmic reticulum (E.R.)**	Absent	Present
5. **Golgi body**	Absent	Present
6. **Lysosomes**	Absent	Present
7. **Mitochondria**	Absent	Present
8. **Nucleolus**	Absent	Present
9. **Genetic material**	DNA or RNA	DNA
Examples :	1. ***Mycoplasma*** cells	1. **Generalized yeast cell**
	2. ***Escherichia coli*** cells	2. **Generalized plant cell**
	3. Blue green algal cells	3. **Generalized animal cell**

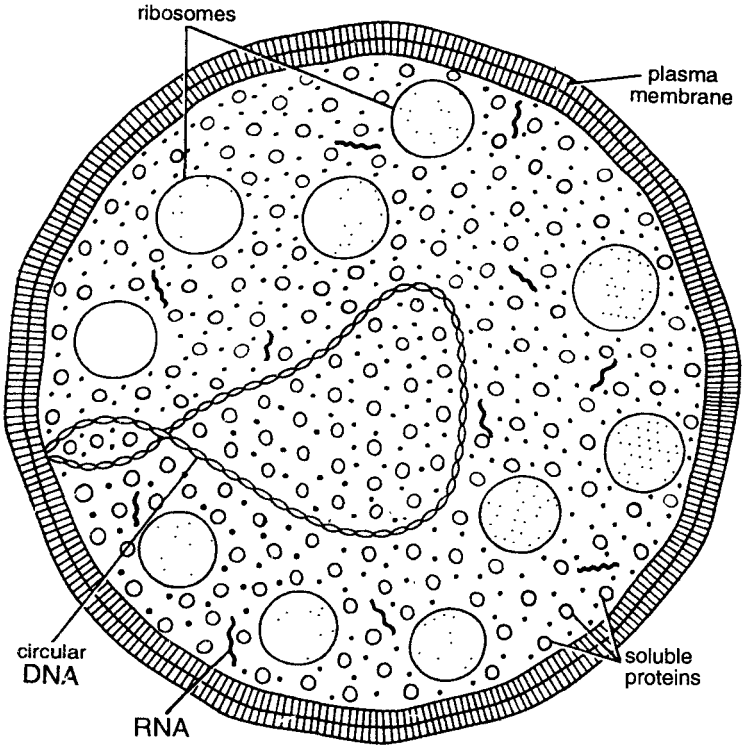


Fig. 1. *Mycoplasma* cell.

(4) Ribosomes large spherical bodies. Soluble proteins rounded small bodies.
(5) DNA distinct, twisted or looped and double helical.
(6) These organisms originated three billion years ago.

Identification : Since the above cell is smallest and contains spherical bodies and twisted DNA, hence it is ***Mycoplasma* cell** (Fig. 1).

[II] *Escherichia coli*

Comments : (1) Most extensively studied prokaryotic cells.
(2) Rectangular or rod-shaped measuring 2 μm in length and 0.5 μm in thickness.
(3) Cell wall rigid composed of proteins, polysaccharides and lipid molecules.
(4) Beneath cell wall is plasma membrane made up of lipoproteins. Plasma membrane contains respiratory chain enzyme system.

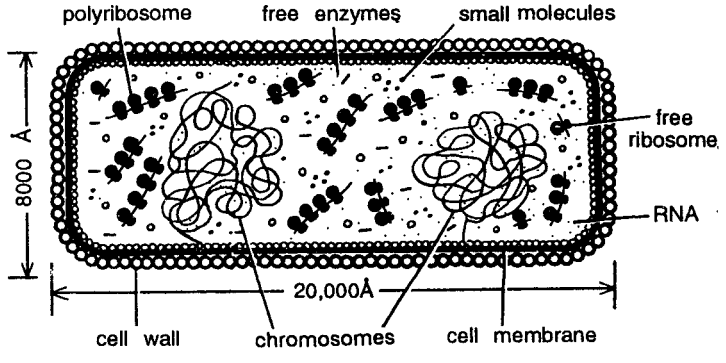


Fig. 2. *Escherichia coli.*

(5) DNA is circular and coiled. Free ribosomes, polyribosomes and RNA are also seen.

Special features : ***Escherichia coli*** constitute our intestinal flora. They are non-pathogenic symbiotic bacteria found in the intestine of man. The colony of ***E. coli*** should not be confused with ***Entamoeba coli*** which is a protozoan. It could be cultured in agar plates. ***Escherichia coli*** have been extensively used in molecular biological studies.

Identification : Since the above cell contains cell wall, plasma membrane and circular DNA, hence it is ***E. coli*** cell (Fig. 2).

[III] Blue green algal cell

Comments : (1) Body rounded in shape.
(2) Resemble bacteiral cells in many respects.
(3) Outer covering is a gelatinous sheath called cell wall.
(4) Beneath cell wall is plasma membrane composed of lipoprotein, mucoprotein and lipopolysaccharide.
(5) DNA is circular and double helical.
(6) These algal cells contain photosynthetic pigments such as chlorophyll and carotenoids.

Identification : Since the above cell contains cell wall, plasma membrane and chlorophyll, hence it is blue green algal cell (Fig. 3).

[IV] Generalized plant cell

Comments : (1) Shape varies.
(2) Cell wall thick contain **cellulose**.
(3) Nucleus, nucleolus, endoplasmic reticulum, mitochondria and ribosomes present.

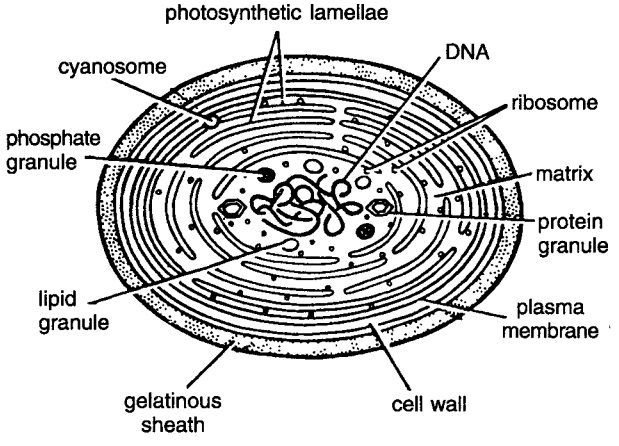


Fig. 3. Blue green alga.

(4) **Plastids present.**
(5) Different kinds of plant cells are **parenchyma, collenchyma, sclerenchyma, xylem** and **phloem.**

Identification : Since the above cell contains thick cell wall and plastids, hence it is a plant cell (Fig. 4).

[V] Generalized animal cell

Comments : (1) Cell wall of cellulose absent.
(2) Outer covering is **plasma membrane** which at certain places is differentiated into **desmosomes, microvilli** or **basal membrane.**
(3) Nucleus contains nucleolus and chromatin or chromosomes having DNA.
(4) Cytoplasm contains **endoplasmic reticulum, mitochondria, ribosomes, Golgi bodies** and **lysosomes.**
(5) Pinocytic vesicles and secretory vesicles are seen.
(6) Different kinds of animal cells are epithelial ciliated, squamous, cuboidal columnar epithelial, flagellated (choanocytes) mesenchyma flame cells, striated muscle cells, simple muscle cells, nerve cells, blood cells (RBC, WBC, platelets), lymphocytes, plasma cells, osteocyte cells, and cancer cells.

Identification : Since cell contains plasma membrane, above features, and no cell wall, hence it is an animal cell (Fig. 5).

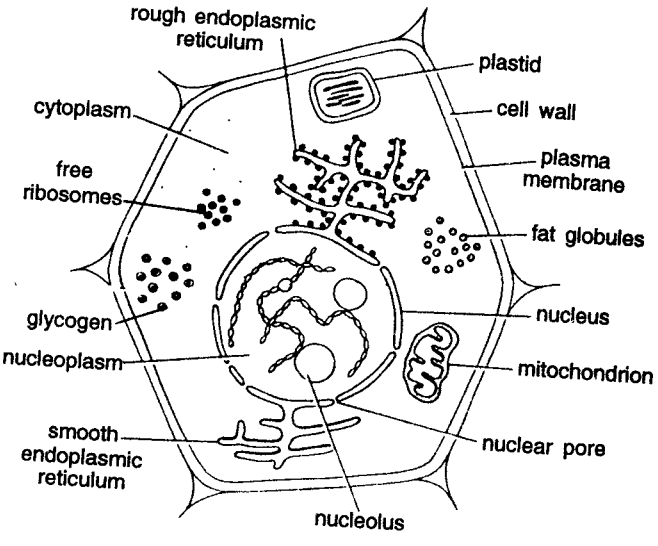


Fig. 4. Plant cell.

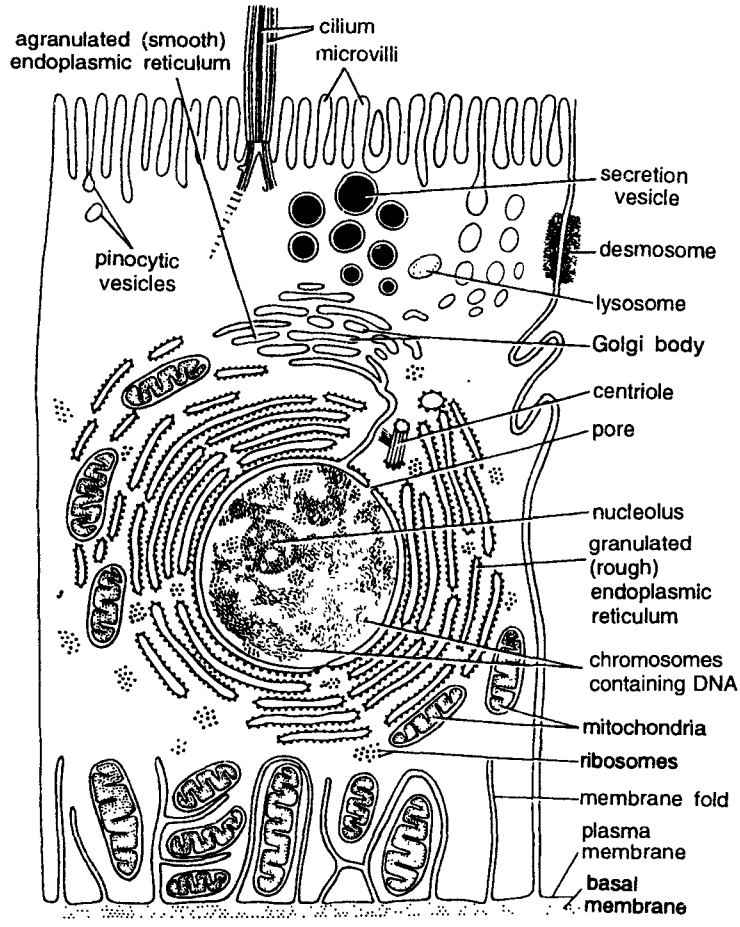


Fig. 5. Generalized animal cell.

2. Preparation of Chromosomes

Introduction : Chromosomes can be prepared from the following plant and animal materials :

(1) Onion root tips for **mitosis** in plants.
(2) Anthers from **Bajra** or other plants for **meiosis.**
(3) Testis from animals for **mitosis** and **meiosis.**
(4) Salivary gland chromosomes (giant chromosomes) from larvae of ***Chironomous*** and ***Drosophila.***

Technique : Chromosomes can be prepared by **squash technique** and **heat dry Giemsa method.** Carnoy's fluid is used as a fixative. (1 cc glacial acetic acid; 3 cc chloroform and 6 cc absolute alcohol). Acetocarmine or Giemsa are used as stains.

[I] Chromosomes from onion root tips for mitosis by squash method

Material : Take a few onion bulbs. Place them in a tray containing moist soil with dried roots facing soil. After 4 or 5 days new roots would appear. Take out onions and wash them. Cut 2 to 3 cm root tips and fix them directly in specimen tubes having Carnoy's fluid.

Method : Take one or two preserved root tips on a slide with acetocarmine stain. Place a coverslip over them and tap it gently with a needle or pencil. Warm it tightly over the flame of a spirit lamp. Now put a piece of blotting paper on coverslip and apply a uniform pressure by your thumb.

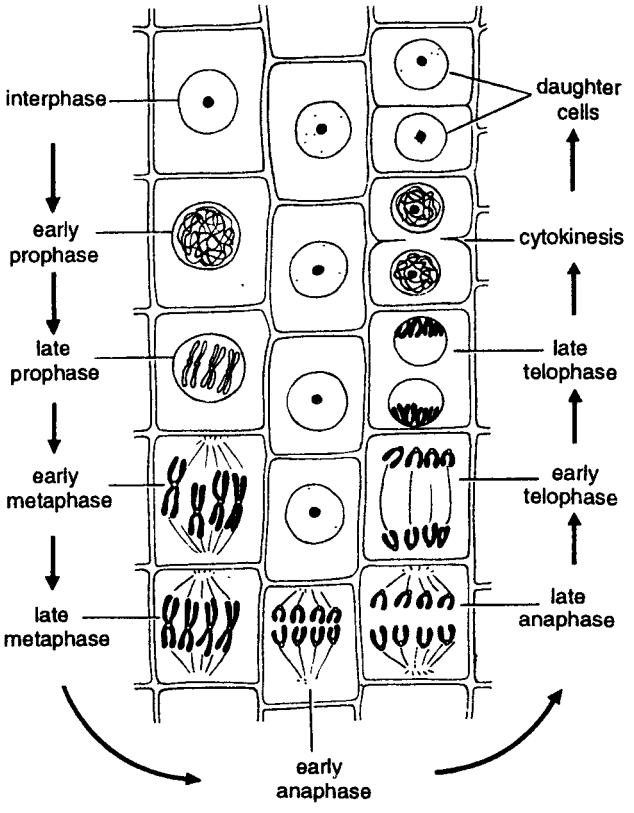


Fig. 6. Different mitotic stages. Onion root tip.

Another method can also be applied. From Carnoy's fluid, transfer all the root tips in a small corning conical flask containing acetocarmine. Boil the material and apply squash technique as above.

Observation : Examine the slide under the microscope. The cells and their chromosomes become spread out and distinct. Search out for different **early** and **late** mitotic stages such as **interphase prophase**, **metaphase**, **anaphase**, **telophase** and **cytokinesis**. Study and draw such stages (Fig. 6) in your practical copy and write comments with the help of practical book.

[II] Chromosomes from pollen mother cells (anthers) for meiosis by squash method

Procedure : For above purpose anthers of **Bajra** plants can be taken in early crop season. Fix anthers in Carnoy's fluid and prepare slide by **squash method** as described in case of onion root tips. Study various meiotic stages such as **Leptotene**, **Zygotene**, **Pachytene**, **Diplotene** and **Diakinesis** of first prophase, first metaphase, first anaphase, first telophase and second meiotic divisions.

[III] Study of chromosomes, both for mitosis and meiosis stages from testis of frog, grasshopper, cricket, *Gryllus* and nematodes (*Ascaris*, *Setaria*, hookworms)

1. Squash method.

Procedure : (1) Collect grasshoppers from the green fields or crickets from stores in houses.

(2) Anesthesize them with chloroform.

(3) Dissect the male insect in a dissecting dish having normal saline (0.78% NaCl).

(4) Remove testes and fix them in Carnoy's fluid for 2 to 12 hours.

(5) Stain testis lobes in acetocarmine.

(6) Take testis lobes (stained) over a slide, and cover with a coverslip. Apply squash method (heat, tap and press) as mentioned for onion root tips.

2. Heat dry Giemsa method for making permanent slide.

Procedure : (1) Take out testes from a grasshopper or nematode. In case of nematode, cut the anterior extremity. Gently apply pressure from the posterior end. The testes alongwith intestine would come out. Separate thread-like testes.

(2) Place testes in 1% sodium citrate hypotonic solution in a cavity block.

(3) Fix the material in 3 : 1 methanol acetic acid for 15 to 20 minutes.

(4) Take a clean slide. Place a fixed testis over it with one or two drops of acetic acid. Tease the material and make a thin smear.

(5) Heat, dry slide at 45°C over hot plate.

(6) Place it over a watch glass horizontally. Flood the slide having smear for 5 to 15 minutes with Giemsa stain.

(7) Rinse slide with distilled water and keep it in vertical position for drying.

(8) If overstained, remove excess of stain with 40% acetic acid.

(9) Rinse the slide with xylol and mount with D.P.X. or Euperol. Let the slide become dry.

(10) Examine the slide under microscope.

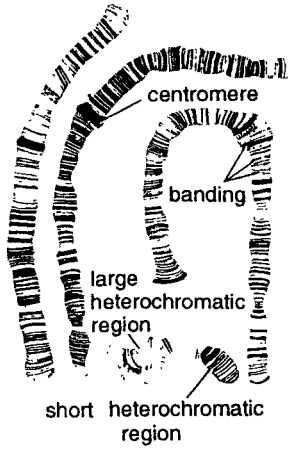


Fig. 7. Salivary gland chromosomes.

[IV] Giant or salivary chromosomes from *Chironomous* larva

Procedure : Collect ***Chironomous*** larvae from a pond or drains. Pull the head region with the forceps. The salivary glands are exposed. Fix the glands in Carnoy's fluid. Place the glands on a slide, stain with acetocarmine and apply squash technique as in the case of onion root tip. Study the giant chromosomes under the microscope.

Comments : (1) Balbiani (1881) published account of giant chromosomes from salivary gland of ***Chironomous*** larva.

(2) Because of their large size (100 to 150 mm) these are called giant chromosomes.

(3) Giant chromosomes are called **polytene** due to their characteristic **banding pattern** or many-strandedness.

(4) Centromeres are found in between the banding.

(5) There are 3 larger chromosomes with characteristic heterochromatic regions at their tips. The fourth shortest chromosome has a long heterochromatic arm.

(6) Cross bandings are very distinct.

(7) Polytene chromosomes of Diptera represent widespread phenomenon of endopolyploidy.

Identification : Since the above chromosomes have giant size and banded appearance, they are giant chromosomes (Fig. 7).

3. Stages of Mitosis from Prepared Slides from Plant and Animal Materials

[I] Prophase

Comments : (1) The nucleus becomes enlarged. DNA synthesis is completed. Prophase comes after interphase (Fig. 8).

(2) Chromosomes become filamentous, thin and distinct.

(3) Prophase may be early prophase or late prophase.

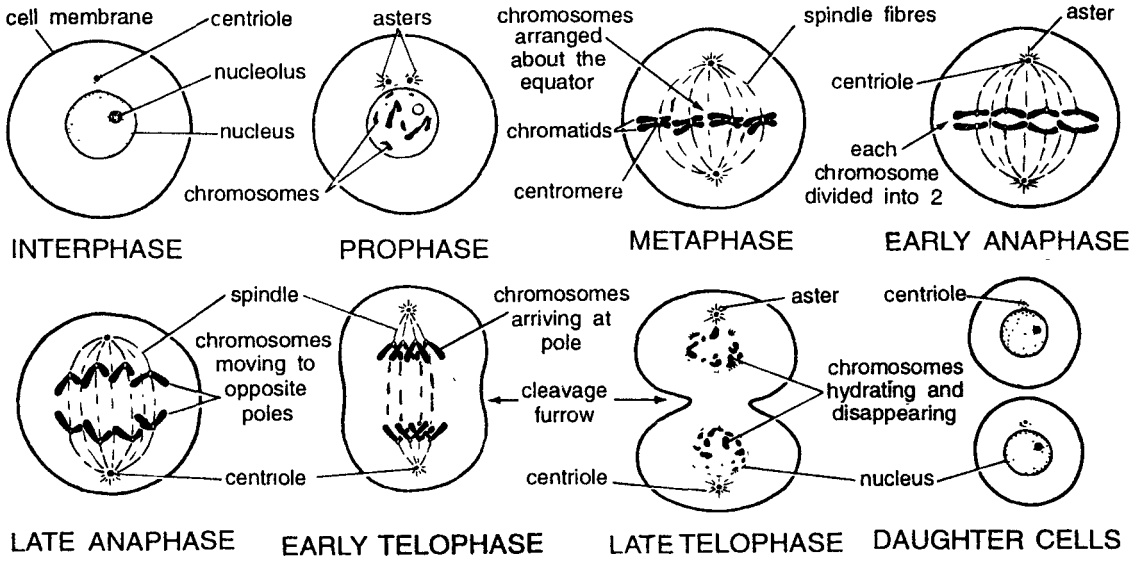


Fig. 8. Mitosis : Different stages.

(4) In late prophase, each chromosome divides into sister chromatids attached at **centromere** or **kinetochore**.
(5) Nuclear membrane and nucleolus disappear and cell enters into metaphase.

Identification : (1) Filamentous chromosomes **Early prophase.**
(2) Sister chromatids attached at centromeres-**Late prophase.**

[II] Metaphase

Comments : (1) The spindle tubules start appearing and get attached with centromeres of chromosomes in early metaphase (Fig. 8).
(2) Chromosomes move actively and become arranged at the **equatorial plate** or **centre** in metaphase.
(3) Specially in animals, the centrosome helps in the formation of **spindle apparatus**. In plants, centrosomes are missing.
(4) Centrosome has two centrioles which separate and each occupies opposite sides of the nucleus.
(5) After metaphase next stage is Anaphase.

Identification : (1) Centromeres attach with spindle tubules-**Early metaphase.**
(2) Chromosomes arranged at equatorial plate-**Late metaphase.**

[III] Anaphase

Comments : (1) Each chromosome splits at the position of centromere, forming sister chromatids or daughter chromosomes showing early anaphase (Fig. 8).
(2) The **sister chromatids move towards poles** with centromeres facing periphery while arms towards each other showing late anaphase.
(3) Depending upon the position of centromeres, the chromosomes may be **V-shaped, J-shaped, I-shaped, *i.e.*, metacentric, sub-metacentric** and **acrocentric**, respectively.

Identification : (1) Chromatids separate and start moving towards poles-**Early anaphase.**
(2) Chromatids sub-equatorial-**Late anaphase.**

[IV] Telophase

Comments : (1) The chromosomes reach towards poles in early telophase (Fig. 8).
(2) Nuclear membrane and nucleolus reappear.

Identification : (1) Chromatids reach at poles-**Early telophase.**
(2) Chromatids become surrounded by nuclear membranes-**Late telophase.**

[V] Cytokinesis

Comments : (1) After appearance of the nuclear membrane two daughter nuclei are produced.
(2) Cytoplasm divides into two by a furrow. Cytoplasmic division is called cytokinesis.

Identification : Since these are two daughter cells, hence it is cytokinesis stage (Fig. 8).

4. Stages of Meiosis from Prepared Slides from Plants and Animal Materials

Meiosis involves two successive divisions forming four daughter cells, each having haploid number of chromosomes. (A) **In first meiotic division**, reduction in the chromosome number occurs without separation of chromatids. The stages involved are **Prophase** I (with 5 substages, *i.e.* **Leptotene, Zygotene, Pachytene, Diplotene** and Diakinesis), Metaphase I, Anaphase I and Telophase I. (B) **In second meiotic division**, separation of chromatids of chromosomes occurs. Four daughter cells with haploid chromosomes are formed during spermatogenesis in males and oogenesis in females. The stages of **second meiotic division** are **Prophase II, Metaphase II, Anaphase II** and **Telophase II.** These are similar to those of simple mitotic division already described which may be referred to for detailed comments.

A. FIRST MEIOTIC DIVISION

[I] Leptotene (Leptonema) of prophase I

Comments : (1) This is the first stage after interphase (Fig. 9).
(2) Chromosomes appear as long thread-like structure interwoven together.
(3) Chromosomes give **beaded appearance** and are called as **chromomeres.**
(4) Ends of chromosomes are drawn towards nuclear membrane, near centriole.
(5) In plants no such polarization occurs.

Identification : Since chromosomes become thread-like and give beaded appearance, hence it is **leptotene stage.**

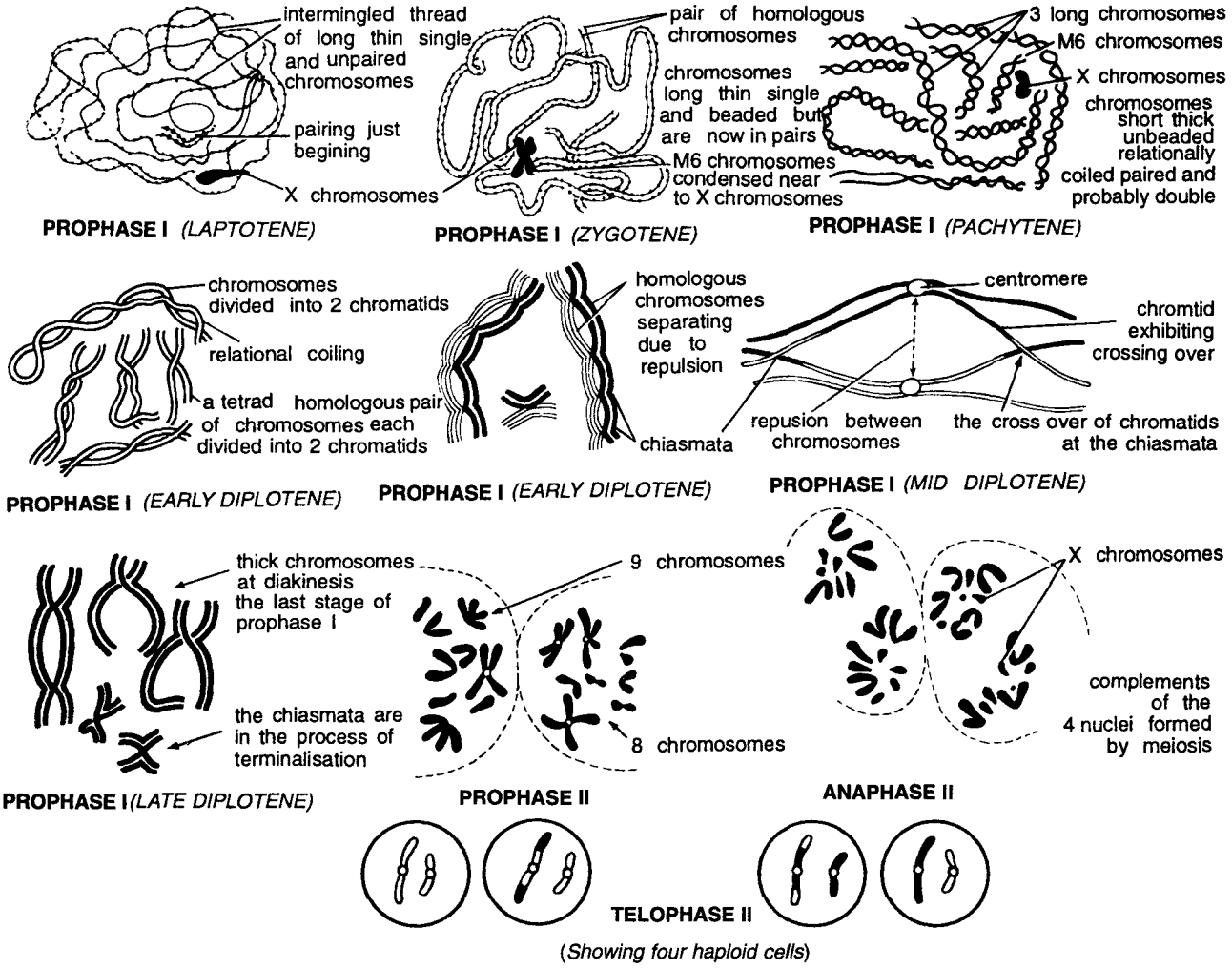


Fig. 9. Different stages of meiosis.

[II] Zygotene (Zygonema) of prophase I

Comments : (1) This stage is characterized by the pairing of homologous chromosomes (synapsis).

(2) Pairing occurs in a zipper-like fashion and between two chromosomes at one region.

Identification : Since above chromosomes show pairing of homologous chromosomes, hence it is **zygotene stage**.

[III] Pachytene of prophase I

Comments : (1) Chromosomes become shortened and coiled (Fig. 9).

(2) Chromosomes appear as thickened thread like structure, haploid in number. Each thread has two homologous chromosomes closely applied upon each other.

(3) These pairs of homologous chromosomes are called **bivalents.**

(4) Each bivalent really consists of four chromatids and is called **Tetrad.**

(5) Crossing over also occurs at this stage.

Identification : Since the above chromosomes show shortened, bivalent appearance, hence it is **pachytene stage.**

[IV] Diplotene (diplonema) of prophase I

Comments : (1) Diplotene stage is characterized by thickening and condensation of chromosomes (Fig. 9).

(2) Homologous chromosomes start separating from one another. Separation starts from centromere and travel towards the ends. This is known as terminalization.

(3) Double nature of chromosomes becomes distinct and hence the name of **diplotene.**
(4) Homologous chromosomes remain in contact at certain points called **chiasmata.**
(5) Chiasmata formation is characteristic of diplotene stage.

Identification : Since the above chromosomes show condensation, doubled structure and chiasmata formation, hence it is **diplotene stage.**

[V] Diakinesis of prophase I

Comments : (1) Chromosomes become more contracted and condensed.
(2) Chromosomes appear as rounded bodies and they can be easily counted.
(3) **Bivalents** have tendency to move towards periphery near nuclear envelope.

Identification : Since the above chromosomes show rounded appearance and chiasmata formation, hence it is **diakinesis stage.**

[VI] Metaphase I

Comments : (1) After Diakinesis next stage *i.e.* first metaphase starts.
(2) Chromosomes become more **condensed.**
(3) Spindle apparatus appears. Bivalents become attached to spindle.
(4) Bivalents are arranged at equatorial plate.

Identification : Since the above chromosomes are arranged at equatorial plate, hence it is **metaphase-I stage.**

[VII] Anaphase I

Comments : (1) Chromosomes of bivalents from equatorial plates move towards poles, in beginning of anaphase stage.
(2) Two sister chromatids do not separate and go to the same pole, while in mitosis, the centromere divides longitudinally and the two sister chromatids pass to two different poles.
(3) Each pole has a haploid number of chromosomes.

Identification : Since chromosomes move towards poles hence it is **anaphase I stage.**

[VIII] Telophase I

Comments : (1) Nuclear membrane appears around group of chromosomes at the poles.
(2) After formation of nuclei, chromosomes pass into a small **interphase** before the second meiotic division will start. As a result of above, dyad is formed. **Cytokinesis** is postponed till the end of second meiotic division.

Identification : Since chromosomes are at the poles and are in the form of dyad, hence it is **telophase-I stage.**

B. SECOND MEIOTIC DIVISION

First meiotic division is followed by second meiotic division which is essentially the mitotic division. At II prophase chromosomes are already double, each having two sister chromatids which arrange at metaphase plate. Centromere splits forming two chromatids which move to poles. This is followed by 11 telophase and cytokinesis forming **four haploid cells.**

5. Microphotographs of Certain Cell Organelles

[I] Mitochondria

Comments : (1) The microphotograph depicts the ultrastructure of mitochondria from a pancreatic glandular cell (Fig. 10).
(2) Mitochondria appears as a rod-shaped structure consisting of **outer** and **inner** membranes.
(3) Each membrane measures 6 **nm** in thickness. Space between the two membranes is 6 to 8 **nm** in thickness. Membranes have **protein lipid-protein** configuration.
(4) Inner membrane divides mitochondria into two chambers : (i) **Perimitochondrial space** between two membranes and (ii) Inner chamber containing **matrix** and **cristae.**
(5) Inner membrane is thrown into finger-like projections or folds called **cristae.**
(6) Cristae have several F_1 **particles** on M face membrane facing matrix.

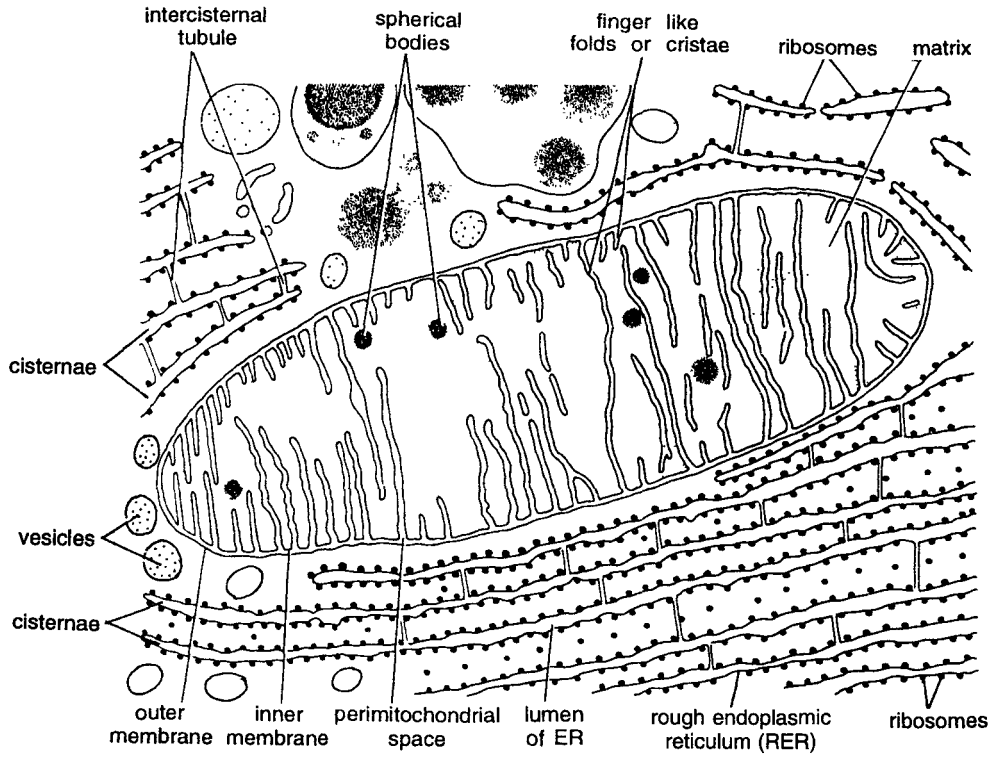


Fig. 10. Mitochondria and endoplasmic reticulum.

(7) F_1 particles are responsible for **respiratory chain oxidative phosphorylation** and **ATP synthesis.**

Identification : Since the above microphotograph has double membranous structure with cristae, hence it is **mitochondria.**

[II] Endoplasmic reticulum

Comments : (1) Ultrastructure of endoplasmic reticulum (ER) is from acini of pancreas (Fig. 10).

(2) Name of endoplasmic reticulum was given by **Porter** (1948). ER constitutes major part of cytoplasmic vacuolar system.

(3) ER is in two main forms or profiles : (i) Long parallel forms called **cisternae,** (ii) small rounded forms called **vesicles.**

(4) ER is a double membranous structure having outer and inner membranes with a lumen. Cisternae are connected together by **intercisternal tubules.**

(5) ER is called granular or rough because of presence of **ribosomes** over them. ER without ribosomes is called **smooth ER.**

(6) Ribosomes are the sites of **protein synthesis.**

(7) Endoplasmic reticulum functions to transport various nutritional chemicals new proteins and antigens in the cytoplasm.

Identification : Since the above microphotograph has tubular double membranous cisternae with ribosomes, hence it is **rough endoplasmic reticulum** (Fig. 10).

[III] Golgi body

Comments : (1) Ultrastructure of **Golgi body** has been taken from ductus deferens (Fig. 11).

(2) Golgi body was described and discovered by **Commilo Golgi** (1898) in Purkinje cells of Barn-owl.

(3) Ultrastructurally Golgi body is double membranous structure. It consists of

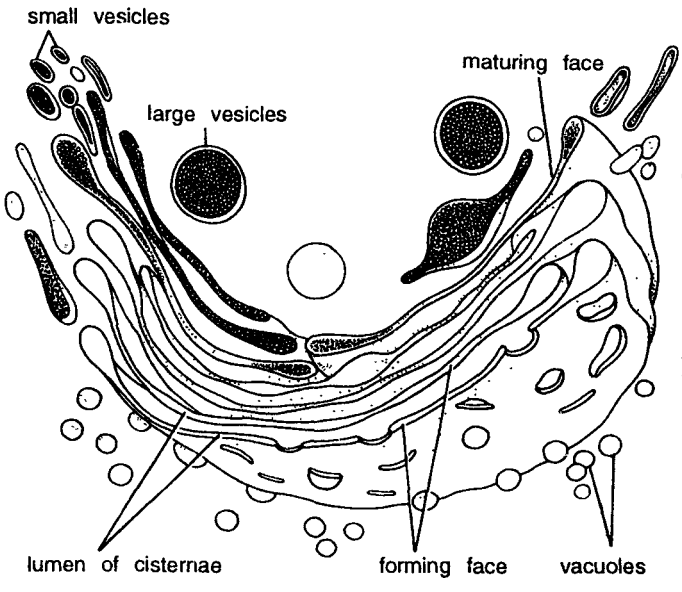


Fig. 11. Golgi body.

(i) **flattened** sacs of cisternae, (ii) small or large **vesicles** and (iii) **vacuoles**.

(4) Golgi body has two faces : (i) a convex **forming face** from where small secretory vesicles are formed. These vesicles control the synthetic products of the cell. The vesicles reach outer-most membrane and fuse with it to release their product, (ii) **concave maturing face** from where large secretory vesicles are formed.

(5) Golgi body is mainly concerned with several secretory activities such as **zymogen secretion, milk secretion, thyroglobin secretion, immunoglobulin, secretion, protein secretions, acrosome formation, sulfation** and **glycosylation**.

Identification : Since the microphotograph has cisternae, vesicles and vacuoles, hence it is **Golgi body**.

[IV] Chloroplast

Comments : (1) Diagram of chloroplast has been taken from thin section of maize plant.

(2) Chloroplast is lens-shaped, 4 to 8 microns in diameter (Fig. 12).

(3) Chloroplast is covered by double membranous structure.

(4) Between outer and inner membranes is periplastidial space of 10 to 30 nm thickness.

(5) Cytoplasm is called **stroma** or **matrix**.

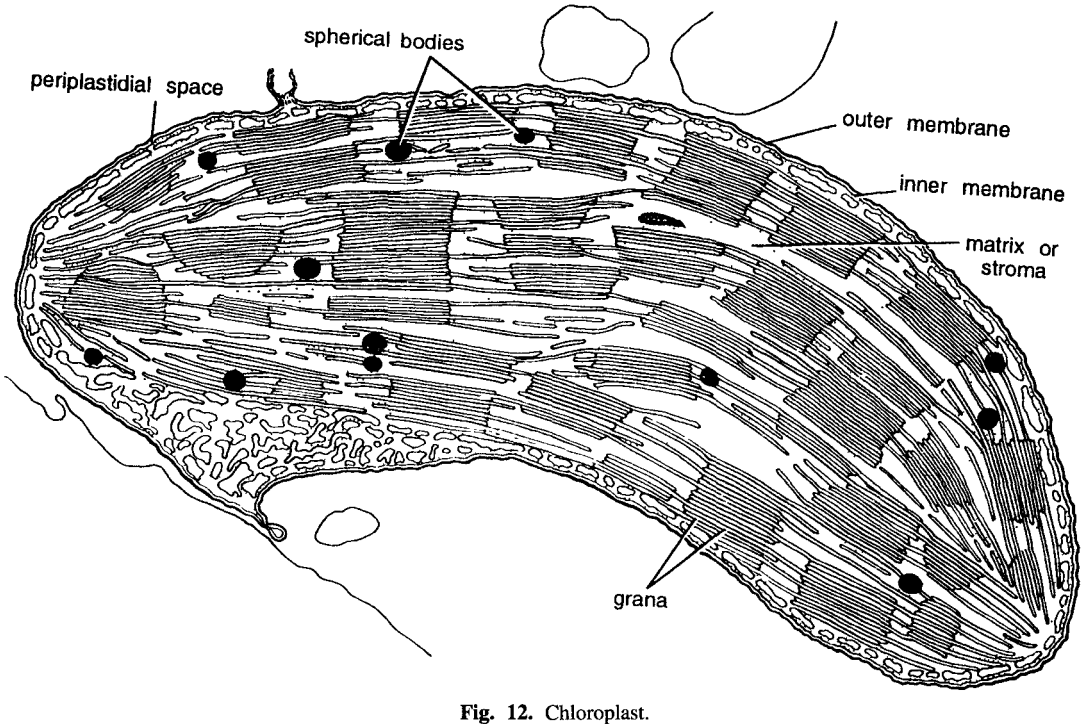


Fig. 12. Chloroplast.

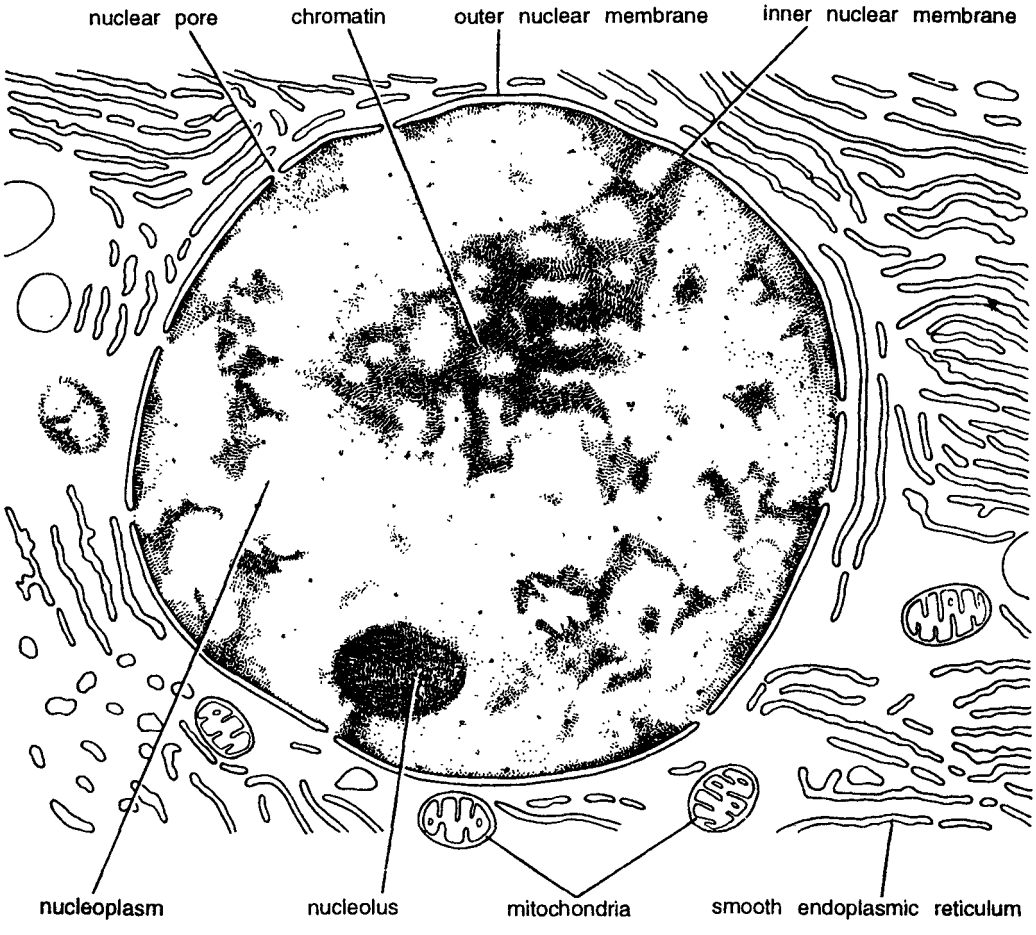


Fig. 13. Nucleus.

(6) Matrix contains two kinds of lamellar systems : (i) **Grana lamellae** in the form of piles of coins concerned with light reactions of photosynthesis, (ii) **Single stroma lamellae** matrix concerned with dark reaction of photosynthesis.

(7) Grana contains **chlorophyll** and accessory enzymes. Chloroplasts are important cell organelles where **photosynthesis** occurs.

Identification : Since the microphotograph shows piles of coin like grana lamellae hence it is chloroplast.

[V] Nucleus

Comments : (1) The microphotograph depicting ultrastructure of nucleus has been taken from a glandular cell of pancreas (Fig. 13).

(2) Nucleus has **outer** and **inner membranes** measuring 7.5 nm in thickness.

(3) Between two membranes is a perinuclear space or cisternae of 15 nm thickness.

(4) Arrows indicate the pores. The Diameter of pores varies from 30 to 100 nm. Pores provide direct contact between cytoplasm and **nucleoplasm**.

(5) Large eccentric dense and body is **nucleolus**.

(6) Dark and dense substance is **chromatin** containing DNA.

(7) Nucleus is a very important cell organelle concerned with structural, functional and hereditary aspects of living organisms especially in eukaryotes.

Identification : Since the above microphotograph has double membrane with pore like structures, hence it is **nucleus**.

12

Study of *Drosophila* and Human Chromosomes

Study of *Drosophila*

Drosophila is commonly called as **fruit fly** as it is commonly found around ripe fruits. It is specially used to study different aspects of animal genetics. The knowledge regarding sex **linked inheritance** of certain diseases has come through the studies on ***Drosophila*** for instance, colour blindness. ***Drosophila*** is very commonly used for genetics researches because of the following reasons :

(1) It is commonly available everywhere.
(2) Its life-cycle is short.
(3) It can be easily maintained and cultured in the laboratory.

Different aspects of the study of ***Drosophila*** in laboratory are as under :

1. Collection of *Drosophila*

Fruit-fly has **cosmopolitan** distribution. Fruit flies can be easily collected. Keep a cut ripe fruit such as apple in a petri-dish in open. Fruit flies are attracted by ripe and cut fruits, they come and feed on fruits and they can be easily collected by brush. Collect these flies in a cleaned wide mouth test-tube or glass stoppered bottle and close the mouth of the test tube or glass-stoppered bottle by cotton plug. Bring the collection to laboratory. Study the fruit flies under stereoscopic microscopes. Separate different fruit flies and keep them in different experimental tubes for culturing.

2. Culture of *Drosophila*

Requirements : (1) Small food vials for culturing the fruit flies.
(2) Morgue bottles.
(3) 250 cc glass stoppered or cotton plugged bottles.
(4) 500 cc glass stoppered or cotton plugged bottles.
(5) Stock bottle for storage of the feed.
(6) Eitherizer bottle.
(7) Re-eitherizer bottles.
(8) Stainless steel needles.
(9) Camel hair brush.
(10) Glass marking pencil.
(11) Petriplates (or) covered petri-dishes 3" size.
(12) Plain glass slides.
(13) Cavity slides.
(14) Glass coverslips (squarish and rectangular).
(15) Stereoscopic microscope.
(16) Research binocular microscope.
(17) 100 cc, 250 cc and 500 cc Borosil beakers.
(18) 3% aqueous solution of sodium hypochlorite.

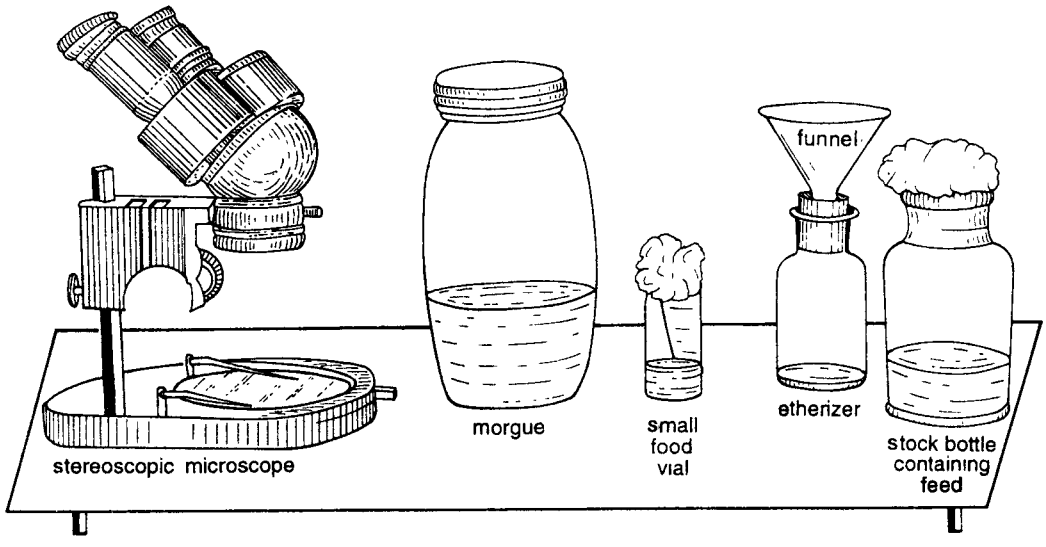


Fig. 1.

Procedure : For culturing and studying ***Drosophila*** eitherizer and re-eitherizer bottles are used. Take a 250 cc glass stoppered bottle. Close the mouth of the bottle with a cork. Make a hole in the cork through the neck of the glass funnel. Put either soaked cotton plug in opening of the bottle. Collect fruit flies in bottle and close with either soaked cotton. Fruit flies become inactivated. Inactivated fruit flies can be easily studied under the microscope. If during microscopic studies the ***Drosophila*** become active, then a fresh either soaked cotton plug is used in the neck of the funnel. Flies become again inactivated. Under stereoscopic microscope different species of ***Drosophila*** are separated. Process of making the fruit flies inactive again is called re-eitherization.

3. Preparation of Feed Medium for fruit flies

The feed of the flies is prepared by mixing definite proportion of the following gradients. In a large glass bowl keep 1400 ml of tap water. add 72 gm corn-flour. 64 gm sugar. 64 gm resin. 24 gm agar agar. 24 gm yeast, 5 ml propionic acid and 1 or 2 gm fungicide (if necessary). Depending upon the requirement the feed quantity can be increased by increasing the gradients 4 or 5 times or 10 times. Mix the gradients well and store the feed in a stock bottle. From stock bottles, take the feed and keep the feed in food vials (number of feed vials as per requirement).

4. Study of Life-cycle Stages of *Drosophila*

Collect ***Drosophila*** as described above. From collection bottles, transfer 15 to 20 fruit flies in 8 cm long, 2.5 cm wide food vials. Close the mouth of the vial with a cotton plug. Keep the food vials containing the flies in BOD incubator maintained at a temperature of 15 to 20 degree. Life-cycle is completed within 10 to 15 days. All the life-cycle stages of ***Drosophila*** could be studied in these food vials (Fig. 2).

Male and female flies copulate. After 2 to 3 hours of copulation female lays fertilized eggs. After 24 hours of fertilization egg hatches into **first instar larva**. First instar larva changes into **second instar larva** after 3 days. Fifth day second instar larva changes into **third instar larva**. On sixth day third instar larva changes into **pupa**.

Collect different stages from the food vials on different days and fix them in corrosive sublimate solution for 5 to 10 minutes. After fixing them keep the stages in 3% chlorax solution (3 gm of sodium hypochloride + 100 cc distilled water) and then in distilled water. Dehydrate the developmental or

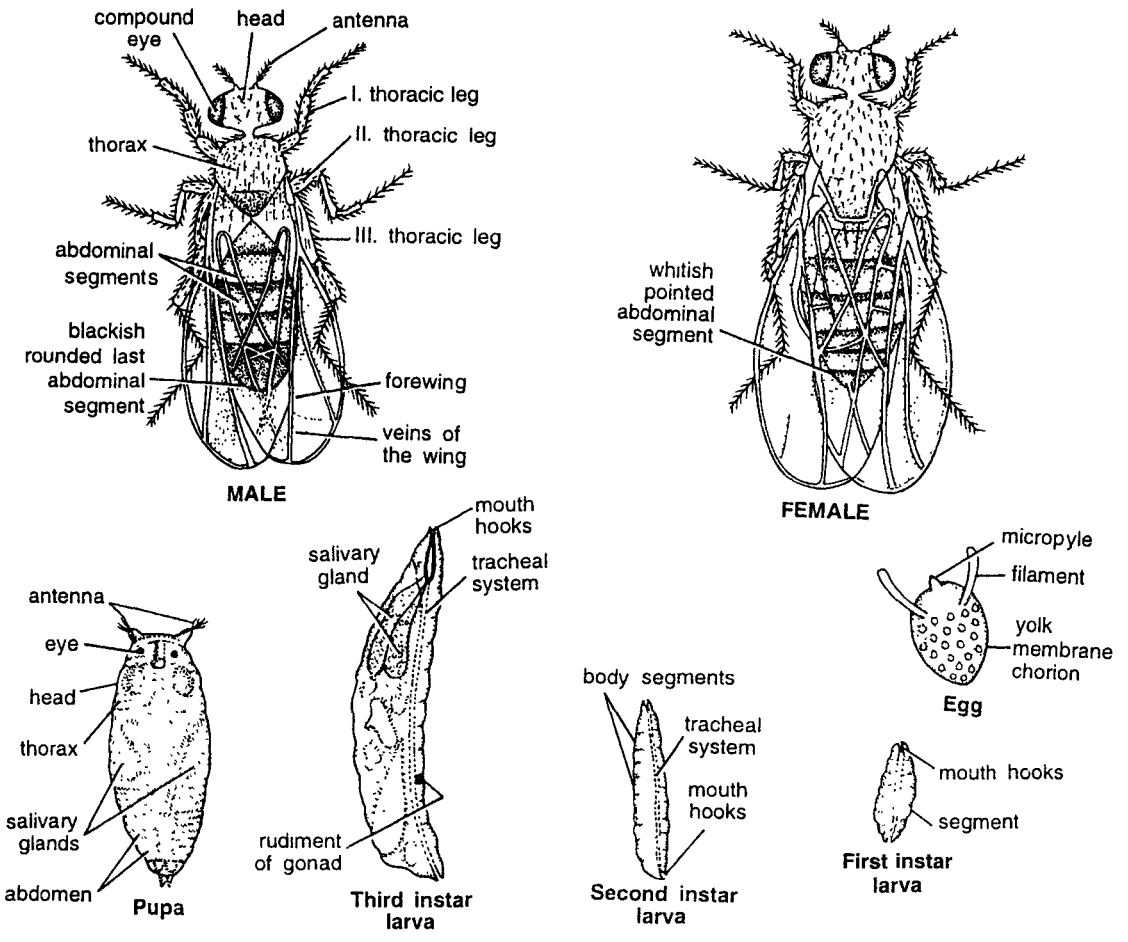


Fig. 2. *Drosophila.* Stages of Life Cycle.

life-cycle stages in 30%, 50%, 70%, 90% and 100% alcohols clear in xylol and mount in DPX. Legs and wings of ***Drosophila*** are mounted by above methods.

5. *Drosophila* Eggs

Comments : (1) Eggs are oval in shape measuring 0.5 mm in length and 0.2 mm in breadth.

(2) Dorsal side of the egg is flatter than concave ventral side (Fig. 1).

(3) Antero-dorsal part of the egg contains **two filaments**.

(4) Filaments prevent eggs from sinking in wet medium and also ensure vital oxygen supply.

(5) Two above filaments are formed from the extension of the chorion of the egg envelope.

(6) Chorion and filaments are secreted by the follicle cells surrounding the egg during **oogenesis**.

(7) Anteriorly egg contains an opening on raised structure called as **micropyle**.

(8) Sperm enter through the micropyle for fertilization

(9) Surface of the egg shows honey comb like appearance.

6. *Drosophila* : First, Second and Third Larval Stages

Comments : (1) After 24 hours of fertilization egg hatches into **first instar larva**. These larvae are seen crawling in the culture vials around yeast cells (Fig. 1).

(2) Larvae feed on yeast cells.

Male	Female
1. Males smaller in size.	1. Females larger in size
2. Have 5 abdominal segments.	2. Have 7 abdominal segments.
3. Posterior abdominal segment is black and rounded.	3. Posterior abdominal segments is transparent and pointed protruding anal plate.
4. First tarsal segment of I-thoracic leaf has characteristics-sex-comb. Sex-comb consists of row of about 10 short thick, black bristles.	4. Sex-comb absent.

(3) First instar larva (4) is characterised by having **body segments** and mouth hooks anteriorly.
(4) After 24 hours of hatching first instar larva changes into **second instar larva** (L_2).
(5) L_2 is characterized by having cylindrical body. Larva has grown in size and is characterized by having **mouth hooks**, body segments and **tracheal system**.
(6) On fifth day second instar larva changes into **third instar larva** (L_3).
(7) Third instar larva has grown considerably measuring 4 to 5 mm in length with narrow anterior and broad posterior region. L_3 is characterized by having **mouth hooks, salivary glands tracheal system** and rudiments of gonads.
(8) On sixth day third instar larva changes into **pupa**.

7. *Drosophila* : Pupa

Comments : (1) At the end of third larval stage it is enclosed in **Puparium**. After an internal molt larval cuticle is changed into pupal case.
(2) Inside puparium body is divisible into **head, thorax** and **abdomen**. Pupa has rudiments of almost all the organs (Fig. 1).
(3) Head contains **antenna** and compound eyes.
(4) In thoracic region there is salivary gland.
(5) Abdominal segments are clearly visible.
(6) Pupa contains folded impressions of **appendages** and **wings**.
(7) Initially puparium is white but in 2 hours colour changes to yellow then to dark brown and **pupal case** hardense.
(8) By histolysis some larval organs and tissues are broken down by histolysis.
(9) Salivary glands visible.
(10) Pupa metamorphosis into adult. A single egg would give rise either to male or female fruit fly.

8. Identification of Male and Female *Drosophila*

***Drosophila* : Male**

Comments : (1) Males are smaller than females.
(2) Body is divided into **head, thorax** and **abdomen** (Fig. 1 and Table 1).
(3) **Head** contains large **compound eyes** and a pair of **antennae**. Antennae bear setae or brisks.
(4) **Head** is joined to thorax by a narrow neck.
(5) **Thorax** contains paired thoracic legs (fore legs) II. Thoracic leg (mid-legs) and III. Thoracis legs (third legs). Each leg bears setae or bristles.
(6) Thorax contains wings extended beyond abdomen.
(7) Abdomen contains 5 segments. Last abdominal segment is **black** and **rounded**.

***Drosophila* : Female**

Comments : (1) Females are larger than males.
(2) Body divisible into **head, thorax** and **abdomen** (Fig. 1, Table 1).
(3) **Head** contains paired large **black compound eyes** and paired antennae. Antennae contain bristles.
(4) **Thorax** contains 3 pairs of legs and 2 pairs of wings. Thorax and legs contain large number of bristles.
(5) **Abdomen** contains 7 segments.
(6) Last abdominal segment contains anal plates which are pointed and last abdominal segment looks like pointed.
(7) Hind wings in fold condition extend males beyond last abdominal segment.

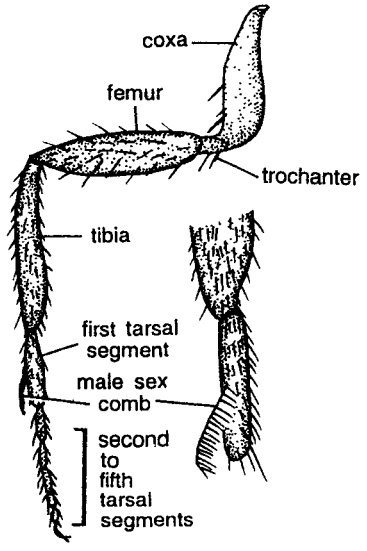


Fig. 3. *Drosophila.* Fore leg and sex comb.

9. *Drosophila* : Fore legs and Sex-comb of Male

Comments : (1) Foreleg is composed of **coxa, trochanter, femur, tibia** and 5 jointed tarsus.
(2) First tarsal segment contains **sex-comb**. Sex-comb contains 10 black coloured **bristles**.
(3) Fore leg contains large number of bristles (Fig. 3).

10. *Drosophila* : Wing

Comments : (1) 2 pairs of membranous wings, fore wings smaller (Fig. 4).
(2) Hind wings larger extending beyond abdomen.
(3) Hind wings contain anterior cross-veins, longitudinal veins and posterior cross veins.

11. *Drosophila* : Diagnostic Features of wild and Mutant Varieties

[I] Wild type

Comments : (1) Body divisible into **head, thorax** and **abdomen**. Head contains **antennae** and **compound eyes** (Fig. 5A).
(2) Wild type was grey or brown colour.
(3) **Eyes** are brick red colour.
(4) Thorax contains wings, halters and secretellum.

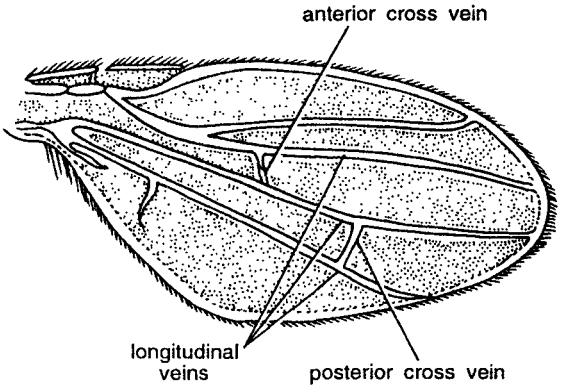


Fig. 4. *Drosophila.* Wing.

[II] Mutant types

Certain mutant types are as under.

(a) Drosophila : Yellow body

Comments : (1) Body divisible into **head thorax** and **abdomen** (Fig. 5A).
(2) Head contains **antennae** and **compound eyes.**
(3) Thorax contains 3 pairs of legs and 2 pairs of wings.
(4) Colour of the adult fruit fly **Yellow.**

(b) Drosophila : Curly wings

Comments : (1) Body divisible into **head, thorax** and **abdomen** (Fig. 5B).
(1) Head contains antennae and compound eyes.
(2) Thorax contains 3 pairs of legs and 2 pairs of wings (fore wings and hind wings)
(3) Hind wings are curly. They are curled upwards.

(c) Drosophila : Scalloped

Comments : (1) Body divisible into **head, thorax** and **abdomen** (Fig. 5C).
(2) Head contains **antennae** and **compound eyes.**
(3) Thorax contains 3 pairs of legs and paired fore wings and hind wings.
(4) Wings have abnormal edges.

(d) Drosophila : Apterous

Comments : (1) Body divisible into **head, thorax** and **abdomen.**
(2) Head contains **compound eyes** and **abdomen.**

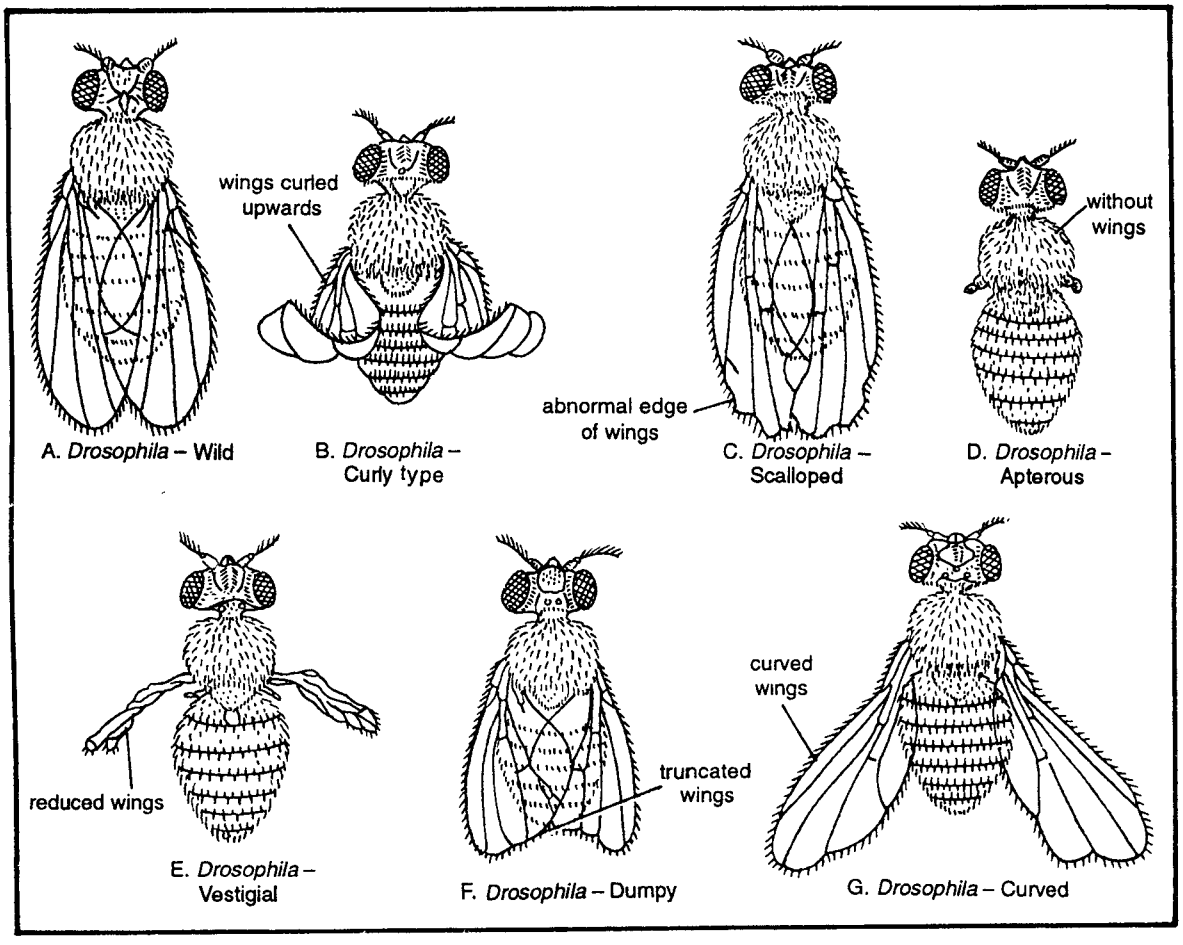


Fig. 5. *Drosophila.* Wild and mutant types.

(3) **Wings absent** hence **apterous** (Fig. 5D).
(4) Bristles present all over body.

(e) Drosophila : Vestigial

Comments : (1) Body divisible into **head, thorax** and **abdomen** (Fig. 5E).
(2) Head contains small antennae and compound eyes.
(3) Thorax has 3 pairs of legs.
(4) **Wings reduced.**

***(f) Drosophila* : Dumpy**

Comments : (1) Body divisible into **head, thorax** and **abdomen** (Fig. 5F).
(2) Head contains **antennae** and **compound** eyes.
(3) **Wings truncated.**
(4) Bristles present all over body.

(g) Drosophila : Curved

Comments : (1) Body divisible into head, thorax and abdomen (Fig. 5G).
(2) Head contains compound eyes and antennae.
(3) Bristles present all over the body.
(4) **Wings curved.**

12. *Drosophila* or Chironomous Larva

Study of DNA by Feulgen reaction. DNA can be studied in the salivary glands of ***Drosophila*** or **chironomous** larva.

Principle : DNA (Deoxyribonucleic acids) can be studied in the paraffin sections of salivary glands of ***Drosophila*** or **chironomous** by **Feulgen-Schiffs** reaction. Feulgen and Rosenbeck (1924) and Pearse (1968) studied

above reaction for DNA. In this reaction DNA is denatured by hydrolization at 60°C. During this process **deoxypentose sugar** and **aldehydes** of DNA are separated. After hydrolization tissues are subjected to Schiff's reagent. The chromatin stained and purple colour is obtained.

Procedure : ***(a) Preparation of Schiffs reagent*** : Schiffs reagent prepared by Berger and Delamater (1948) gives best result. Take a 500 cc conical flask and clean it by chromic acid solution. Chromic acid solution is prepared by mixing 10 gm potassium dichromate in 100 cc of concentrated sulfuric acid (1180). Rinse conical flask by chromic acid solution. Wash the flask 9 times with tap water and 3 times with distilled water. Keep flask in inverted position for drying on a filter paper. Dissolve 1 gm basic fuchsin in 400 cc of boiling distilled water in a conical flask. Borosil or Corning conical flask should be taken. Cool the flask to 50°C and then filter it in another conical flask. To the filterate add 1 cc of thionyl chloride. Let the solution stand for 12 hours in dark. Add 2 gm activated charcoal to the solution. Shake it for 1 to 2 minutes. Filter the solution and store in the dark at 0°- 4°C.

(b) ***Feulgen staining method*** : Dissect ***Drosophila*** or take out salivary glands of Chironomous larva. Fix the salivary glands in 10% formalin solution. Prepare paraffin sections of salivary glands. Dry the sections for 24 hours. Keep the sections in xylene to remove. Pass the sections through 100%, 90%, 70%, 50%, 30% alcohols and then into distilled water. Keep the sections in N-HCL (normal hydrochloric solution) at 60°C for 30 min. for denaturation of DNA. After this keep the sections in cool N-HCL and then in distilled water. Then stain in the sections in Schiff's reagent. After staining wash the sections in potassium bisulphide, then in ammonium chloride and then in distilled water. Dehydrate sections in 30, 50, 70, 90 and 100% alcohols. After dehydration keep sections in xylene for 5 to 10 minutes and then mount them in DPX.

Result : In the sections purple coloured dot shaped structures depict DNA.

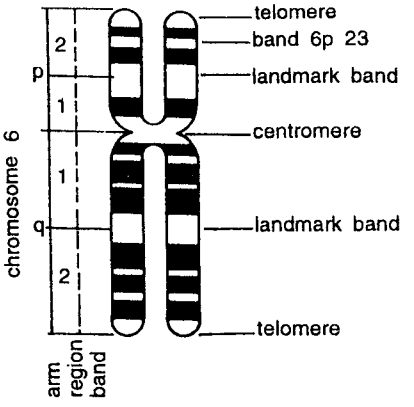


Fig. 6. Man. Chromosomes.

Study of Human Chromosomes

Procedure : Human chromosomes can be studied by **Giemsa** staining and by G. banding technique. Human chromosomes and karyotypes can be studied by tissue culturing of **skin, fibroblasts, bone marrow**, peripheral blood. Colchicine and hypotonic solution is used to block mitosis at metaphase stage and to separate the chromosomes.

Take a small vial or glass tube and add a little anticoagulant in it. Take blood from tip of the finger and mix it with anticoagulant. Separate serum and blood corpuscles by centrifugation. Take blood corpuscles over slide and treat with 1% potassium chloride solution or 1% sodium citrate solution. After this flood the slide with carnoy fluid or 3 : 1 methanol acetic acid for 15 to 20 minutes for fixing the chromosomes. Keep the slide for drying for one week. Write date over the corner of the slide. After a week treat the slide with 0.25% trypsin solution (0.25 gm trypsin + 100 cc distilled water). Wash the slide with 100% alcohol. Dry the slide and then stain with Giemsa stain, and mount in DPX.

Comments : (1) By Giemsa staining detailed structure can be studied (Fig. 6).

(2) By G **banding** 3 kinds of chromatin can be seen (i) **centromeric** or **kinetochromatic** which are **heterochromatin**, (ii) **intercalary heterochromatin**, and (iii) **euchromatin**.

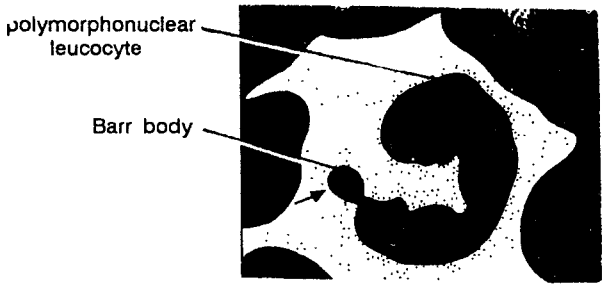


Fig. 7. Female. Barr body.

(3) In chromosomes 6 bands can be seen like telomere, centromere and land mark band, etc.
(4) Q **band** and G **bands** are equal.
(5) G bands contain excess of adenine and thymidine bases.
(6) G and Q bands are active in transcription.
(7) Human chromosomes depicts macrocoiling.

Barr body

Barr and Bertram (1949) made outstanding discovery that in the interphase nucleus of **females**, there is small chromatin body called as sex chromatin or **Barr body**. This sex-chromatin body is absent in **males**. Now this chromatin body is called as **X-chromatin**.

Medical significance : Study of above has great medical applications and it has potential to relate certain congenital diseases and chromosomal abnormalities. In Olympic games certain males disguise themselves as females to compete in the events of female games. Barr body helps in identification of such **suspected males** because it is absent in males.

The X-chromatin in interphase stage become heterochromated and condensed and are best seen. Frequency of detection of X-chromatin or Barr body varies with tissues to tissue-60% in nervous tissue, 96% in amniotin epithelium and in oral smears and leucocytes 20-50% and in human polymorphic (polymorphonuclear leucocytes). Barr-body is clearly observed as **drum stick** in a nuclear appendage.

Procedure : From the finger tips of females, blood is collected by puncturing the tip of finger by sterilized needle. Make a thick blood film of the blood on slide. Let the film dry for 30 minutes. Treat the slide with a mixture of glacial acetic acid and tartaric for hydrolysis of haemoglobin. Stain the slide with **Leishman stain** and wash the slide with tap water. Dry the slide and study under oil immersion.

Result : Barr body is seen like **drumstick** in one of the nuclear appendage of a chromosome.

13 Genetic Exercises

Following exercises have been planned including :

(1) Multiple alleles.
(2) Mendel's law of independent assortment.
(3) Interaction of genes.
(4) Sex-linked inheritance

1. Based on Multiple Alleles

EXERCISE (1)

What will be the phenotypes as to blood groups of offsprings of parents having the following genotypes for blood groups ?

1. IAi × IBi
2. IAIB × IBi
3. IBi × IBi
4. IAIA × IAIB
5. IBIB × IBi
6. IAIB × IAIB

Observations : Blood types A and B are codominant. They both are dominant over O and hence :

IAIA or IAi will be 'A' type
IBIB or IBi will be 'B' type
IAIB will be 'AB' type
ii will be 'O' type

Result : The phenotypes of blood group offsprings are as indicated in parenthesis ( ) in crosses I-VI (Fig. 1).

EXERCISE (2)

In rabbits Agouti colour C^+ is dominant over C^h (chinchila), C^{ch} over Himalayan and C^h and C^h over C (Albino).

What will be the appearances of the offsprings from the following crosses in rabbits ?

1. $C^+ C^{ch}$ X C_2^+
2. $C^{ch} C^h \times C^h C^h$
3. $C^h c \times C^{ch} C^h$
4. $C^+ C^{ch} \times C^{ch} C$
5. $C^{ch} C^h \times C^h C$
6. $C^{ch} C^h \times cc$

Observations : Agouti (C^+) is dominant to all while albino (c) is recessive to all.

Result : The appearance of offsprings is indicated in crosses I-IV in parenthesis (Fig. 2).

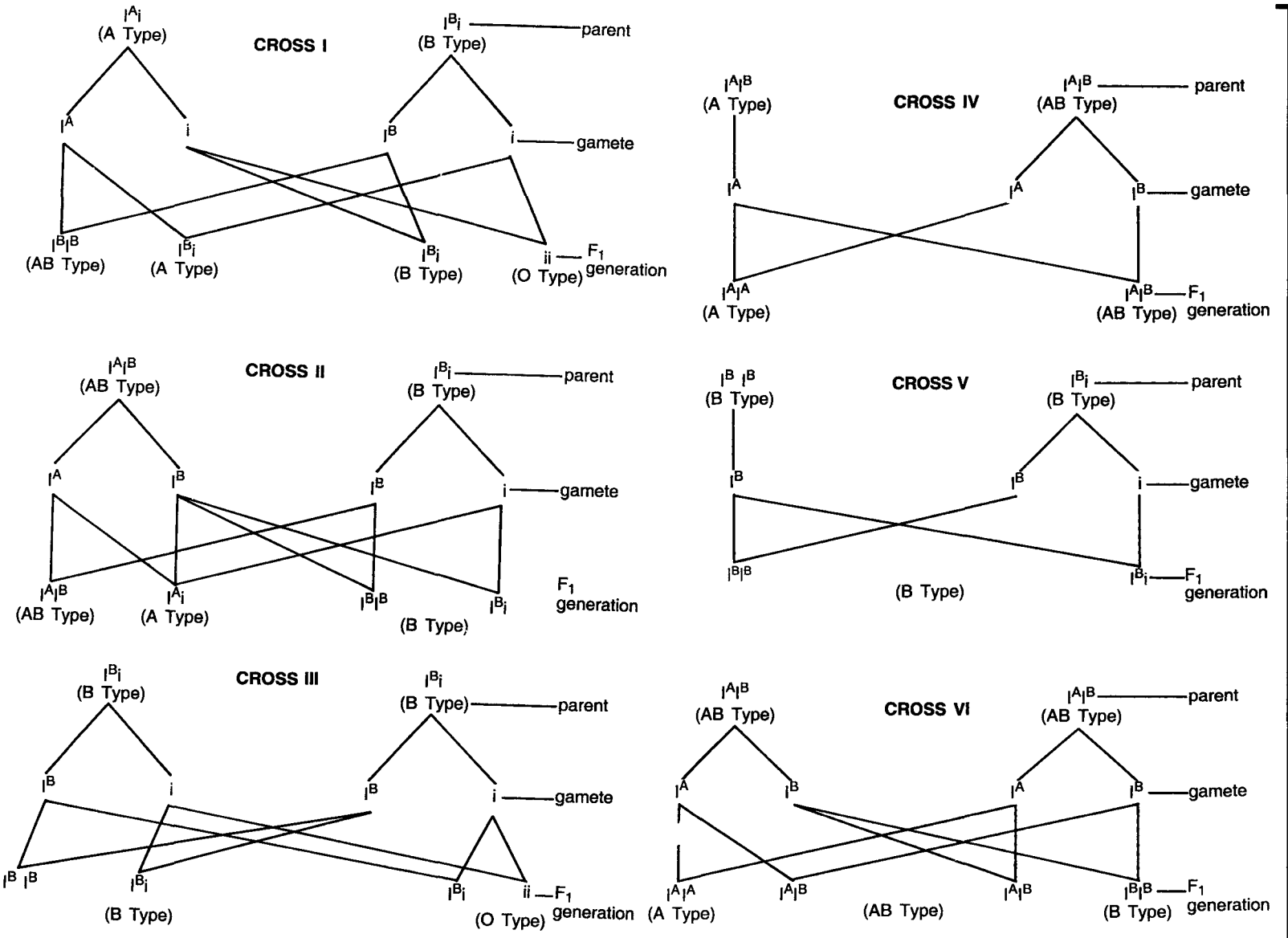


Fig. 1. Crosses I-VI based on multiple alleles.

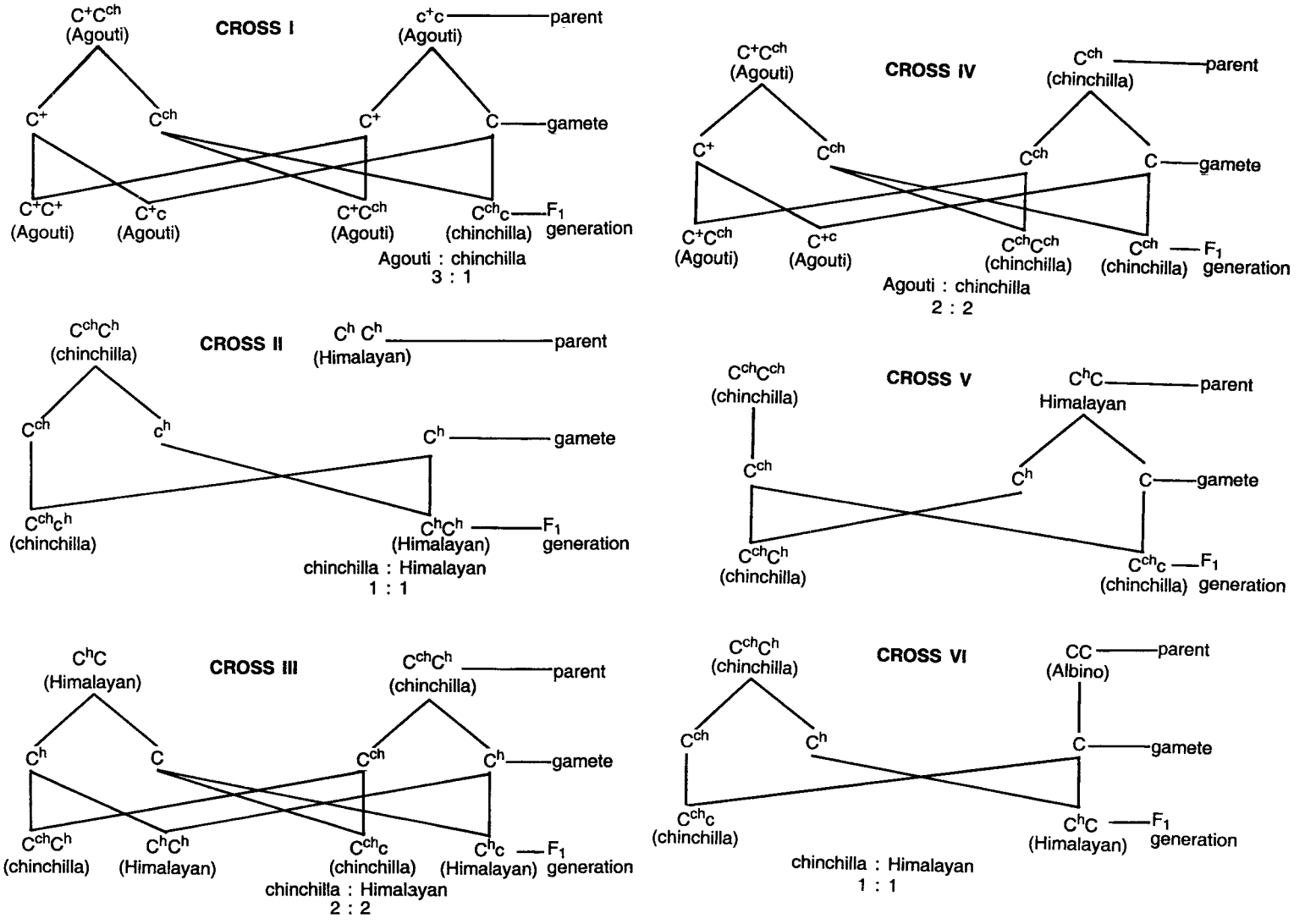


Fig. 2. Crosses I-VI based on multiple alleles.

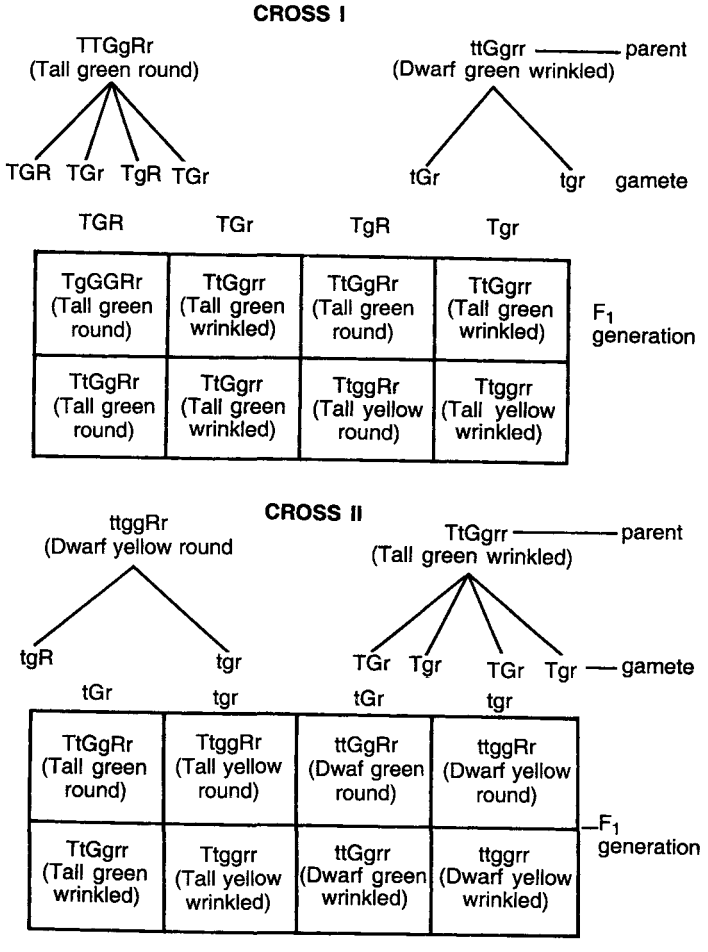


Fig. 3. Crosses I-II based on law of independent assortment.

2. Based on Law of Independent Assortment

EXERCISE (3)

In pea Tall (T) is dominant over dwarf (t), green (G) over yellow (g) and round (R) over wrinkled (r). What will be the phenotypes of the hybrids from the following crosses assuming independent assortment.

1. *TT Gg Rr* × *ttGgrr*
2. *tt gg Rr* × *TtGg rr*

Observations : The following crosses are based on Mendel's Law of Independent Assortment (Fig. 3).

Result : The appearance of the offsprings is indicated in crosses I-II in parenthesis ( ).

3. Based on Dihybrid Cross

EXERCISE (4)

Determine the colour of the flower of offsprings as a result of the following crosses of sweet pea.

1. *CcPp* × *ccPp* 2. *ccPp* × *CCpp*
3. *CcPp* × C_cPP 4. *Ccpp* × *cc Pp*

Note : Genes *C* or *P* alone produce white flower but when present together produce purple colour due to complementary interaction between *C* and *P*.

Observations : The above exercise is based on interaction of genes representing di-hybrid cross (Fig. 4).

Result : The colour of the flowers of offsprings of above crosses are indicated in crosses I, II, III and IV in parenthesis. The ratios of purple and white in crosses I, II, III and IV are 3 : 5, 1 : 1, 1, 6 : 2 and 1 : 3 respectively.

4. Based on Interaction of Genes

EXERCISE (5)

In maize *C* and *R* are both necessary for the production of red aleurone colour. The absence of either of them results in white colour.

Assuming independent assortment, what would be the aleurone colour of the offsprings from the following crosses.

1. *CcRr* × *ccRr* 2. *CCrr* × *CcRr*

Observations : The above exercise is based on interaction of genes (Fig. 5).

Result : The colour of the offsprings are indicated in parenthesis ( ) in crosses I and II.

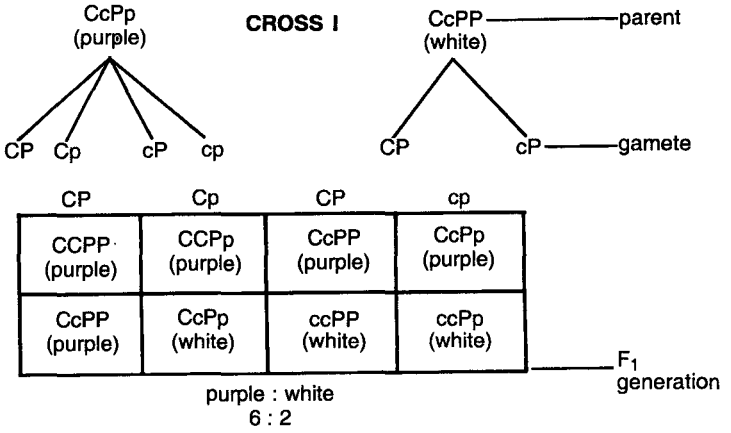


Fig. 4. (a)

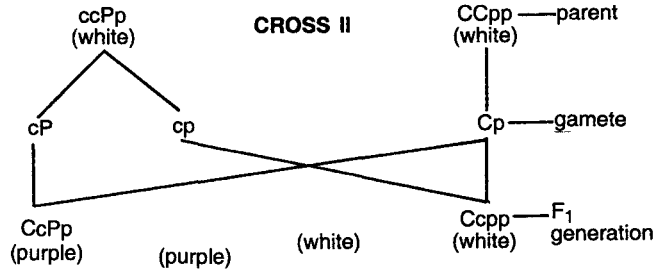


Fig. 4. (b)

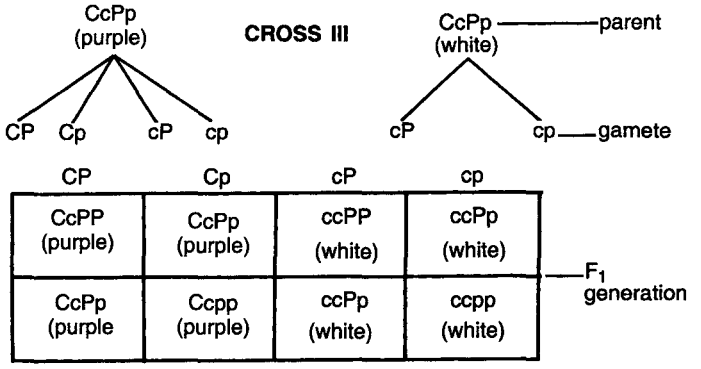


Fig. 4. (c)

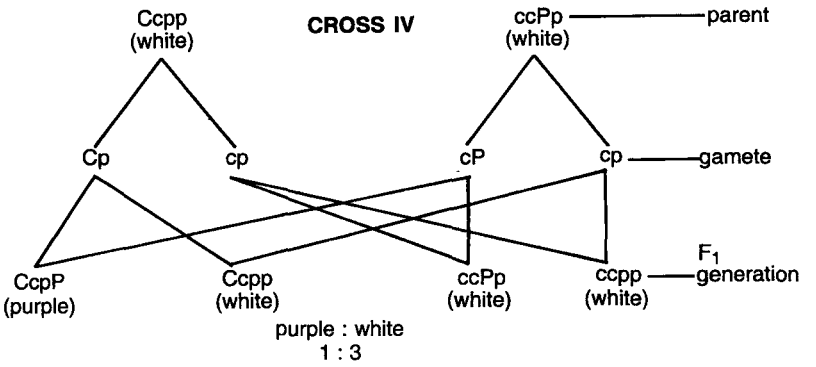


Fig. 4. (a-d) Crosses I-IV based on dihybrid cross.

CROSS I

	CR	Cr	cR	cr	
cR	CcRR (red)	CcRr (red)	ccRR (white)	ccRr (white)	gamete
cr	CcRr (red)	Ccrr (white)	ccRr (white)	ccrr (white)	F_1 generation

parent

red 3
white 5

CROSS II

	CR	Cr	cR	cr	
Cr	CCRr	CCrr	CcRr	Ccrr	gamete
	(red)	(white)	(red)	(white)	F_1 generation

parent

red 1
white 1

Fig. 5. Crosses I-II based on interaction of genes.

14 Experimental Ecology

Experimental ecology includes the following experiments :

(1) Study of certain **modifications** in animals due to micro-ecological and macro-ecological conditions. In the former, modifications or adaptations in various parasites because of differential micro-ecological niches, and in the latter certain aquatic and aerial modifications, are studied.

(2) Study of **biotic** and **abiotic factors**.

Modifications or Adaptations

Micro-ecological conditions such as pH, enzymes and other chemical constituents, affect the parasites which undergo various modifications.

1. Blood fluke *(Schistosoma)*

Comments : (1) Blood flukes live in blood vessels of vertebrates. Blood vessels provide nutritionally very rich environment for the parasites. There are three species of blood flukes found in man namely ***Schistosoma haematobium***, ***S. mansonii***, ***S. japonicum***.

(2) In order to swim freely in tubular blood vessels, their dorsoventrally flattened body becomes tubulated.

(3) Ventral sucker present but not meant for attachment.

(4) Female is always carried by the male in his **gynecophoric canal**.

(5) Outer covering is tegument through which sugars, amino acids and lipids are observed.

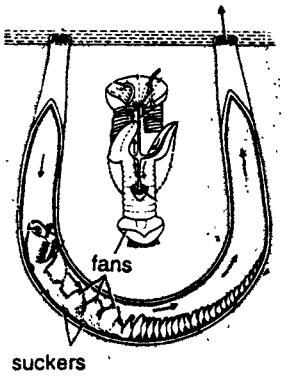
2. Liver fluke *(Fasciola)*

Comments : (1) Micro-ecologically these parasites live in the bile duct, biliary passages and live in the lobules of sheep, man and other herbivorous mammals. Four species namely ***Fasciola hepatica***, ***Fasciola gigantica***, ***F. indica*** and ***F. magna*** are prevalent.

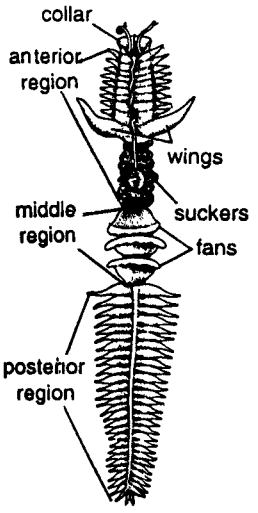
(2) Body of parasite is soft, shiny and dorsoventrally flattened.

(3) Parasite can roll its body inside the bile duct and liver lobules.

(4) Ventral sucker or acetabulum has strong radial muscles. It forms a sort of vacuum to attach with the host tissues.



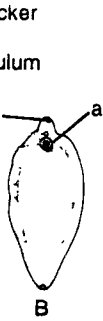
Chaeopterus in burrow



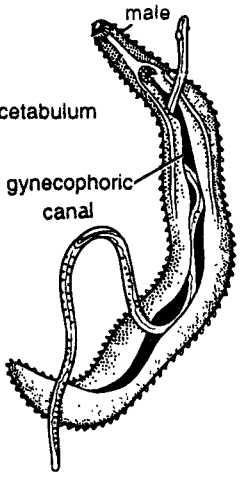
Chaeopterus



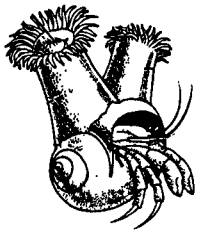
A *Fasciola gigantica*



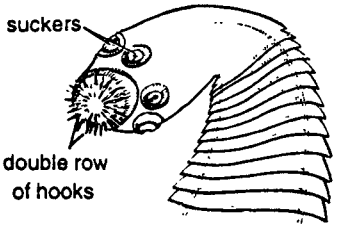
B *Fasciola hepatica*



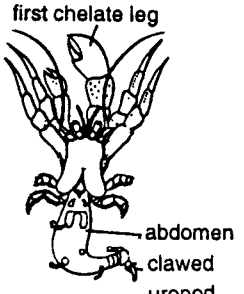
Schistosoma



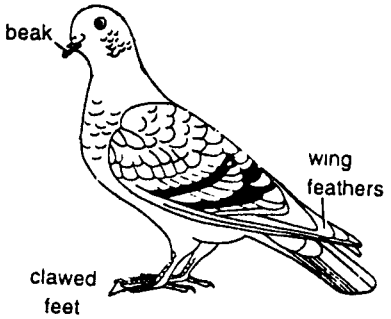
Hermit crab and sea anemone



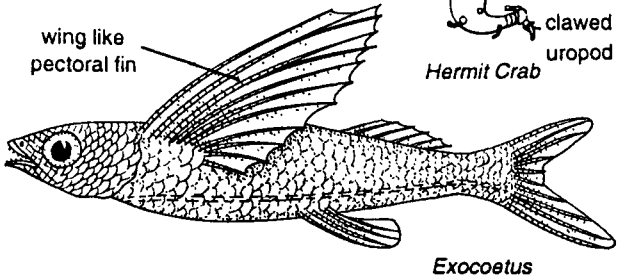
Taenia solium



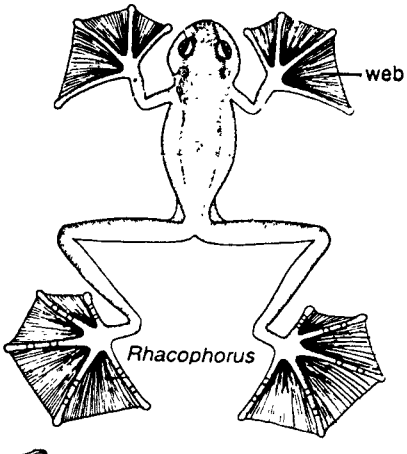
Hermit Crab

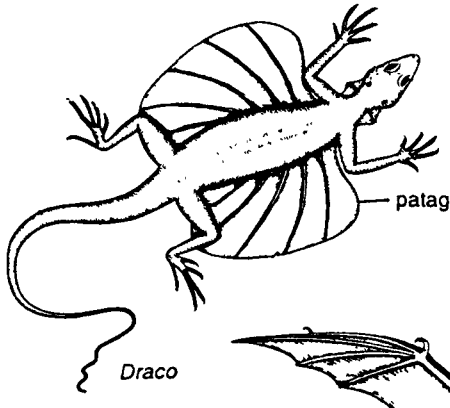


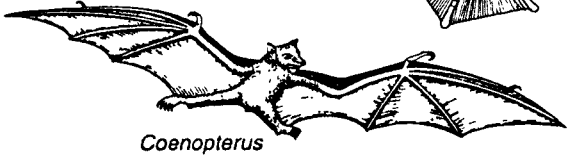
Columba livia



Exocoetus







Coenopterus

Fig. 1. Adaptations in animals.

(Z–20)

(5) Anterior extremity has oral sucker for feeding and sucking.

3. Tapeworm *(Taenia solium)*

Comments : (1) ***Taenia solium*** is found in the small intestine of man. Small intestine provides very good micro-ecological niche for these cestodes.
(2) Body is divided into **scolex, neck** and strongly dorsoventrally **flattened segments**.
(3) Scolex lies burried in the intestinal mucosa. It has four well developed suckers for firm attachment.
(4) Attachment is further strengthened by the presence of a circlet of small and large rostellar hooklets or hooks. Each hook is **anchorshaped**.
(5) Digestive system completely absent.
(6) Body is covered with tegument through which amino acids, sugars and other nutritional chemicals are absorbed.

4. *Chaetopterus*

Comments : (1) ***Chaetopterus*** is a marine polychaete tubicolous worm. Its burrow is made up of sand and mucous. Because of tubicolous, sedentary and ciliary feeding the animal shows several modifications.
(2) **Notopodia** of 15 to 20 anterior segments form a **collar** of funnel-like structure for generating water current inside the tube or burrow.
(3) There is a mucous bag anteriorly to filter the food.
(4) Notopodia of tenth segment becomes enlarged and **aliform** (wing-like) for collecting food (particles).
(5) Three middle segments are modified as **fan-like** structures. They have strong muscles and act as pumping organ to maintain the water current.
(6) Posterior body region has reduced segments.

5. Hermit crab *(Eupagurus)*

Comments : (1) Hermit crabs are marine anomuran crustaceans. On every sea beach several hermit crabs are seen occupying molluscan shells. Only their appendages are seen moving. Rest of their body remains inside the shell.
(2) Body proper is asymmetrical and divided into cephalothorax and abdomen.
(3) Right chelate leg, right antennae and right walking legs are larger than left ones.
(4) Abdomen is asymmetrical, soft, fleshy, elongated and twisted to fit inside the coils of the shell. Abdominal appendages of right side absent while reduced on left side.
(5) Sixth abdominal segments or **uropods** are modified as hook-like structures to be anchored inside the shell.
(6) Sea anemones are attached on the external surface of the mollusc shell. The sea anemone, mollusc shell and hermit crab show fine example of **commensalism**.

6. Flying fish *(Exocoetus)*

Comments : (1) Flying fish is found in warmer seas. It is pelagic feeding on prawns etc.
(2) Body is elongated. **Pectoral fins** are **exceptionally large**, spread like wings for gliding.
(3) Pelvic fins are also adapted to lift the body out of water.
(4) By powerful strokes of pectoral fins, fish is able to leave water to avoid enemies. It glides over the surface of the water.
(5) Ventral lobe of tail fin is elongated (hypoblastic tail).

7. Flying frog *(Rhacophorus)*

Comments : (1) ***Rhacophorus*** lives on trees. It has completely modified itself for aerial mode of life by gliding.
(2) Body of the frog is comparatively lighter.
(3) Hind limbs are elongated.
(4) Both the fore and hind limbs contain **well developed** webs which act as **parachutes** during gliding.
(5) Digits contain adhesive pads for attachment.

8. Flying lizard *(Draco)*

Comments : (1) Flying lizard lives on trees and is adapted for aerial environment and arboreal living.
(2) Body is **dorsoventrally compressed**.
(3) Thoracic ribs are expanded and folds of skin between them form patagia or membranous wings, one on either side of body.

9. Pigeon *(Columba livia)*

Comments : (1) Pigeon is the most familiar bird. It shows several modifications for aerial mode of life.
(2) Eyes are large with monocular vision.
(3) Neck is short and mobile.
(4) Fore limbs are modified into wings. Tail feathers elongated.
(5) Hind limbs have claws and modified for walking as well as **perching** on **trees.**
(6) Body is very light because of **pneumatic bones.**

10. Bat (*Cynopterus*)

Comments : (1) Amongst mammals extreme modifications for arboreal life are shown by bats.
(2) Forelimb bones are elongated for supporting membranous wings.
(3) Skin folds forming membranous wings or patagia are well developed.
(4) Bats are capable of true flight. They are mostly nocturnal and swift fliers.

Study of Biotic and Abiotic Factors

Every ecosystem consists of abiotic and biotic factors.

1. Abiotic factors contain :
(1) **Inorganic substances** such as chlorides, sulphates, phosphorus, sulphur, nitrogen, hydrogen, etc.
(2) **Organic substances** such as carbohydrates, proteins and lipids.
(3) **Climatic conditions** such as rains, temperature, light, moisture, etc.

2. Biotic factors consist of autotrophs, heterotrophs, producers and consumers.

A. Study of Biotic Factors

EXERCISE (1)

Object : Study of ecosystem in a glass trough.

Procedure : Take a glass trough or a small aquarium and fill it three-fourth with ordinary tap water. Make its bottom rocky and muddy. Plant on the bottom ***Hydrilla***, ***Chara*** or ***Vallisneria***. Add *Spirogyra* and ***Nymphea*** as floating plants. Add certain ciliates, ***Euglena***, ***Cyclops***, ***Brachionus***, etc. Keep some frogs and fishes. Keep the trough in sunlight. Study the following :

1. **Abiotic components :** (i) Measure the temperature of the pond by a thermometer, (ii) Find the pH of the water by pH papers.
2. **Biotic components :** Study the following :

(a) ***Producers*** **:** Consisting of green plants. The plants may be submerged such as ***Hydrilla***, ***Vallisneria***, ***Chara*** and ***Ceratophyllum***. The free floating and rooted floating consist of ***Spirodella***, ***Wolffia***, ***Lemna*** and ***Nelumbo*** respectively. The phytoplankton includes Xanthophycea and Chlorophyceae.

(b) ***Consumers*** **:** Consumers are **primary**, **secondary** and **tertiary**. Primary consumers include bottom consumers, insects and zooplankton. Secondary consumers comprise small fish, insects and frogs, while tertiary consumers include big fish and birds.

EXERCISE (2)

Object : To study the biotic components of a pond ecosystem.

Requirements : Collection nets with different mesh sizes, metallic chains with hooks, specimen tubes, glass jars, hand lens, scissors, forceps, hand centrifuge, microscopes and stains.

Procedure : Plants and animals from pond could be collected by nets and placed in jars and polythene bags.

Pond water with vegetation could be collected in a glass trough also. Metallic chains and hooks may be used to collect various plants. Planktons (algae and protozoans) are collected by nylon nets. Bring pond water sample to laboratory for further examination.

Observation : Observe three biotic components of pond ecosystem namely producers, consumers and decomposers.

1. **Producers :** Comprise following green plants:
   (a) Sub-merged : Hydrilla, Vallisnaria, Ceratophyllium, Chara.
   (b) Free floating : Spirodella, Pistia, Wolffia, Eichornia, Azolla, Lemna.
   (c) Rooted floating : Alelumbo, Nymphaea.
   (d) Amphibious : Typh ranunculus.

(e) ***Phytoplankton*** : Members of Chlorophyceae, Myxophyceae, Bacillariophyceae and Xanthophyceae.

2. **Consumers :**
   (f) ***Primary*** : Bottom fauna such as molluscs, insects and Zooplankton.
   (g) ***Secondary*** : Small fish insects.
   (h) ***Tertiary*** : Large fishes and birds.
3. **Decomposers** : Bacteria and fungi, especially ***Aspergillus***, ***Penicillium***, ***Fusarium***, ***Paecilomyces***, ***Rhizopus***, etc.

EXERCISE (3)

Object : Study of community structure of grassland. Grasslands are present between forests and deserts, and the climate in this region is of the intermediate type. Winters are cold, summers warm and rainfall average. Flora and fauna of the grasslands are as under :

1. **Study of the flora of grasslands :** Perennial grasses constitute the dominant climax vegetation. Climax grasses may be tall (1.5 to 3 m), medium (0.5 to 1.5 m) or short (below 0.5 m) and grow in bunches. Grasses grow quickly after the onset of warm and rainy weather and are adapted for long quiescent periods of dryness and cold. Leaves or top of the grasses die during unfavourable seasons, but underground kinds regenerate new growth during the next favourable period. Tall and short grasses are observed in a grassland.

Tall and mid grasses	Short grasses
1. *Andropogon*-Blue stem	1. *Aristichia*-Triple armed grass
2. *Agropyron*-Wheat grass	2. *Bontelous*-Grana grass
3. *Elymus*-Poric grass	3. *Buchli*-Buffaloe grass
4. *Poa*-Blue grass	

Note : Collect grasses and make their Herbarium.

2. **Study of the fauna of grasslands :** Due to presence of grasses in abundance, in grasslands, large populations of grazing animals are present. Large herbivorous ungulates reach their largest population. They feed in large herds. Bison and proghorn antelopes are the main occupants. Predators feeding on these animals, like wolves and bears, rodents and lagomorphs constitute the other principal groups of mammals. Ground squirrels, pocket gophers, mice and jack rabbits are common nearly everywhere.

B. Study of Abiotic Factors

EXERCISE (4)

Object : To estimate the chlorides and sulphates of calcium for hardness of water.
Glass apparatus : Burette, stand, pipette (50 ml graduated), beaker and titration flasks.

Preparation of reagents

1. **Calcium chloride solution :** Dissolve 55 gm of calcium chloride in 1000 cc of distilled water in a titration flask.
2. **Sodium versnate solution :** Dissolve 2.5 gm of sodium versnate in 2000 cc of distilled water. Add 13.5 cc of 1 N.NaOH (40 gm of NaOH in 1000 cc of distilled water). Make the volume upto 2500 cc. For making it as standard solution, titrate it with Eriochrome Black-T as an indicator.
3. **Eriochrome Black-T (Standard solution) :** Add 1 gm of Eriochrome Black-T in 30 ml of distilled water. Add to this 1 ml of 1N.Na_2CO_3. Make the volume to 100 cc with isopropyl alcohol.
4. **Buffer solution :** Dissolve 40 gm of borax in 800 ml of distilled water in a beaker. In another beaker, dissolve 10 gm of NaOH and 5 gm of sodium sulphide in 100 ml of distilled water. Mix the two solutions together and make it up to 1000 cc with distilled water.

Procedure : (1) Take 100 ml of sample water from any pond, river or lake.
(2) Add few drops of 0.01 N.HCL to make it acidic.
(3) Boil it for few minutes.
(4) Add 0.5 ml of buffer solution.
(5) Add few drops of Eriochrome Black-T indicator solution.
(6) Titrate with standard versnate solution. Take initial reading. Then take end point reading on the appearance of blue water.
(7) Repeat the experiment 5 times.

Amount of sodium versnate used represents 1 part per ml of chlorides and sulphates.

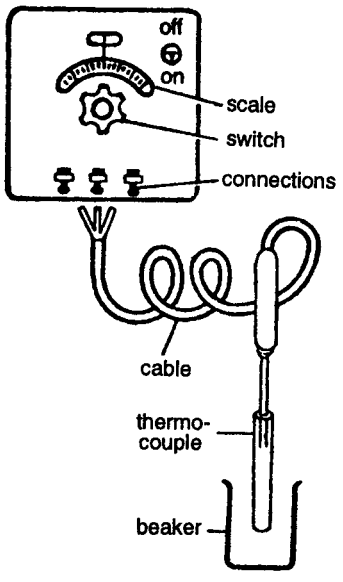


Fig. 2. Thermistor.

EXERCISE (5)

Object : To determine pH turbidity, temperature and light intensity.

Requirements : pH universal indicator, Secchi disc, long thread, meter scale, thermistor and sealed photometer in water tight containers with glass windows.

Procedure :

1. **pH :** For determining pH of a pond water, collect water of pond from different places and depths. Keep these water samples in different wide mouthed glass stoppered bottles. Mark these bottles according to the place of their collection. Take 5 ml of water of a bottle, add few drops of universal indicator. Compare the colour developed with the colour chart pasted on the indicator bottle and find out approximate pH. Determine pH of all the bottles and make a chart showing place of collection and pH.
2. **Turbidity :** For determining turbidity, take Secchi rounded discs having white and black stripes. With both hands gradually lower the disc in water whose turbidity is to be determined. A point would come when white and black stripes would be indistinguishable. This depth of water is referred to as **turbidity index**. Collect water from different ponds for determining turbidity. Note the depth of turbidity index in each case.
3. **Temperature :** For determining the temperature of the pond, use thermistor (Fig. 2). It consists of a glass globule with thermocouple, electric cord and potentiometer with graduated scale collect pond water in a beaker. Dip the glass globule in beaker holding with hands. Switch on potentiometer and note directly the temperature indicated by the needle. Note the temperature of the pond at different places and at different depths.
4. **Light intensity :** For determining light intensity, place the sealed photometer at different sites and depths in pond and note directly the reaching of light intensity.

EXERCISE (6)

Object : To determine dissolved oxygen (DO).

Requirements : Titration flasks, titration tube, maganous sulphate solution, Alkali-iodide-azide reagent, concentrated sulphuric acid, phosphoric acid, sodium thiosulphate solution (0.1N and 0.025N), and starch solution.

Principle : If maganous sulphate is added to the sample containing alkaline potassium iodide, maganous hydroxide is formed which is oxidised by the dissolved oxygen on addition of sulphuric acid. If further sulphuric acid is added, the basic maganic oxide liberates iodine equivalent to that of dissolved oxygen originally present in the sample. The liberated iodine is titrated with standard solution of sodium thiosulphate using starch as indicator. By calculating the amount of iodine liberated, the DO could be determined.

Preparation of reagents

1. **Maganous sulphate solution :** Take 250 ml titration flask. Weigh 91.0 gm of maganous sulphate monohydrate and dissolve it in titration flask in 9 litres of distilled water. Then dilute with distilled water upto 250 ml mark.
2. **Alkali-iodide-azide reagent :** In a titration flask, dissolve 175 g Potassium hydroxide (OR 125 g sodium hydroxide) and 37.5 g potassium iodide (for 33.7 g sodium iodide) in

a little distilled water and dilute with distilled water upto 250 ml.

3. **Sodium thiosulphate solution.** Dissolve 24.82 g sodium thiosulphate in a little double distilled water in a volumetric flask. Dilute with distilled water upto 1000 ml. To make 0.025 N sodium thiosulphate solution, take 250 ml of 0.1 N sodium thiosulphate and dilute it to 1000 ml with double distilled water.
4. **Starch solution :** Take 1 gm starch in a little water. Make a thin paste and pour it in 100 cc boiling water. Keep on boiling for 2 minutes and then cool.

Procedure : (1) Collect the sample in BOD bottles.

(2) Add 2 ml maganous sulphate solution in the bottle by pipette. The pipette should never touch the water level. It should always be above the water level.
(3) Add 2 ml alkali-iodide-azide solution.
(4) Close the bottle with stopper and invert the bottle 10 times. A brown precipitate appears indicating presence of oxygen. If white precipitate, no oxygen.
(5) Allow the precipitate to settle completely.
(6) Remove stopper carefully and add 2 ml of concentrated sulphuric acid by the sides of the bottle.
(7) Take 203 ml of the solution from the bottle into a conical flask of 500 ml capacity.
(8) Titrate immediately with 0.025 N sodium thiosulphate solution using starch as indicator.

Calculation : If the thiosulphate solution is exactly 0.025 N, then mg/l dissolved oxygen = ml thiosulphate XI.

EXERCISE (7)

Object : To determine carbon dioxide (CO_2).

Requirements : Distilled water, sodium carbonate, phenolphthalein, measuring cylinder, conical flask and Zeoondroff apparatus.

Principle : CO_2 constitutes basic component of photosynthesis in plants. Without CO_2 hardly any life can exist. Oceans serve as biospheric CO_2 reservoir. Industries created by man and burning fuel increase CO_2. CO_2 is continuously absorbed by sea but the oceans do not absorb CO_2 at the rate at which it is being produced. Climatologists are of the opinion that small changes in the atmospheric CO_2 bring disturbances in the terrestrial environment.

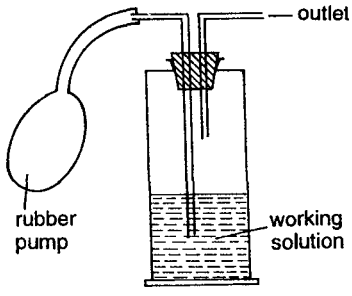


Fig. 3. Zeoondroff apparatus.

Procedure : Dissolve 0.53 gm of sodium carbonate in 100 ml of distilled water in a conical flask, boil the solution and cool it. Add 0.1 gm of phenolphthalein to the solution. The solution becomes pink. Shake the solution. Take 10 ml of sodium carbonate solution in Zeoondroff apparatus. Keep the apparatus in a normal or benign environment with normal CO_2 concentration on a table. Pump the air through the rubber pump. Count each stroke of pump, till the pink colour disappears.

After disappearance of pink colour, clean the above apparatus thoroughly. Again add 10 ml of working solution to the Zeoondroff apparatus. Take the apparatus where CO_2 is to be measured. Keep the apparatus on a table. Here also pump CO_2 through rubber pump. Count the number of stroke till the pink colour disappears. Calculate percentage of CO_2 by the following formula :

$$CO_2\ (\delta) = \frac{B}{S \times 25}$$

where B = number of strokes applied in benign environment, S = number of strokes applied in polluted area. Thus calculate percentage of CO_2.

Analysis of Soil

The soil analysis involves physical characters of soil, chemical characteristic and moisture content.

EXERCISE (8)

Object : To study physical characteristics of soil texture, colour and temperature.

Procedure :

1. **Texture :** Collect different soil samples. Observe with hand lens. Also examine and observe the soil between thumb and fingers. The following kinds of soils can be observed :
   (a) ***Sandy*** **:** Individual grains (0.02-2.0 mm) are observed, crystal-like structure. Moist sands are squeezed.
   (b) ***Sandy loam*** **:** Dry grains fall separate. Moist form does not break and forms casts.
   (c) ***Loam*** **:** Can be squeezed when dry. Moist soil forms casts and can be easily handled without breaking.
   (d) ***Silt loam*** **:** Dry as well as moist soils can be easily handled without breaking. Grain size 00.02-0.2 mm.
   (e) ***Clay loam*** **:** Hard when dry. Breaks into lumps. Moist soil is pinched forming thin ribbon which breaks easily.
   (f) ***Clay*** **:** Forms a very hard lump when dry. Moist and wet soil sticky. Size of soil particles 0.002 mm.
2. **Colour :** Collect soil samples and spread over a cardboard or white paper sheet. Spread the particles of the soil. Match the colour of different particles with Munsell's colour chart. Note different colours of the soil particles.
3. **Temperature :** Special thermometer, called **soil-thermometer**, is used to measure the temperature of different soils by inserting the bulb of thermometer in soil. Temperature can also be taken from different depths. Dig the soil at different depths such as 1, 6, 12 and 18 inches.

EXERCISE (9)

Object : To study chemical characteristic of the soil.

The pH, moisture content, nitrate and carbonate contents of the soil could be studied.

Requirements : Different soil samples, hot oven, china clay, tiles, test tubes, capillaries, universal indicator, barium sulphate, hydrochloric acid, diphenylamine, concentrated sulphuric acid, ammonium thiosulphate solution and hydrogen peroxide.

Procedure :

1. **pH value :** For determining pH of the soil collect the sample of the field. Take small amount of soil in a test tube. Weight the soil and add equal amount of barium sulphate. Add 15 ml of water. Stir the soil and then allow the solution to stand for sometime. Take few drops of the supernatant fluid in a watch glass. Add equal amount of universal indicator in the watch glass. Match the colour of the fluid with colour chart for different pH values on indicator bottle. Note the pH value. Detect pH of different soil samples.
2. **Moisture content of the soil :** For determining moisture of the soil, collect moistured soil, weight and then keep in hot oven at a temperature of 105-110°C, for 24 hours. Weight the sample. Calculate the moisture percentage by the following formula :
   (i) Weight of the soil before heating = X gm
   (ii) Weight of the soil after heating = Y gm
   (iii) Moisture present = X – Y gm
   (iv) Moisture percentage = $\frac{X-Y}{Y} \times 100$
3. **Carbonate content of the soil :** For determining carbonates, take the samples of the soil in different test tubes. Add few drops of hydrochloric acid in each test tube. Effervescence occurs. The degree of effervescence varies in different test tubes. The tubes showing maximum effervescence indicates maximum carbonates in the soil.
4. **Nitrate content :** For determining nitrates, take 1 gm of each soil sample and mix it with 5 ml of water. By a pipette take small amount of each sample in a white plate or glass plate. To each sample add 2-3 drops of diphenylamine and 2 drops of concentrated sulphuric acid. Blue colour develops. The intensity of the colour varies in different sample tests.

Study of Embryology Slides 15

SPERMATOGENESIS

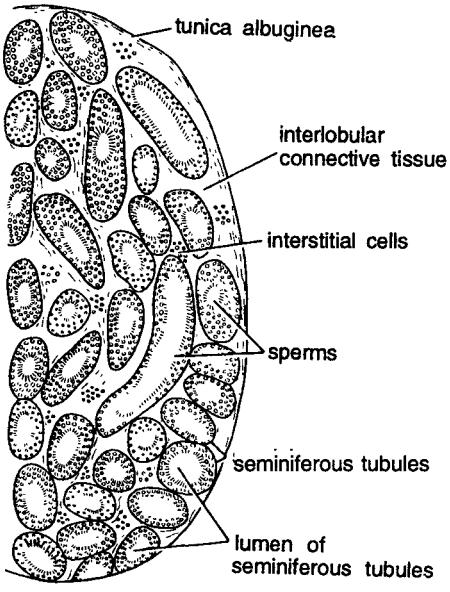
Spermatogenesis can be studied through histological preparation of tissues (testis) or by **squash technique** or **heat dry Giemsa** technique. For histological studies, testis of Albino rat is taken out after chloroforming rat. After fixing testis is 10% formaline, its sections are cut through **microtomy process**. Stain sections in **haematoxylin** and **eosin**, dehydrate, clear in xylol and mount in DPX. Study various stages under the microscope. For spermatogenesis, various changes undertaking in chromosomes, slide can be made by squash technique and heat dry Giemsa technique. Study the slides under microscope for various stages as under.

1. Rabbit : T. S. Passing Through Testis and Spermatogenesis

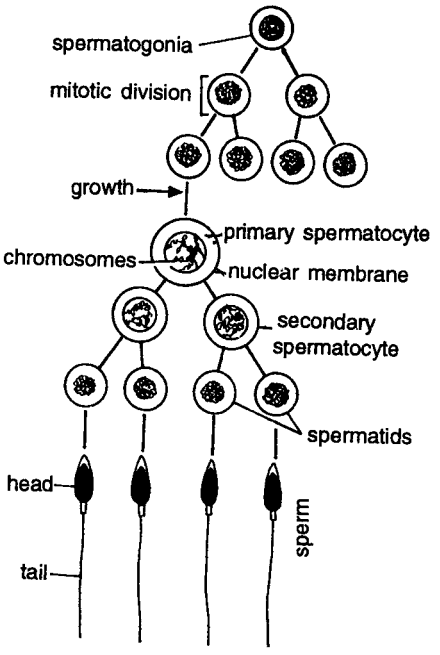
Comments :

(1) T. S. Testis shows various stages of spermatogenesis.
(2) Serosa is a hard cellular layer called on **tunica albuginea.**
(3) Each **seminiferous** tubule is covered by a thin basement membrane and lined germinal epithelium.
(4) Germinal epithelium has **sperm mother cell** which undergoes **mitotic division** to give rise to **diploid spermatogonia.**
(5) Each spermatogonium gives rise to two **primary spermatocytes.** Each primary spermatocyte gives rise to two **secondary spermatocyte** which are haploid after reduction division.
(6) Each secondary spermatocyte undergoes second meiotic division or mitotic division and gives rise to two **spermatids.** These spermatids again divide and give rise to four spermatozoa.
(7) In the first reduction division, **prophase-I, leptotene, zygotene, pachytene, diplotene** and diakinesis occurs followed by anaphase-I and telophase-I. Because of above stages this is longest stage.

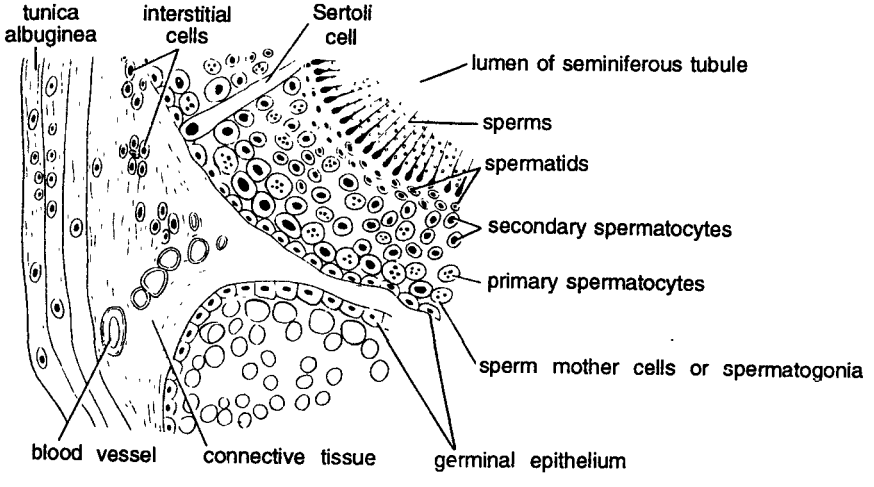
Identification : Since the section has spermatids, spermatozoa and above feature, hence it is T. S. of **testis of rabbit.**



A



C



B

Fig. 1. Rabbit : T.S. passing through testis and spermatogenesis. **A.** Low magnification. **B.** High magnification, **C.** Stages of spermatogenesis.

OOGENESIS

Development of fully mature oocyte is called as oogenesis. In males one spermatogonium gives rise to 4-spermatozoa. In female one oogonial mother cell gives rise to four oocytes. Out of four oocytes, three of them degenerate and only one develops into mature ovum. Ovum is always larger because it has to carry bulk of development and it is ovum which is transformed into adult individual either male or female. Oogenesis can be studied by **histological** studies of tissue or by **squash technique** or by **heat dry Giemsa** method. Take a albino rat, chloroform it, dissected and take out **ovaries** and fix is 10% formalin. Cut sections by microtomy process. Stain sections in Haematoxylin and eosin. Dehydrate, clear and mount is DPX. Study under high and low magnification.

2. Rabbit : T. S. Passing Through Ovary and Oogenesis

Comments :

(1) T. S. through ovary shows **serosa**, oogonial mother cells and oogonial cells (Fig. 2).
(2) Serosa is outer most layer lined by **oogonial mother cells**.
(3) Oogonial mother cells divide mitotically forming oogonial cells which develop into **oocytes**.
(4) Oogonial cells pass through growth phase and maturation phase.
(5) Older oocytes contains yolk platelets, DNA, RNA, E.R. (endoplsmic reticulum), ribosomes, Golgi body and cortical granules.
(6) Appearance of two polar bodies of maturation indicates ovum.
(7) In ovary other structures seen are **tunica albugines stroma**, blood vessels, **interstitial cells, oogonic**, developing **follicles, germinal epithelium, oocytes, Graafian follicles, young follicles and corpus luteum**.

Identification : Since the section has Graafian follicle and above features, hence it is T.S. of **ovary of rabbit**.

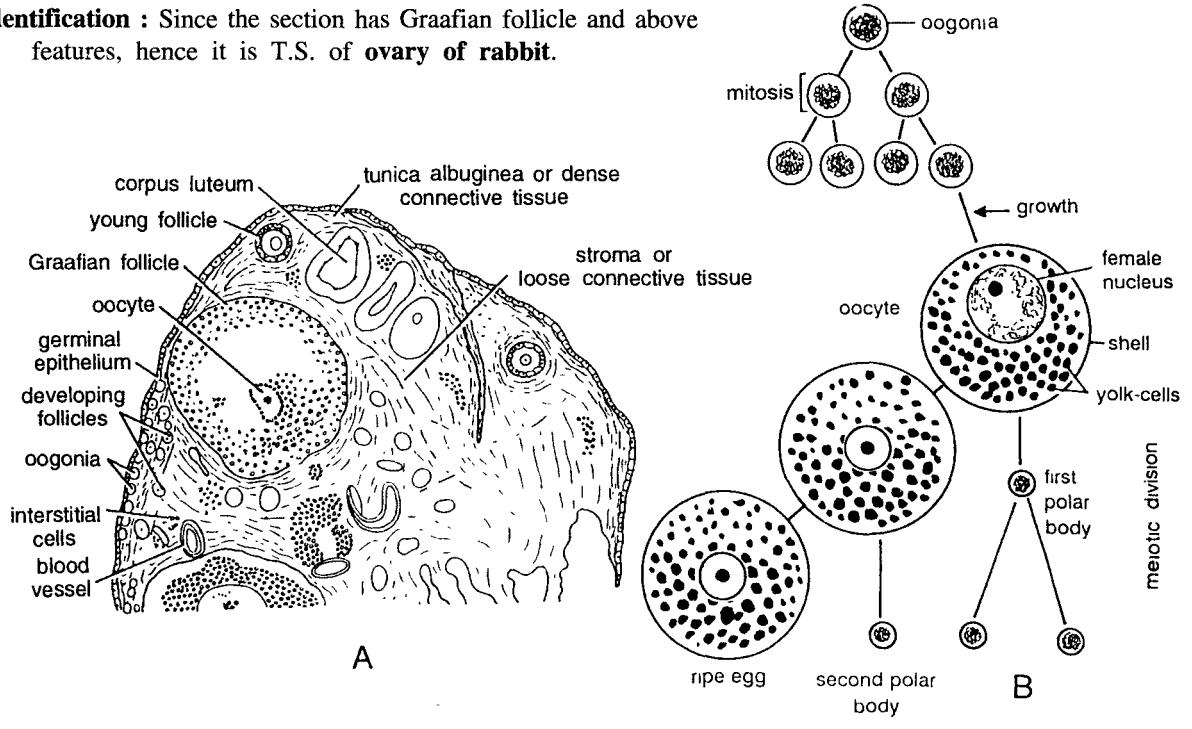


Fig. 2. Rabbit : T.S. passing through ovary and oogenesis. **A.** Low magnification, **B.** Stages of oogenesis.

3. Study of Fertilization Through A Model Diagram

Comments :

(1) In the model diagram a **haploid ovum** fuses with a **haploid spermatozoa** to give genetically **diploid zygote** (Fig. 3).

(2) In both internal and external fertilization on one egg one or several active sperm reach but only one fertilizes the ovum.

(3) Sperm contains tail, mitochondria, nucleus and acrosome sperm first recognizes the plasmamembrane of female nucleus and then penetrates. Only head enters the egg after encountering cortical granule.

(4) Plasma membrane of sperm fuses with egg plasma membrane through agglutination.

(5) Fertilizin and antifertilizin help in fertilization and head nucleus fuses with female nucleus forming **zygote**.

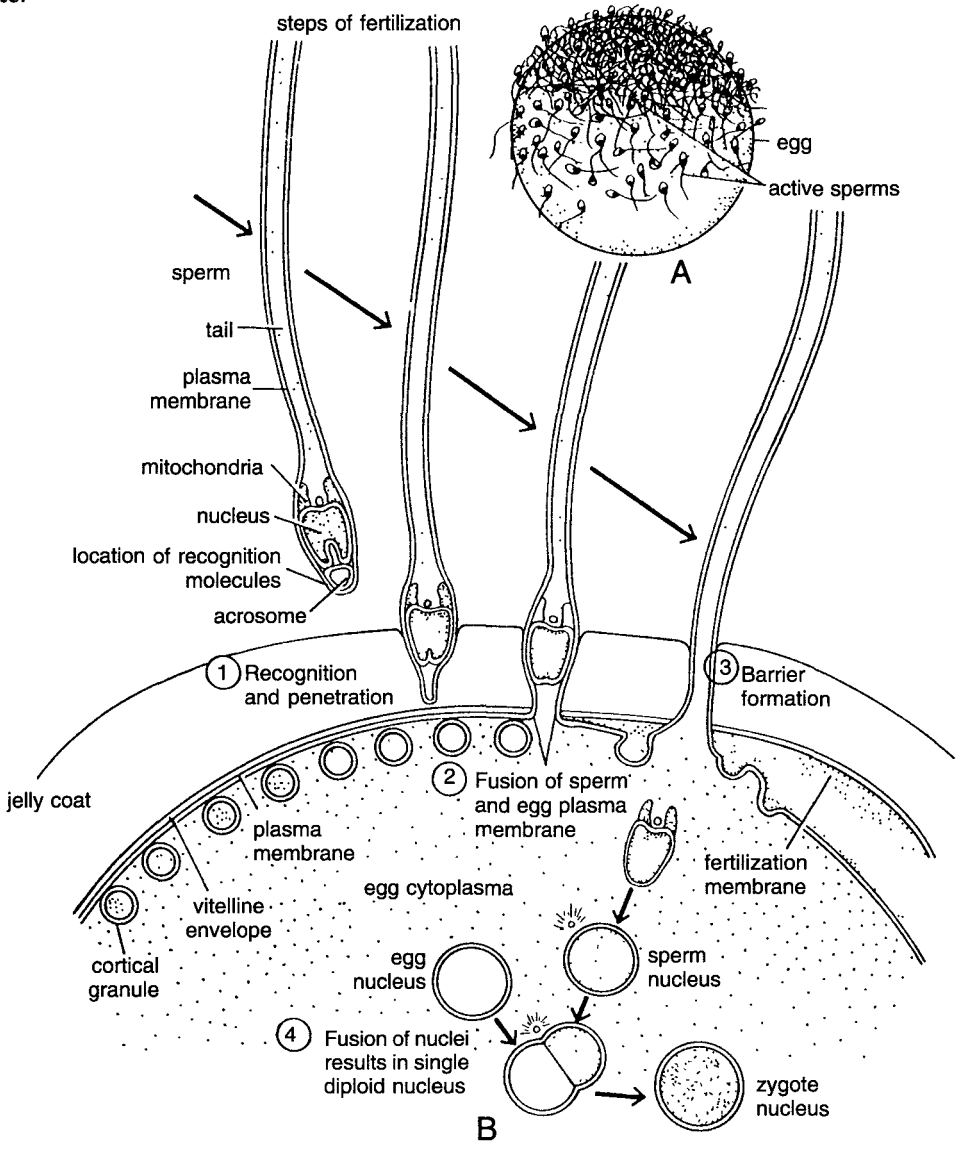


Fig. 3. Different stages of fertilization-Model.

(6) Penetration of sperm head is helped by proteolytic **hyaluronidase enzyme.**
(7) After fertilization and formation of zygote no other sperm enters as by chemical reaction a barrier membrane is formed to prevent entry of any other sperm.
(8) In diagram **cortical granules, vitelline envelope**, fusion of sperm and egg plasma membrane fertilization membrane, sperm nucleus and diploid zygote is seen.

Identification : Since the figure has zygote and above features, hence it depicts model for **fertilization.**

DEVELOPMENT OF FROG

4. Frog : Structure of Ovum

Comments :

(1) The **ovum** is rounded in shape and covered by albumen layer, chorion and vitelline membrane.
(2) It measures 1.6 mm in diameter (Fig. 4).
(3) One half of the **zygote** is **pigmented black** called animal hemisphere and the remainder is almost **white.**
(4) **Vitelline** membrane swells up on the exposure to water. The interspaces contain minute plants, which give oxygen by their manufacture of food to the embryo.
(5) Cytoplasm of the egg contains **yolk, nucleus**, polar body and vitelline membrane.
(6) Blackish brown pigment **granules** of **melanin** assemble at future animal hemisphere forming a superficial pigmented layer.
(7) Centre of the pigmented area is the **animal pole** and the opposite end is the **vegetal pole.**
(8) Soon after fertilization the embryo rotates within the **vitelline membrane** so that the animal hemisphere is the uppermost.

Identification : Since the egg contains pigmented hemisphere towards animal pole, hence it is **ovum of frog.**

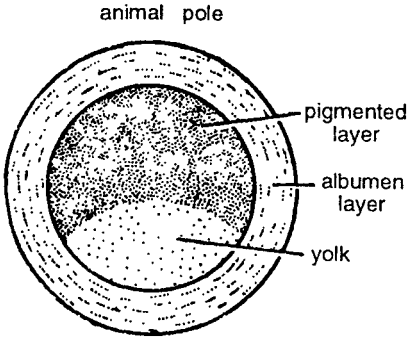


Fig. 4. Frog : Structure of ovum.

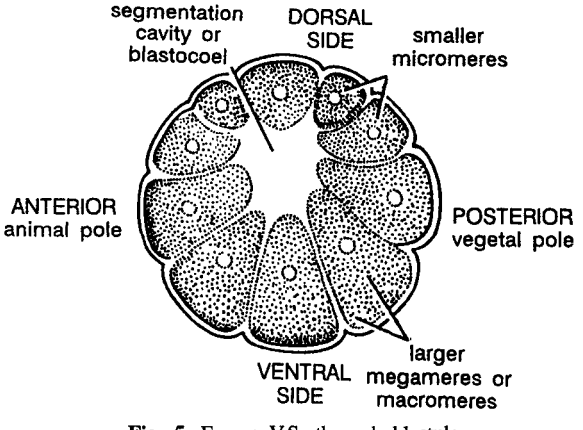


Fig. 5. Frog : V.S. through blastula.

5. Frog : V.S. Passing Through Blastula

Comments :

(1) Egg cleaves and forms blastula at 8-cell stage (Fig. 5).
(2) Blastula contains a **blastocoel** cavity surrounded by unequal blastomeres.
(3) **Smaller** blastomeres are called as **micromeres**, found in upper half and contain dark pigments.

(4) Larger blastomeres are called as **macromeres**, found in more than lower half and laden with yolk.
(5) Lower side or **vegetal hemisphere** is composed of large yolky megameres. Because of their large size the blastocoel is excentric lying towards the **animal pole**.

Identification : Since the egg contains blastocoel and above features hence it is V. S. through **blastula of frog.**

6. Frog : V.S. Passing Through Gastrula

Comments :

(1) **Gastrulation** is a rearrangement of cells already present in the blastula. This completely reorganizes embryo. During this process three **germinal layers** are formed (Fig. 6).
(2) Future prospective organ forming cells are organized at their proper places at gastrula stage.
(3) Gastrulation occurs by **epiboly, blastopore involution** and **invagination**. During this process mesodermal and notochordal cells migrate inside, forming roof of **archenteron**.
(4) Gastrula has three germinal layers-namely, **ectoderm, endoderm** and **mesoderm** from which various organs are derived. Section shows dorsal side, ventral side, animal pole and vegetal pole.
(5) Other structures seen in section are dorsal lip of **blastopore, yolk plug, ventral lip of blastopore, notochordal cells** and **neural plate**. The **blastocoel** is reduced due to the development of archenteron.
(6) **Ectoderm** gives rise to epidermis, cutaneous glands, **nervous system, eye parts** and **lining** of mouth cavity and cloaca.
(7) **Endoderm** forms lining of alimentary canal, liver, pancreas, lung and urinary bladder.
(8) **Mesoderm** gives rise to musculature, connective tissue, vascular system, genital organs, excretory organs, skeleton and notochord.

Identification : Since the section shows 3 germinal layers and above features, hence it is V. S. through **gastrula of frog.**

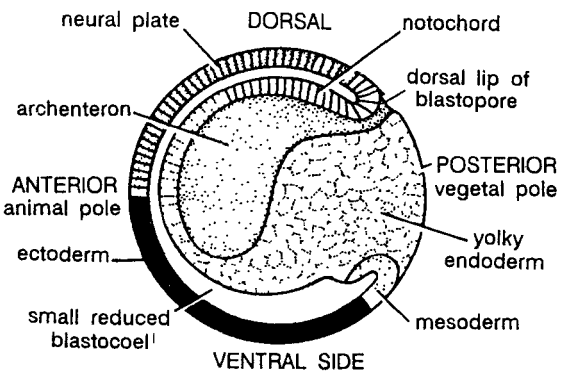


Fig. 6. Frog : V.S. through gastrula.

7. Frog : Tadpole Larva : Whole Mount

Comments :

(1) Egg hatches into **tadpole larva** within 48 hours (Fig. 7).
(2) It is whitish with dark pigment granules and 5 **to** 6.5 **mm** long.
(3) Larva is differentiated into **body** and **tail** with **tail fin.**
(4) Larva contains **rudiments of eyes, olfactory pit, gill clefts, stomodaeum, cloaca** and **myotomes.**
(5) **Mouth** contains horny jaws or **horny teeth.**
(6) Larva feeds on vegetation. Intestine is coiled.

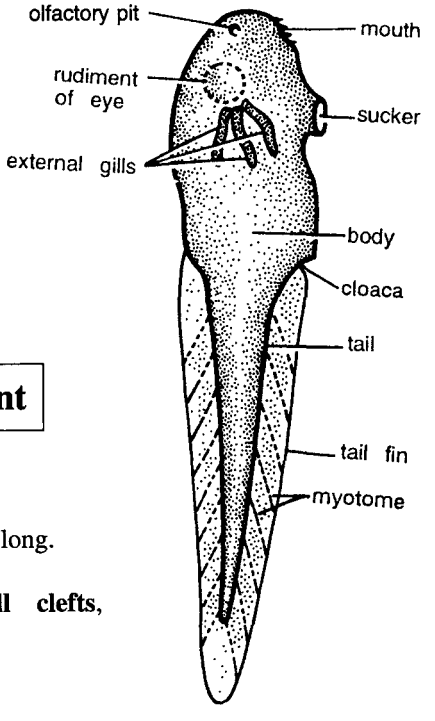


Fig. 7. Frog : Whole mount-Tadpole larva.

(7) There are three pairs of external **feathery gills** which act as functional respiratory organs.
(8) Tadpole larva **metamorphoses** into adult.

Identification : Since the larva contains 3 pairs of gills and above features, hence it is whole mount of **tadpole larva of frog.**

8. Frog : Tadpole T.S. Passing Through Eyes

Comments :

(1) Eyes are most conspicuous and portuberant structures and they begin to develop very early. Eyes develop from **optic vesicles**, which originate from a pair of diverticula given from **thalamencephalon** on each side. Below forebrain is trabecula.
(2) Section shows a pair of **large eyes** on the sides of forebrain. Each eye is composed of **eye muscles, lens** and sensory layer of **retina.**
(3) Other structures seen in section are jaw **muscles, large pharynx, palatoquadrate bar, Meckels cartilage, hyoid arch, connective tissue and epidermis.**

Identification : Since the section contains eye, hence it is T. S. **tadpole of frog through eyes.**

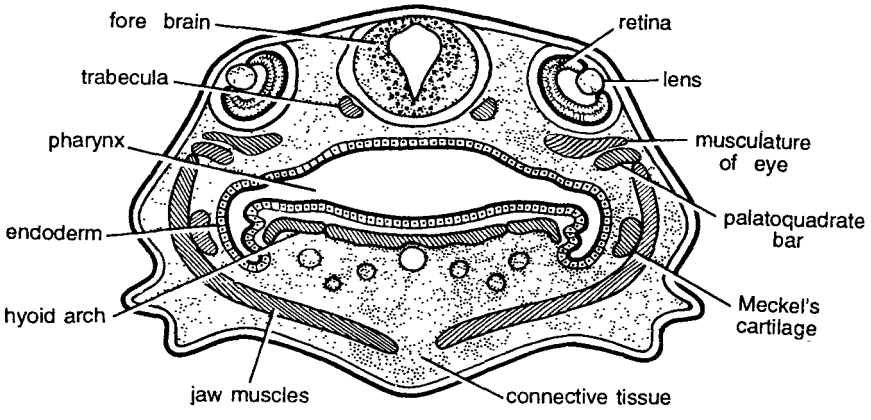


Fig. 8. Frog : T.S. of tadpole through eyes.

9. Frog : Early Tadpole T.S. Passing Through Ears

Comments :

(1) Ears develop as a pair of **auditory pits** from epiblast on sides of **hindbrain** (Fig. 9).
(2) Auditory pits become **vesicle like** called auditory vesicle and enclose the **middle ear. Semicircular canals** develop as outgrowths from the wall of auditory vesicles.
(3) Auditory vesicles develop at early tadpole stage and found on dorsal side of the section. Between two auditory vesicles is situated the **medulla oblongata**, enclosing **IV ventricle.** Beneath medulla oblongata the notochord is present.
(4) Lower portion of the section contains large **pharynx, laryngeal chamber, branchial arches** pericardial cavity and **pericardium**, enclosing developing **auricle** and **ventricle.**
(5) Other structures seen are first, second, third and fourth branchial arches, epidermis of operculum, news and ectoderm.

Identification : Since the section contains auditory vesicle and above features hence it is T.S. through **ear** of **early tadpole of frog.**

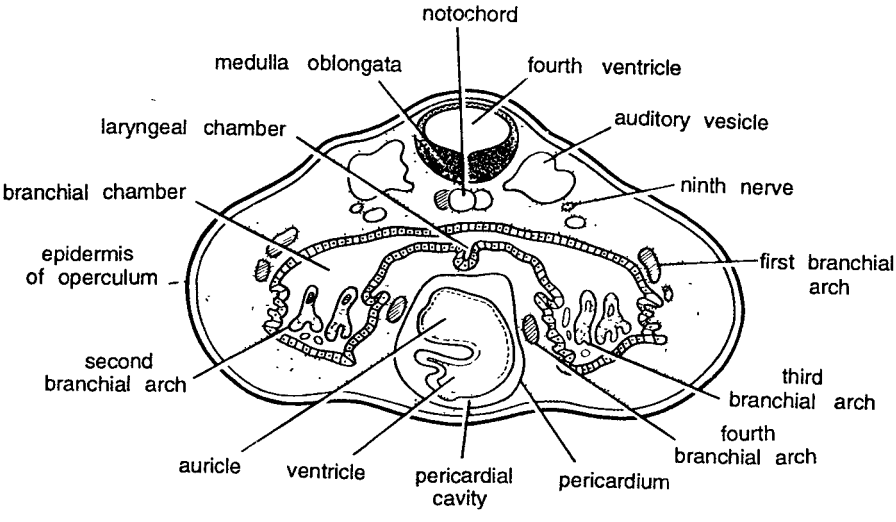


Fig. 9. Frog : T.S. of tadople through ears.

DEVELOPMENT OF CHICK

10. Chick Embryo : Whole Mount of 4 Hours of Incubation

Comments :

(1) Four hours of incubation of the egg shows differentiation of the blastodisk into **area pellucida** and **area opaca**. Egg has cephalic end and caudal end (Fig. 10).

(2) One quadrant of area pellucida becomes thickened, which marks the future caudal end of embryo.

(3) After 7 to 8 hours, the thickening becomes more elongated and represents start of **primitive streak.**

Identification : Since embryo shows beginning of primitive streak, hence it is **chick embryo** whole mount 4 **hours of incubation.**

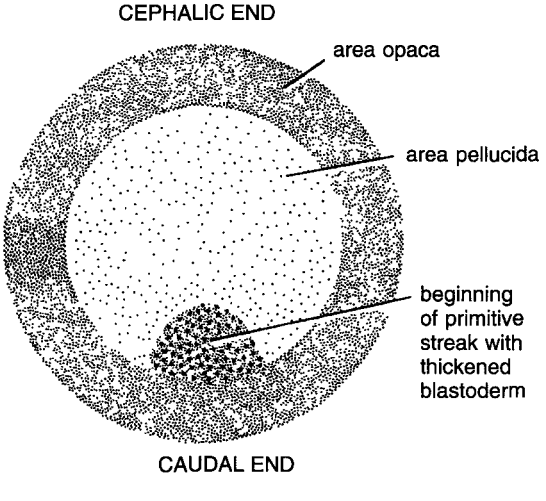


Fig. 10. Chick embryo : Whole mount. 4 hours of incubation.

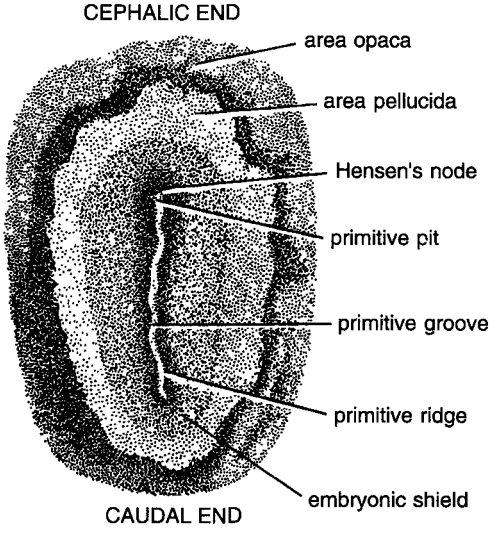


Fig. 11. Chick embryo : Whole mount. 16 hours of incubation.

11. Chick Embryo : Whole Mount of 16 Hours of Incubation

Comments :

(1) By 16 hours of incubation the primitive streak becomes so distinct that embryos are characterized as being in **primitive streak stage** (Fig. 11).

(2) In fixed and stained slide, w.m. primitive streak is composed of **central furrow, called as primitive groove** lined by thickened **primitive ridges** and ending in primitive pit.

(3) At the cephalic end of the primitive streak, closely-packed cells form thickened area, called as **Hensen's node**. Part of area pellucida adjacent to the primitive streak shows increased thickness and forms embryonic area or **embryonic shield**.

(4) Area pellucida assumes **elliptical shape**.

(5) Elongated **primitive streak** represents long axis of future embryonic body.

(6) Caudal and cephalic ends are demacrated by Hensen's node and end of primitive streak respectively.

Identification : Since it has primitive streak, hence it is whole mount of **chick embryo** after **16 hours of incubation**.

12. Chick Embryo : L.S. of 17 Hours of Incubation

Comments :

(1) L.S. through 17 hours embryo represents the stage shortly after primitive streak formation and it also marks the beginning of **morphogenetic movement** of cells to form **notochord**.

(2) The section shows **ectoderm, Hensen's node, primitive pit, primitive groove, notochord** and **primitive gut** and endoderm.

(3) The **mesoderm** extends on either side between **ectoderm**.

Identification : Since the section shows primitive pit and above features, hence it is L. S. of **chick embryo of** 17 **hours of incubation**.

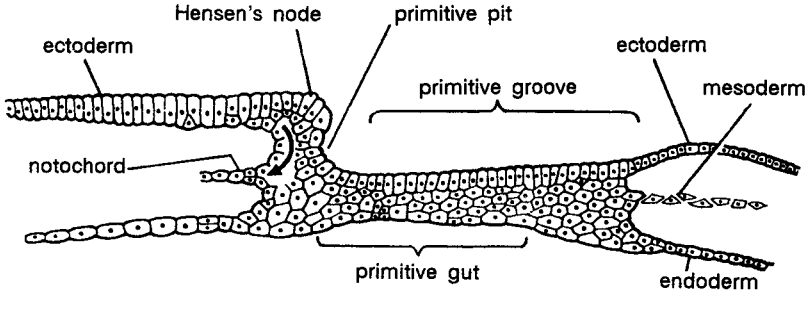


Fig. 12. Chick embryo : L.S. of 17 hours of incubation.

13. Chick Embryo : Whole Mount of 18 Hours of Incubation

Comments :

(1) After 18 hours of incubation the **notochord** has become markedly elongated, forming a prominent structure (Fig. 13).

(2) **Notochord** extends towards cephalic region in the mid-line from Hensen's node.

(3) 18 hours incubated embryo is spoken of as being in the **head process stage**.

(4) At the tip of the notochord **neural plate** develops. Caudal and cephalic ends are seen.
(5) In front of notochord and neural plate there is a space called as **pro-amnion**.
(6) **Embryonic area**, anterior border of mesoderm **area pellucida** and **area opaca** become more prominent.
(7) Primitive streak gradually decreases in size.

Identification : Since it has proamnion hence it is whole mount of **chick embryo after** 18 **hours of incubation.**

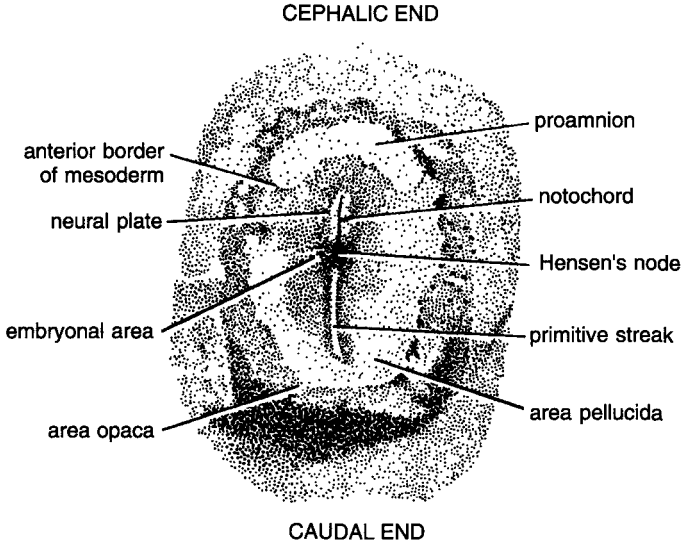


Fig. 13. Chick embryo : Whole mount. 18 hours of incubation.

14. Chick Embryo : L.S. of 18 Hours of Incubation

Comments :

(1) Incubated embryo shows advanced inner structure.
(2) **Ectoderm** is shown by striated lines, the cells of **mesoderm** are represented by heavy angular dots and endoderm is represented by stippling backed by a single line.

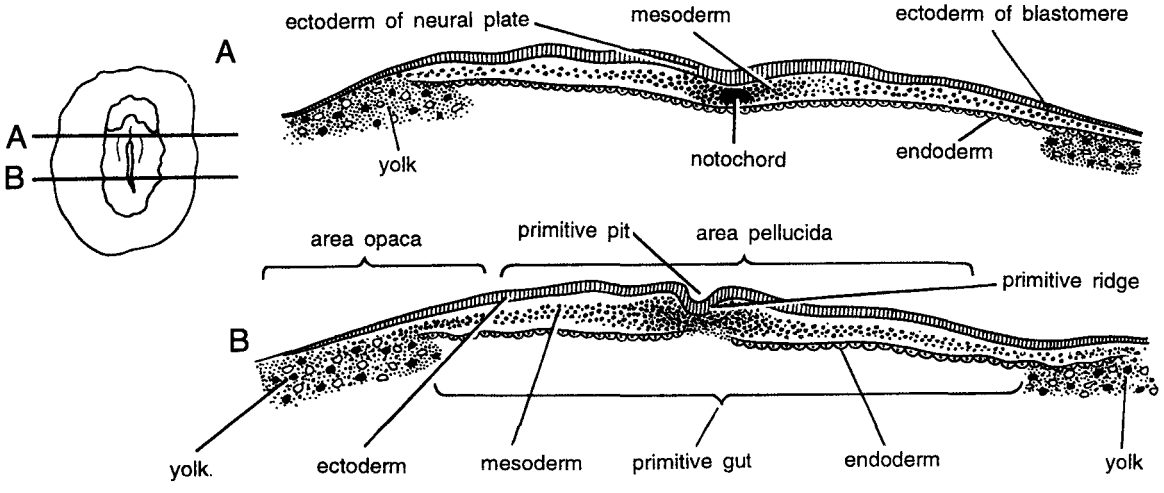


Fig. 14. Chick embryo : (A) and (B), L.S. of 18 hours of incubation. *(Z–20)*

(3) **Section A** shows yolk, **ectoderm of neural plate, notochord, mesoderm, ectoderm** and **endoderm** of **blastoderm. Section B** shows **yolk, endoderm, primitive pit, primitive ridge, mesoderm** and **primitive gut, area pellucida** and **area opaca.**

Identification : Since the sections shows neural plate (A) and primitive pit (B) hence they are sections of **chick embryo** L.S. after 18 **hours of incubation.**

15. Chick Embryo : Whole Mount of 24 Hours of Incubation

Comments :

(1) At 24 hours of incubation the folding of the neural plate is much more clearly marked. In stained and transparent preparation of entire embryo **neural folds** appear as a pair of dark bands forming neural groove (Fig. 15).

(2) **Neural folds** at cephalic end are more prominent than at caudal end.

(3) **Foregut** is also established at this stage and the gut caudal to foregut called as **midgut** and the opening from midgut into foregut, namely **anterior intestinal portal**, also appears.

(4) In the middle, **four pairs of somites** are seen. The **Hensen's node** is pushed caudally and **primitive streak** is further reduced.

(5) Other structures seen are **area opaca vitellina, ectoderm of head, area pellucida, mesoderm, blood island, area vasculosa, notochord, mesenchyme, proamnion,** Hensen's node, sub-cephalic pocket and unsegmented mesoderm.

Identification : Since it has neural fold and above features hence it is whole mount of **chick embryo of** 24 **hours of incubation.**

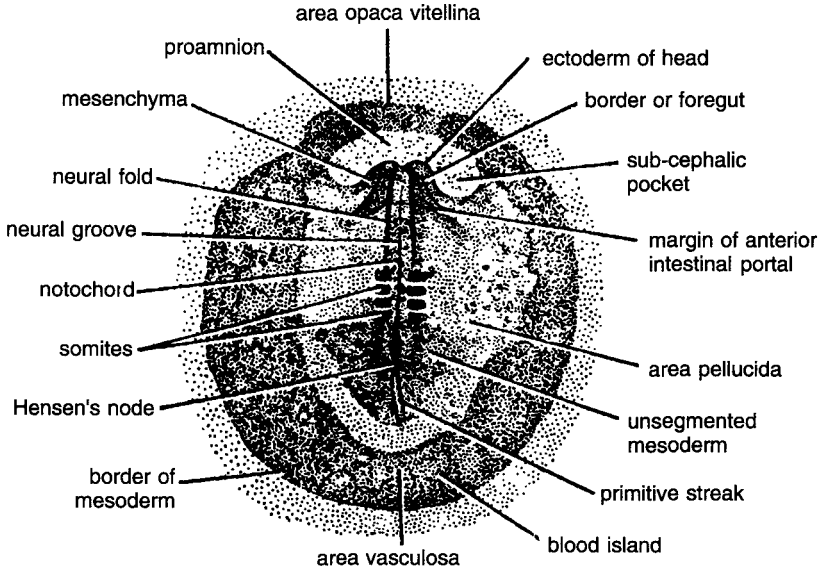


Fig. 15. Chick embryo : Whole mount. 24 hours of incubation.

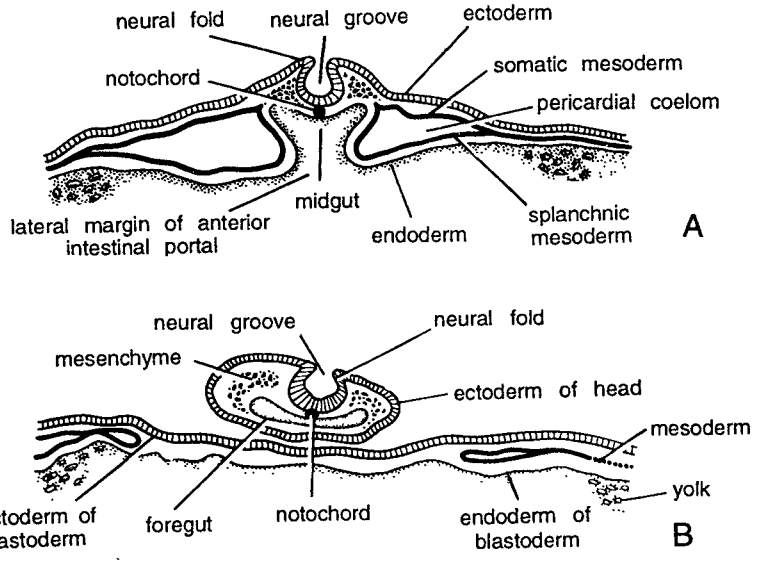


Fig. 16. Chick embryo : (A) and (B) T.S. 24 hours of incubation.

16. Chick Embryo : T.S. Passing Through 24 Hours of Incubation

Comments :

[A] T.S. passing through head

(1) T.S. passing through head region shows neural plate folded to form a complete neural tube.
(2) Beneath neural fold is **notochord**.
(3) Other structures seen in section are **mesenchyme, foregut, ectoderm of head, mesoderm** and **endoderm** of blastoderm and ectoderm of blastoderm.

[B] T.S. through mid-body

(1) Shows formation of **somites** and changes in mesoderm.
(2) Mesoderm is differentiated into dorsal mesoderm, intermediate mesoderm and lateral mesoderm.
(3) Dorsal **mesoderm** forms somites, lateral mesoderm differentiates into **somatic** and **splanchnic** layers and **intermediate mesoderm** forms nephrotomic plate.
(4) Other structures seen are **ectoderm, endoderm, lateral margin of anterior intestinal portal, midgut** and **pericardial coelom.**

Identification : Since sections (A) has neural groove, (B) has somatic and splanchnic mesoderms and above features hence they are transverse sections of **chick embryo after** 24 **hours of incubation.**

17. Chick Embryo : Whole Mount of 28 Hours of Incubation

Comments :

(1) Entire embryo of 28 **hours** of incubation shows marked advance in the development of cephalic region (Fig. 17).
(2) **Neural folds** completely fuse forming **neural tube**, which becomes completely separated from superficial ectoderm.

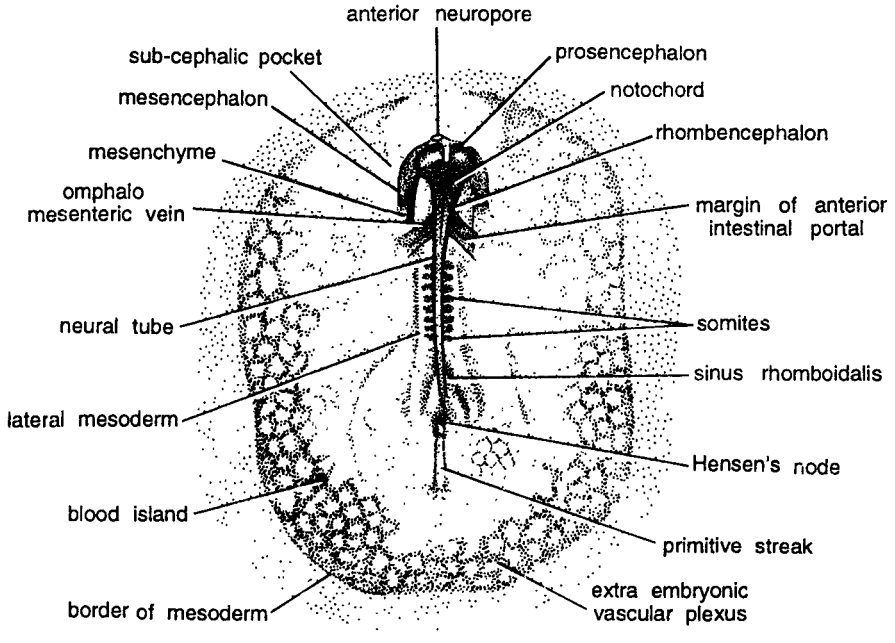


Fig. 17. Chick embryo : Whole mount. 28 hours of incubation.

(3) **Head** projects free from blastoderm.
(4) Three primary brain vesicles, namely **prosencephalon** (forebrain), **mesencephalon** (mid-brain) and **rhombencephalon** (hind brain) are differentiated.
(5) Eight pairs of somites develop.
(6) Anterior **neuropore** still remains open.
(7) **Hensen's node** still pushed back and **primitive streak** becomes much smaller.
(8) Other structures seen in section are anterior **intestinal portal**, **extra-embryonic vascular plexus**, **blood island**, **omphalomesenteric vein** and **sub-cephalic pocket**, **blood island**, **lateral mesoderm border** of **mesoderm** and **mesenchyme**.

Identification : Since the embryo shows divisions of brain cavities and above features, hence it is whole mount of **chick embryo of** 28 **hours of incubation.**

18. Chick Embryo : T.S. Passing Through 28 Hours of Incubation

Comments :

(1) T.S. through 28 hours of incubation shows formation of **heart** from mesoderm (Fig. 18).
(2) **Epi-myocardium**, **endocardial primordium** and cardiac jelly are seen.
(3) The section also shows closed **neural canal**, **notochord**, line of fusion of margins of anterior **intestinal portal**, **somatopleure**, **splanchopleure**, **pericardial coelom**, **foregut**, **dorsal mesocardium** and ventral mesocardium are seen.

Identification : Since the section contains endocardial primordium and above structure hence it is T.S. of **chick embryo of** 28 **hours of incubation.**

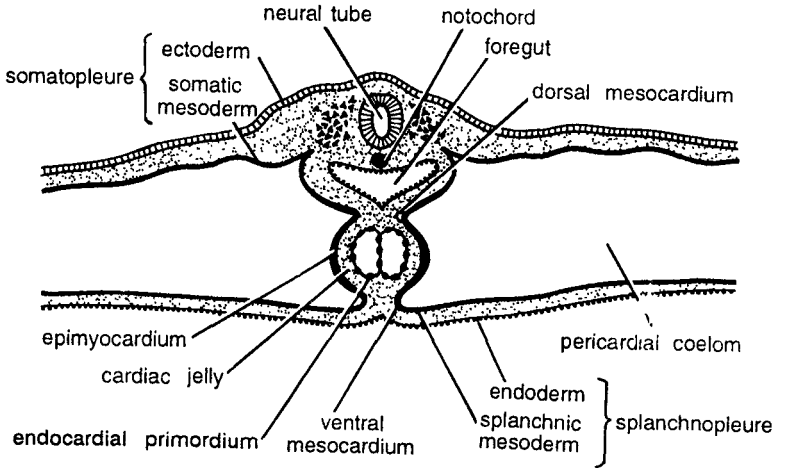


Fig. 18. Chick embryo : T.S. 28 hours of incubation.

19. Chick Embryo : Whole Mount of 33 Hours of Incubation

Comments :

(1) Thirty-three hours incubated embryo shows some of the fundamental steps in the formation of **central nervous system** and **circulatory system**.

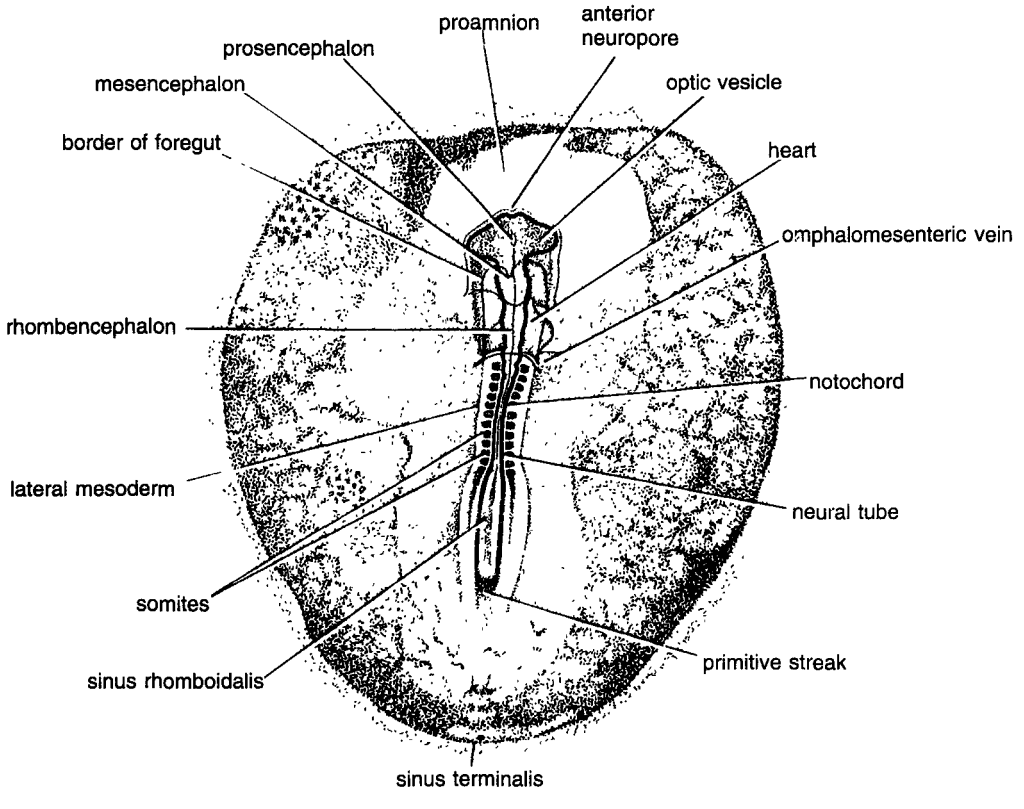


Fig. 19. Chick embryo : Whole mount. 33 hours of incubation.

(2) Various **neuromeric** enlargements form brain regions.
(3) Brain is differentiated into **prosencephalon** (fore brain), **mesencephalon** (mid brain) and **rhombencephalon** (hind brain).
(4) Optic vesicles are established as paired lateral outgrowths of the prosencephalon.
(5) **Infundibulum** is formed as a sort of depression in the floor of the prosencephalon.
(6) **Twelve pairs of somites** are formed.
(7) Mid-region of the **heart** is considerably dilated and bent to the right.
(8) Anterior **omphalomesenteric** veins have developed. Border of foregut is formed.
(9) **Primitive streak** becomes shorter because of the lengthening of the neural tube.
(10) **Proaminon, neural tube, notochord, sinus rhomboidalis** and **sinus terminalis** are also present.

Identification : Since it has 12 pairs of somites and above feature hence it is whole mount of **chick embryo of** 33 **hours of incubation.**

20. Chick Embryo : T.S. Passing Through 33 Hours of Incubation

Comments :

(1) This section shows **ectoderm, prosocoel, opticoel, mesenchyme, somatic mesoderm, splanchnic mesoderm** and **endoderm** and **yolk** (Fig. 20).
(2) It shows mid-structures namely, **mesocoel, anterior cardinal vein,** dorsal **aortic root, somatopleure, splanchnopleure, foregut, notochord** and ventral aortic root.

Identification : Since the section shows somatopleure, splanchnopleur and above features hence it is T.S. of **chick embryo** passing through 33 **hours of incubation.**

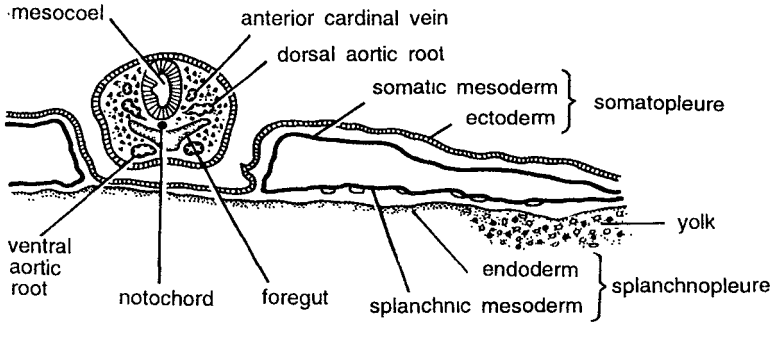


Fig. 20. Chick embryo : T.S. 33 hours of incubation.

21. Chick Embryo : Whole Mount of 43 Hours of Incubation

Comments :

(1) 43 hours incubated embryo shows **cranial flexure** and **torsion** (Fig. 21).
(2) Cephalic region of embryo is **twisted** in such a way that left side comes to lie next to the yolk and right side away from yolk.
(3) Brain is differentiated into **prosencephalon, mesencephalon, metencephalon** and **myelencephalon.**
(4) **Heart** becomes 4 chambered. It is differentiated into **ventricular, arterial** and **sinus regions. Truncus arteriosus** also develops.
(5) **Auditory pit** also makes its appearance.

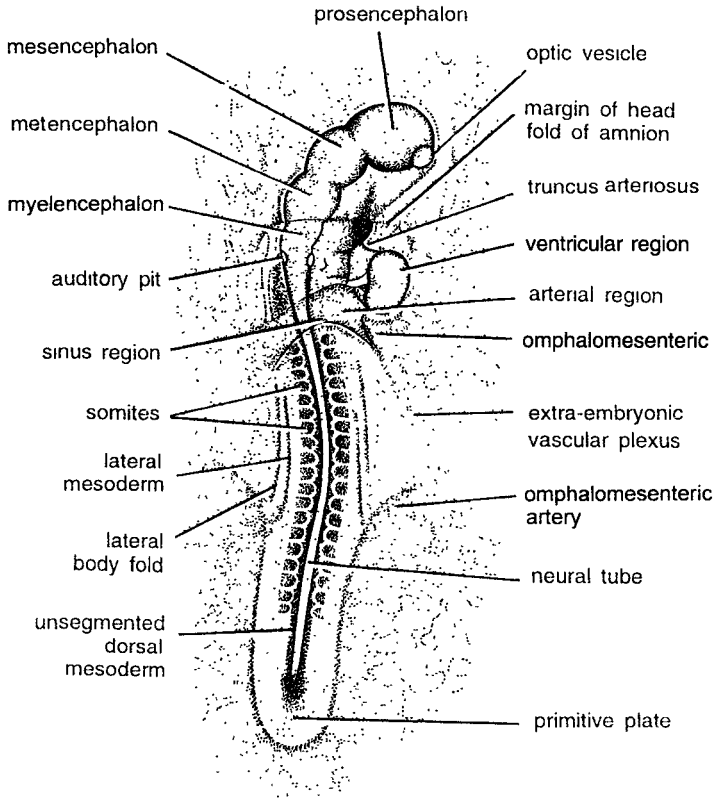


Fig. 21. Chick embryo : Whole mount. 43 hours of incubation.

(6) Vitelline vessels communicate with **omphalomesenteric vein**. Omphalomesenteric arteries and extra-embryonic vascular plexus are well developed.
(7) **Nineteen pairs of somites** are formed.
(8) **Primitive streak** diminishes to a small primitive plate. Head fold margin develops.
(9) **Neural plate** becomes well developed.
(10) **Lateral mesoderm** insegmented mesoderm is seen. After 43 hours of incubation, the embryo develops rudiments of most of the organs.

Identification : Since it has 10 pairs of somites and above features, hence it is whole mount of **chick embryo of** 43 **hours of incubation.**

22. Chick Embryo : Whole Mount of 72 Hours of Incubation

Comments :

(1) After 72 hours of incubation, body is affected throughout by torsion and entire body is turn to 90°.
(2) **Torsion** is complete, well posterior to the level of heart, but caudal portion of embryo is not turned on its side (Fig. 22).
(3) Due to the **cranial** and **cervical** flexures, the long axis of the embryo shows nearly right angled bends in the mid brain and in the neck region.
(4) **Mid-body** becomes concave.
(5) **Visceral arches** develop.
(6) **Mandibular arch** forms caudal boundary of oral depression and becomes more distinct.

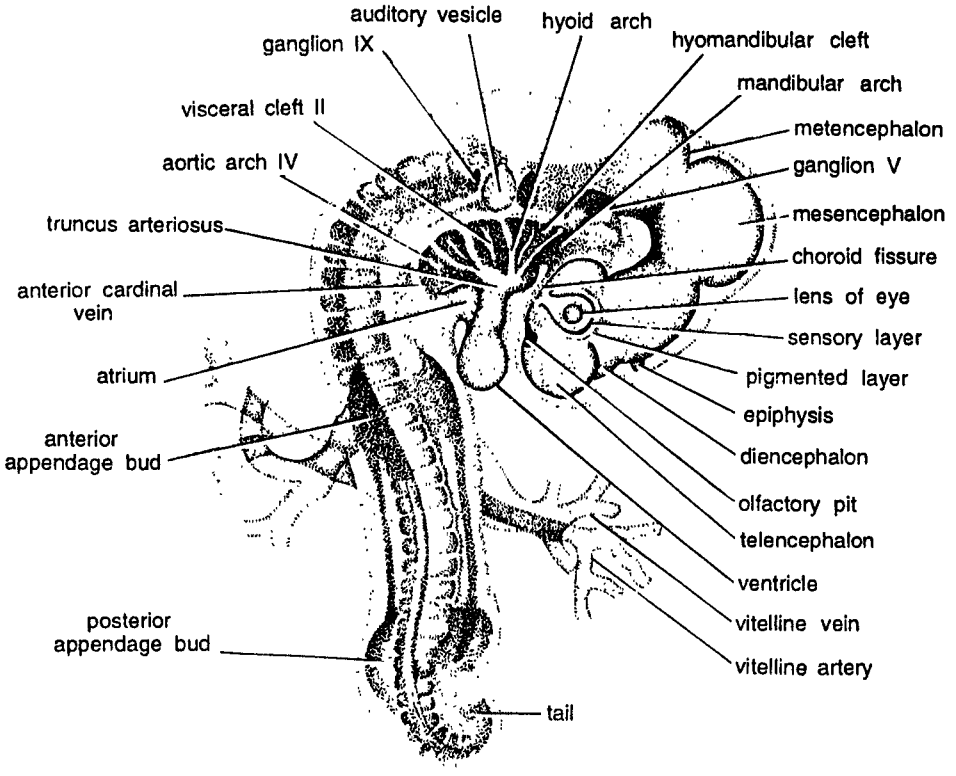


Fig. 22. Chick embryo : Whole mount. 72 hours of incubation.

(7) **Nasal pits** appear as shallow depressions.
(8) **Appendage rudiments** also make their appearance.
(9) **Cephalization** is going on. Telencephalon also develops **anterior appendage bud** near mid body and posterior appendage near the tail.
(10) In the **eye**, **lens**, **sensory** and **pigmented** layers are differentiated.
(11) Number of somites increases to 36 pairs. Vitelline arteries and vitelline veins also make their appearance.

Identification : Since it contains 36 pairs of somites and above features, hence it is whole mount of **chick embryo of** 72 **hours of incubation**.

CHICK EMBRYO : PRESERVED

Take one dozen fertilized eggs and incubate them is a incubator. Take out incubated eggs after 3, 6, 12, 18 and 21 days and preserved them in formaline. Study the developing embryos.

23. Chick Embryo : Three Days Old Formalin Preserved Whole Embryo from Ventral Side

Comments :

(1) After 3 days to embryo after torsion becomes like telephone receiver. It bends at 90°.
(2) Body divided into broad head and narrow tail (Fig. 23).

(3) Three divisions of brain namely **prosencephalon, mesencephalon** and metancephalon are clearly seen.
(4) Optic and auditory capsules have developed.
(5) Sinus venosus has started developing.
(6) Vitelline and allantoic vessels have started appearing. Right vitelline artery, posterior **vitelline artery, left vitelline artery** and **left vitelline vein** have appeared.

Identification : Since the embryo has shape of telephone receiver and above features, hence it is **chick embryo** 3 **days old.**

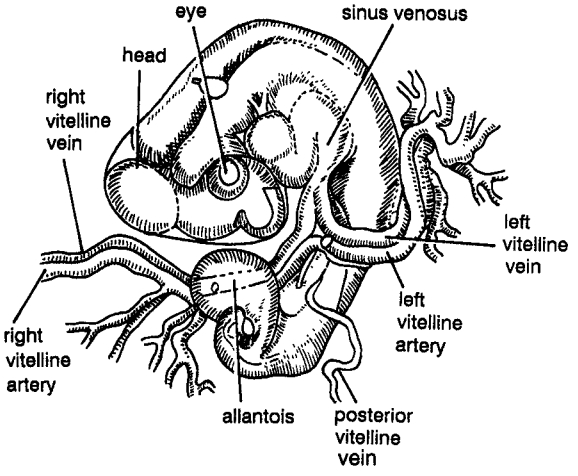


Fig. 23. Chick embryo : Formalin preserved 3 days old specimen.

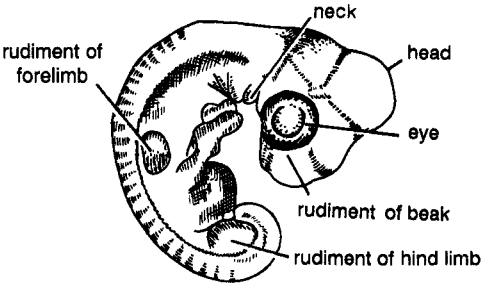


Fig. 24. Chick embryo : Formalin preserved 6 days old specimen.

24. Chick Embryo : Six Days Old Formalin Preserved Whole Embryo from Dorsal Side

Comments :

(1) After 6 days embryo has considerably grown with **broad head** and narrow bluntly ending tail.
(2) **Prosencephalon, mesencephalon** and **metencephalon** have distinctly developed.
(3) Optic vesicle has developed more.
(4) Rudiments of anterior and posterior limbs are seen.
(5) Toes contain **claw.**
(6) Near head beak is also appearing.

Identification : Since above specimen has beak rudiment and above features, hence it is **chick embryo** 6 **days old.**

25. Chick Embryo : 12 Days Old Formalin Preserved Whole Embryo from Dorsal Side

Comments :

(1) After 12 days chick embryo take the shape of a bird (Fig. 25).
(2) Body is distinctly divided into **head, neck, trunk** and **tail.**
(3) Head contains **eyes** with developing **eyelids.**
(4) Upper and lower **beaks develope.**
(5) Forelimbs **develop** into **wings.**

(6) Hind limbs develop clawed toes.

Identification : Since the embryo has beak and above feature hence it is **chick embryo** 12 **days old.**

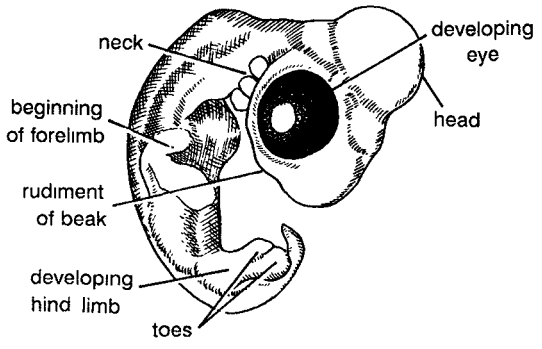


Fig. 25. Chick embryo : Formalin preserved 12 days old specimen from dorsal side.

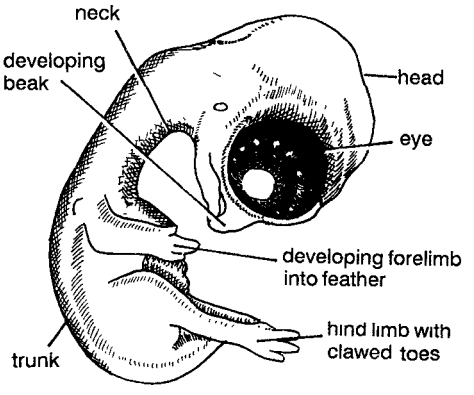


Fig. 26. Chick embryo : Formalin preserved 18 days old specimen from dorsolateral side.

26. Chick Embryo : 18 Days Old Formalin Preserved Whole Embryo from Dorsolateral Side

Comments :

(1) At this stage young chick considerably acquires features of adult bird (Fig. 26).
(2) Body divided into **head**, **neck**, **trunk** and **tail**.
(3) Eyes become well developed along with eyelids.
(4) Pointed beak develops like pig.
(5) Entire body is covered with down feathers called as plumes.
(6) **Wings** develops. **Hind limb** develop **claw**.

Identification : Since the specimen contains down feathers and above features, hence it is 18 **days old chick embryo.**

27. Chick Embryo : 21 Days Just Hatched Chick

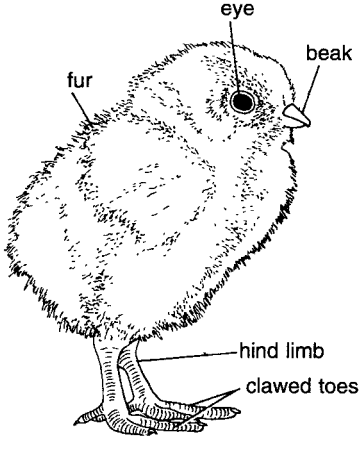


Fig. 27. Chick embryo : 21 days old just hatched chick.

Comments :

(1) After 21 **days** chick comes out of the egg (Fig. 27).
(2) Except beak and toes, entire body is covered with soft whitish **down feathers** which are called as plumes. **Plumes** are softer than silk and they do not contain **rachis**.
(3) Plumes form **natal covering** over young chick.
(4) Body is divided into **head**, **neck**, **trunk** and **tail**.
(5) **Eyes** and **beak well developed.**
(6) Rudiments of developing flying feathers distinct.

Identification : Since the chick contains over, feather all over body except beak and claws hence it is **just hatched chick.**

Practicals on Evolution and Animal Behaviour

16

Evolution is a well established process both in case of animals and plants. Process of evolution is supported by **theories** of evolution and **evidences** of evolution. Various evidences from Comparative Anatomy, Taxonomy, Homology, Analogy, Developmental biology, Palaeontology, Physiology, Genetics, Molecular biology give support to process of organic evolution.

So far evolution has been the subject of theory courses. Practicals on evolution have been incorporated in this book for the first time.

Practicals on evolution consists of :

(A) Study of Evolution of Horses through models,
(B) Study of Homologous organs or forms and
(C) Study of Analogous forms.

A. STUDY OF EVOLUTION OF HORSE THROUGH VARIOUS MODELS

Present day modern horses *Equus* are most useful domesticated animals. Horses have gradually evolved. The evolution of horse can be studied through various geological periods such an Eocene, Oligocene, Myocene and Pleistocene. Gradual important changes in various pedigree of horses consists of (i) increase in size (ii) lengthening of distal portion of legs (iii) reduction of accessary digits (iv) relative increase of front part of skull (v) increase of depth of teeth (hypsodonty) and grinding part of molars and (vi) approximation of pre-molars to molars and completion of post-orbital bar. Evolution of horse can be studied through various models.

1. *Hyracotherium* : Model

Geological event : The first horse belonged to coenozoic era of tertiary period and eocene epoch about 54 million years ago.

Geographical conditions : Tertiary period was marked by separation of continent and rise of mountains in Asia, Europe and western north America with emergence of temperate gross lands, forests and higher plants.

Distribution : ***Hyracotherium*** was found in North America where they became extinct.

Comments :

(1) Size of first horse was very small (Fig. 1/1).
(2) Body was divisible into **head, neck, trunk** and **tail.**
(3) Neck was raised upwards.
(4) Fore limbs contained 4 **toes.**
(5) Hinder premolars were molar like.

Identification : Since above horse contains 4-toes and above features hence it is model of ***Hyracotherium.***

2. *Eohippus* : Dawn Horse : Model

Geological event : ***Eohippus*** evolved from ***Hyracotherium.*** Second horse in evolutionary line was present in coenozoic era of tertiary period and eocene epoch about 54 million years ago.

Geographical conditions : Same as in ***Hyracotherium.***

Distribution : Fossils of above horse were collected from north America.

Habit and habitat : ***Eohippus*** lived in forests feeding on soft vegetation (Fig. 1/2).

Comments :

(1) Commonly called as **Dawn horse.**
(2) Size of above horse increased measuring about 12 inches. It looked like smaller dog and cat.
(3) Body was divided into **head, neck, trunk** and **tail.**
(4) Head contained elongated jaws, eyes and ear. Back was arched and flexible.
(5) Forelimbs contained 4 **toes.** First toe was splint and flat.
(6) Hind limb contained 3 **toes.** Third toe was elongated.
(7) Premolars were unlike molars.

Identification : Since the above horse contains splint and possess above features, hence it is model of ***Eohippus.***

3. *Mesohippus* : Model

Geological event : ***Mesohippus.*** The third horses were found in south Dakota in coenozoic era of tertiary period and oligocene epoch about 38 million years ago.

Geographical conditions : Same as in ***Hyracotherium.***

Distribution : ***Mesohippus*** migrated to old world where they became extinct.

Habit and habitat : ***Mesohippus*** was browser feeding on soft vegetation and living in forest.

Comments :

(1) Size of above horse increased (Fig. 1/3).
(2) Body was divided into **head, neck, trunk** and **tail.**
(3) Both forelimbs and hind limbs possessed functional toes. Central toe was longest. They walked on ground 3 toed horse.

(4) Head contained eyes, ears and horse like jaws.
(5) Premolars became molar like i.e. molarised.
(6) Inner cusps were still separated teeth were low crowned.

Identification : Since above horse possessed molarized premolars and above features hence it is model of ***Mesohippus***.

4. *Parahippus* : Model

Geological event : ***Parahippus*** horses were abundant in coenozoic era of tertiary period and miocene epoch about 35 million years ago and then they became extinct.

Geographical conditions : Same as in ***Hyracotherium***, but luxuriant grassess were abundant.

Habit and habitat : ***Parahippus*** revealed beginning of adaptations for life on plains and it initiated **running pasture**. Later it became extinct.

Comments :

(1) ***Parahippus*** further increased in size and weight.
(2) Body was divided into **head, neck, trunk** and **tail. 3 toed horse** (Fig. 1/4).
(3) Second and fourth lateral digits still carried hoops. Central phalanx was very much elongated and strongest.
(4) The lateral digits provided support by touching uneven ground to maintain balance.
(5) Teeth were still low but started elongating and showing cement on crowns.

Identification : Since above amimal had elongated central phalanx and above features hence it is model of ***Parahippus***.

5. *Merychippus* : Model

Geological event : ***Merychippus*** evolved in coenozoic era of tertiary period and eocene epoch about 26 million years ago. Later they became extinct.

Geographical conditions : Same an in ***Hyracotherium***.

Distribution : ***Merychippus*** was found in North America.

Habit and habitat : ***Merychippus*** existed in great plains and was very successful horse grazing on luxuriant ground vegetation and grasses.

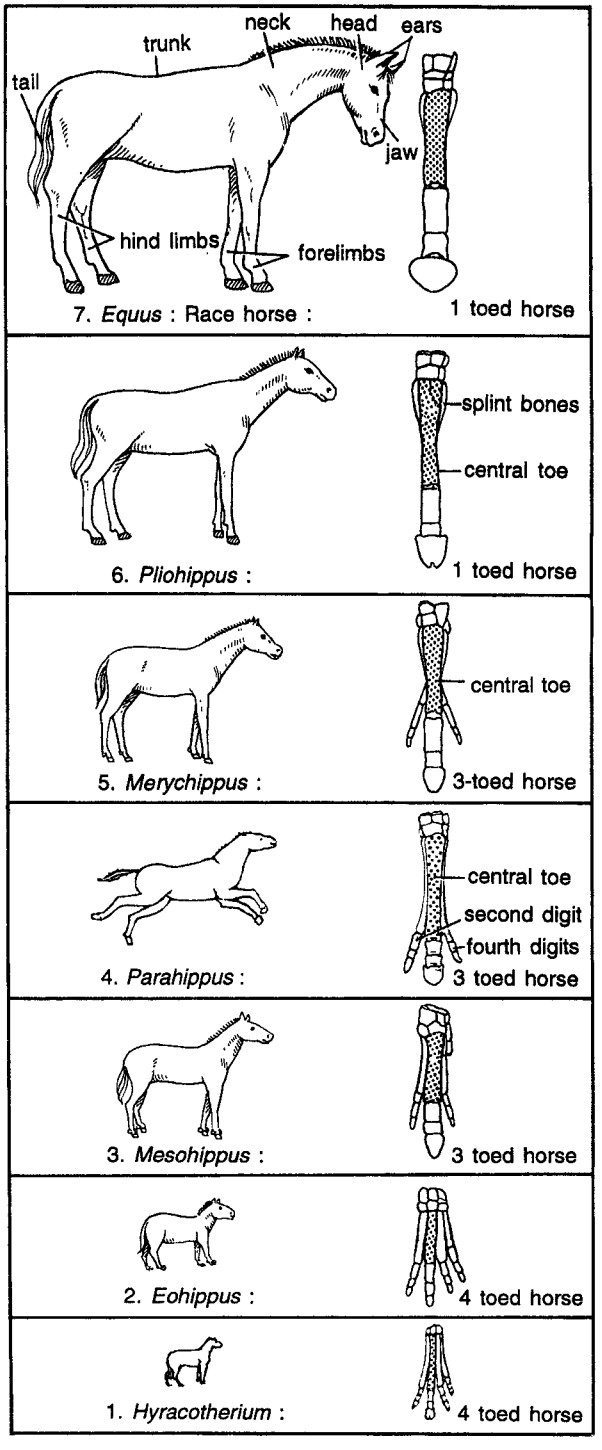


Fig. 1. Evolution of Horse.

Comments :
(1) Size of the horse further increased and it was like present day donkey **3 toed horse.**
(2) Body was divided in **head, neck, trunk** and **tail.**
(3) Head contained eyes, ears and modern horse like jaws (Fig. 1/5).
(4) Lateral digits shortened to stumps.
(5) Both fore and hind limbs contained 3 toes. Middle toe contained hoof.
(6) Depth of the teeth increased.
(7) High crown with some cusps developed and teeth were cemented.

Identification : Since the size of above horse is like donkey and it contains above features hence it is model of ***Merychippus***.

6. *Pliohippus* : One Toed Horse : Model

Geological event : ***Pliohippus*** evolved from ***Merychippus*** in coenozoic era of quaternary period in pliocene epoch nearly 7 million years ago. Later they became extinct.

Geographical conditions : Same as in ***Hyracotherium***.

Distribution : Earlier found in North America but when land connections were established they migrated to South America where they became extinct.

Habit and habitat : ***Pliohippus*** was perfect grazer and well adapted for fast running.

Comments :
(1) Size of horse increased to 50 inches tall and it was first **one toed horse.**
(2) Body was divisible into **head, neck, trunk** and **tail** (Fig. 1/6).
(3) Head contained horse like jaws.
(4) Lateral digits were completely lost by pliocene epoch.
(5) Fore and hind limbs contained only third toe. Other toes were present as vestigial splint bone.
(6) Teeth were longer with cusp and were heavily cemented.

Identification : Since the above horse contains one toe and above features, hence it is model of ***Pliohippus***.

7. *Equus* : Modern Race Horse

Geological event : ***Pliohippus*** stock of North America finally reduced the lateral metapodials and became **one toed horse.** ***Equus*** evolved in coenozoic era of quaternary period of pleistocene epoch approximately 3 million years ago.

Geographical conditions : Land connections with luxuriant grasses and ground vegetation were present.

Distribution : Cosmopoliton. Modern horse *(Equus)* is found all over the world.

Habit and habitat : ***Equus*** in perfect grazer and fastest runner.

Comments :
(1) Size of the horse increased considerably measuring 60 to 65 inches in height.
(2) Stoutly built body is divisible into **head, neck, trunk** and **tail** (Fig. 1/7).
(3) Head contains eyes, ears and elongated characteristic jaws.
(4) Teeth are specialized and adapted for grazing and grinding silicons grasses.
(5) Neck is long mobile. Mane is longer and pendant. Trunk is large.
(6) Both fore and hind limbs each contained hoofed toe.
(7) ***Equus*** is successfully flourishing. It is best domesticated animal used for war, transportation, racing and horse riding.

Identification : Since the above horse contains one toe each in fore and hind limbs and above features, hence it is ***Equus***.

B. STUDY OF EVOLUTION THROUGH HOMOLOGOUS AND ANALOGOUS ORGANS AND FORMS

Homologous and analogous organs and forms give evidence for the process of evolution. Homologous organs are those organs which have common origin but perform different functions. Analogous organs and forms are those animals have different origin but having same functions.

Homologous Organs

The forelimbs of ***Talpa*** (Mole) bat, monkey, gibbon, whale and horse are homologous organs because in these animals forelimbs are adapted for different functions.

8. *Talpa* : Mole

Classification :

Phylum..... Chordata	→	Dorsal tubular nerve cord, notochord and gill-slits present.
Group..... Craniata	→	Definite head. Cranium with brain present.
Sub-phylum..... Vertebrata	→	Vertebral column present.
Division..... Gnathostomata	→	Jaws and paired appendages present.
Super-class..... Tetrapoda	→	Paired limbs, lungs, cornified skin and bony skeleton.
Class..... Mammalia	→	Body covered with hairs. Females have mammary glands.
Sub-class..... Theria	→	Viviparous mammals.
Infraclass..... Eutheria	→	Placental mammal. Vagina single.
Order..... Insectivora	→	Feed on insects.
Geuns..... *Talpa*		

Geographical distribution : ***Talpa*** is found in India (Assam) and the western Himalayas. Cretaceous to Recent.

Habit and habitat : It is **adapted** for **subterranean burrowing** and lives in tunnels. It feeds on small worms, insects and sprouted seeds. It runs deeper into tunnels.

Comments :

(1) Commonly called as **mole**.

(2) **Pigmentation** is uniformly velvet-black, with a silver-grey glossy texture.

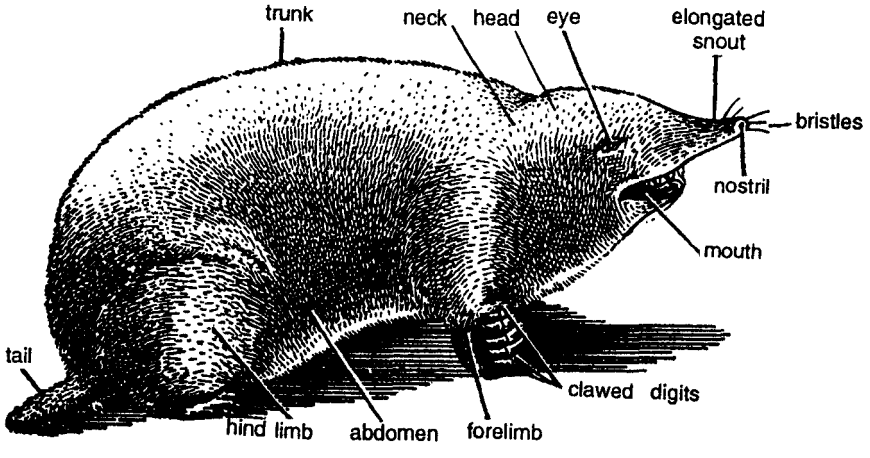


Fig. 2. *Talpa*

(3) Body measuring 15 cm in length, divided into **head, short neck, trunk** or back and abdomen.
(4) **Head** wedge-shaped. **Snout** elongated having prenatal bone. Snout contains **bristles** or vibrisae at the tip.
(5) **Eyes** are very much reduced and covered with skin. **External ears (pinnae) absent.**
(6) Tail is short, sensory and without hair. **Tail** and feet are fleshy white.
(7) Hind limb large and broad containing 5 digits, each having broad nail, used for digging.
(8) Forelimb usually with 5 clawed-toes; inner toes not opposable.
(9) **No marsupial pouch. Single vagina.** Foetus develops within the body of female attached by a placenta to wall of uterus.

Special features : It represents a **primitive Eutherian** having **small cranial cavity**, low grade brain (smooth cerebral hemispheres), **inguinal** testes, discoidal and deciduate **placenta** with provision for yolk sac placenta.

Identification : Since this mammal has elongated snout, wedge-shaped head and above features, hence it is ***Talpa.***

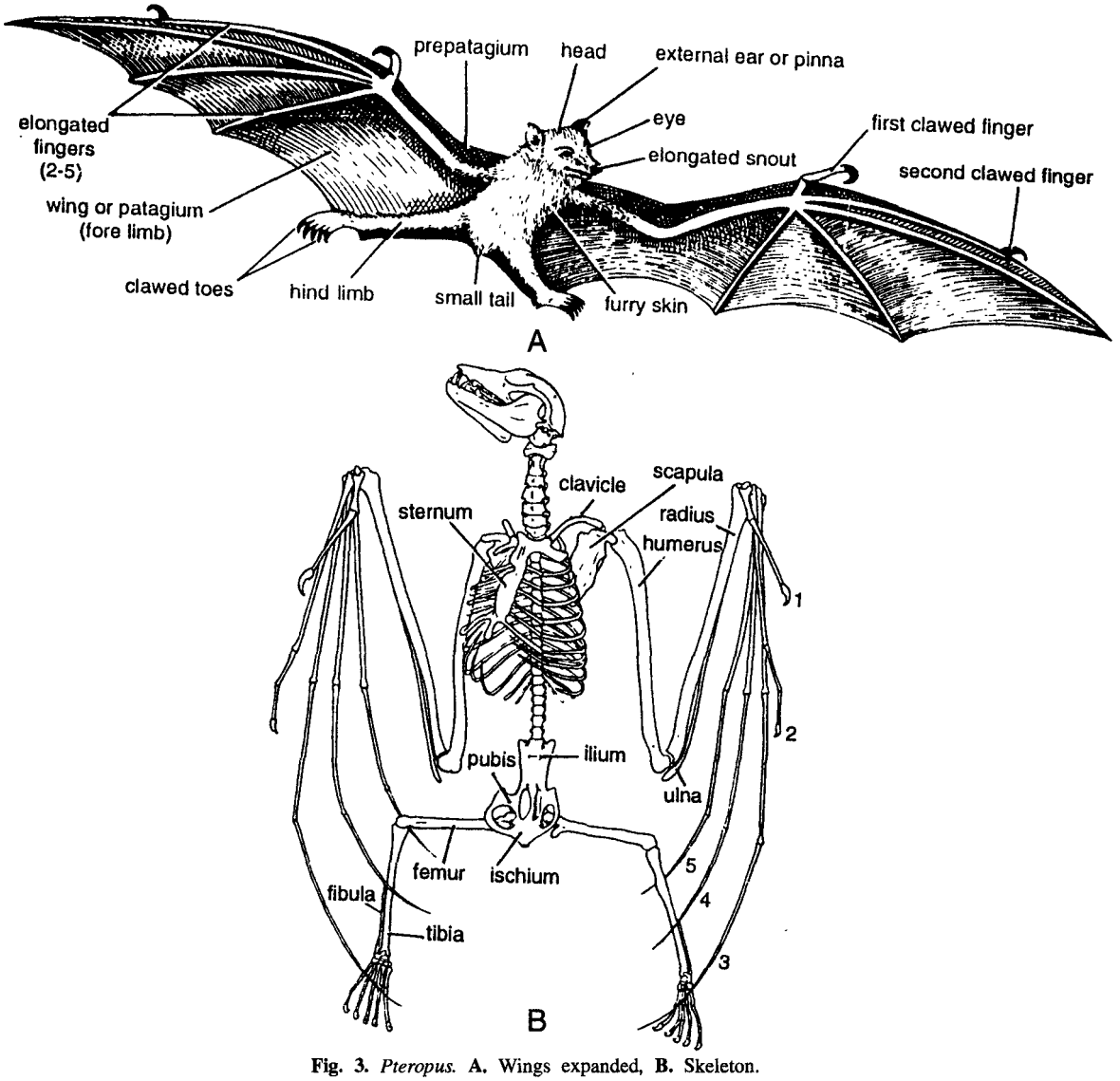


Fig. 3. *Pteropus.* **A.** Wings expanded, **B.** Skeleton.

9. *Pteropus* : Flying Fox

Classification : Same as in ***Talpa***. Order Chiroptera, Suborder Megachiroptera.

Genus.....*Pteropus*

Geographical distribution : Found in South Eastern Asia, especially in India. Pliocene to Recent.

Habit and habitat : Adapted for **arboreal** and aerial mode of life. Lives in groups and feed on fruits **(fruigivorous)** and often damage orchards. They sleep by day on tree branches.

Comments :

(1) Commonly called **Fruit bat** or **Flying fox** and in Hindi **Chamgadar**.

(2) Body is dark-brown coloured and shoulders are golden yellow. Body divisible into **head, neck, trunk** and **tail** and **patagium**.

(3) It is capable of **true flight**. The forelimbs are modified into wings. Humerus, radius, ulna and finger bones are elongated for the support of **patagium**.

(4) Each **wing** formed by a fold of **skin** or **patagium** supported by elongated forelimb and 2nd to 5th fingers. Only 1st and 2nd fingers bear claws.

(5) **Hind limbs** and tail also included in **patagium**. Before patagium is **prepatagium**. Hindfeet small with sharp and curved claws. **Tail** small and **stumpy**.

(6) **Head** small having small external **ears**, large eyes, **snout** and small **teeth**.

(7) During sleep, **head hangs downwards** with wings folded clock-like around body.

Special features : Bats are important due to five reasons : (i) They have **phylogenetic** significance with **insectivores**. (ii) They are the only **flying mammals**, (iii) They are used for **experimental** purposes, (iv) Faeces of bats are used as **fertilizer**, (v) Bats have highly developed **Sonar** or **Echo-apparatus**, a kind of **radar**. While flying they constantly send out ultrasonic sound waves consisting of periodic clicks, which strike on objects or wire and are reflected back to bat. Rate of click increases 50 to 150 seconds as the object is approached. **Ultrasonic sounds** are produced from the **vocal cords**.

Identification : Since the animal has patagium and above features, hence it is ***Pteropus***.

10. *Macaca* : Rhesus Monkey

Classification : Same as in ***Talpa***.

Order.....Primates → Head turns easily on neck.
Sub-order.....Anthropoidea → Eyes directed forwards.
Genus.....*Macaca*
Species.....*mulata*

Geographical distribution : Old world monkeys found in India, China, Vietnam and Asia.

Habit and habitat : Arboreal (tree living), terrestrial, diurnal and social.

Comments :

(1) Commonly called as **Rhesus monkey** or **Bandar**. Body divided into **head, trunk, tail** and **abdomen.** Head contains, mouth, eye and nostril.

(2) **Cranium enlarged**, nostrils ringed by bare skin.

(3) Protrusible **facial muscles** permit emotional expression.

(4) Body covered with brownish or golden hairs.

(5) **Nostrils** parallel and directed downwards.

(6) Internal **cheek** pouched for storing the food.

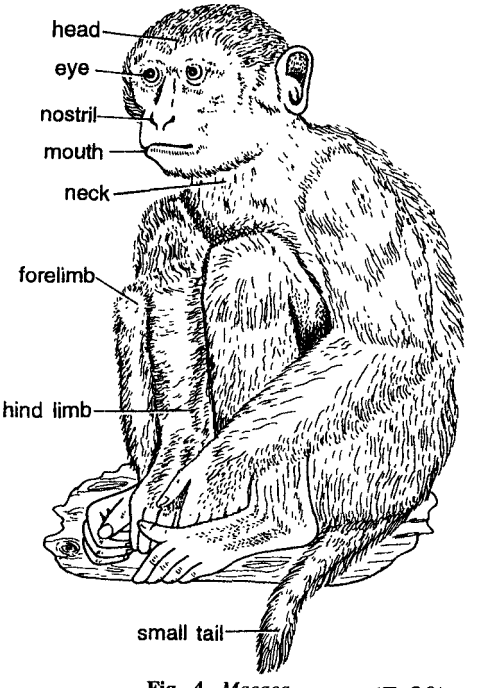


Fig. 4. *Macaca.*

(7) **Buttocks** contain two dried **tuberosities** with exposed **calloused skin.**
(8) Stomach single.
(9) **External ear** reduced. Forelimbs and hind limbs well developed.
(10) Thumb is fully opposable which is perfectly adapted for tightly catching branches of trees, twigs and fruits for eating.

Special features : Monkeys are famous for carricaturing. Trained monkey's dance provides amusement to children. **Rh blood** factor was first discovered in monkeys which has great significance in blood transfusions. Monkeys exhibit **parental care.** Other monkeys are Squirrel monkey (*Saimiri*), Spider monkey (*Ateles*), Marmoset (*Callithrix*) and Langur (*Presbystis*).

Identification : Since the animal contains ischial tuberosities and all above features hence it is ***Macaca.***

11. *Hylobates* : Gibbon

Classification : Same as that of **Rhesus monkey.**

Genus..... *Hylobates*

Geographical distribution : South East Asia and Malaya Archipelago.

Habit and habitat : Chiefly arboreal, found in rain forests upto 71,000 feet. Strongly territorial. Rarely descend to ground. Forelimbs are modified for **Brachiating** (swinging).

Comments :

(1) Commonly called as **gibbon.**
(2) Body slender, **thickly furred** and **tailless.**

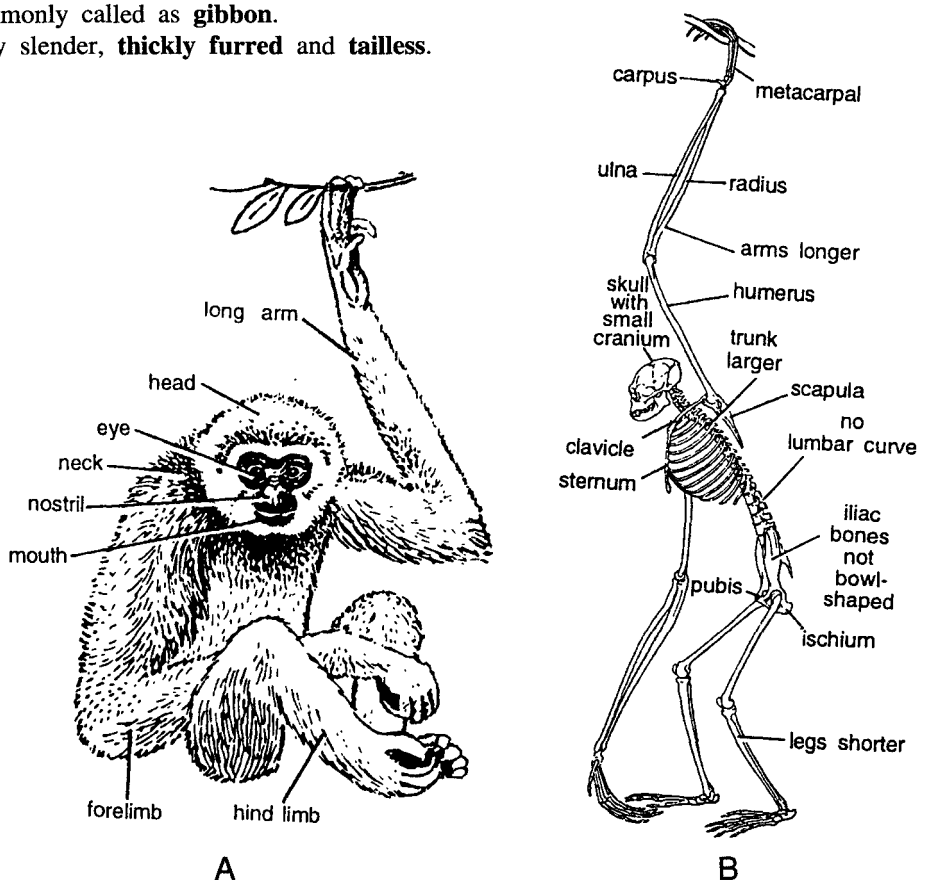


Fig. 5. *Hylobates.* **A.** Adult, **B.** Skeleton.

(3) **Height** 3 feet. Body divided into **head, neck, trunk.**
(4) Head contains **sunkes orbit** (eyes) **flat nose** and black face with mouth.
(5) Prominent **callous pads** on buttocks.
(6) Gibbons are known for their **remarkable calls.**
(7) Male and female differ in colours. Female basically fawn. Female brownish.
(8) **Forelimbs** and **hind limbs** well developed. Forelimbs are long and Gibbons swing around trees with great speed. **Brachiating habit** has induced changes in entire skeleton. Humerus, radius, ulna, carpus and metacarpals are elongated. Thumb is short but long metacarpals and digits with curved phallanges help in catching branches of trees tightly.
(9) Female produces young one after every 2 years. **Gestation period** 7 months.
(10) On ground they walk on their hindlegs slowly but they seldom descend from trees.

Special features : Prominent animal of Zoological gardens. Extremely noisy. They howl, bark and cry.
Identification : Since the animal has sunken orbit and all above features hence it is **Gibbon.**

12. *Balaenoptera* : Whale

Classification : Same as in ***Talpa.***
Order..... Cetacea → Fish like aquatic mammal.
Genus..... *Balaenoptera*
Distribution : Found in arctic and antarctic waters.
Habit and habitat : Largest and heaviest mammal **adapted** for aquitic marine life. It migrates to temperate waters for breeding purposes.
Comments :
(1) Commonly called as blue whale because body is blue above and yellow below.
(2) Above whale has massive size measuring 35 meters in length and 1.5 lac kg in weight.
(3) ***Balaenoptera*** is longest whale and largest mammal flourishing very well.
(4) Body is divisible into small **head, large trunk** and **tail.**
(5) Body contains **paddle-like forelimbs, dorsal fin** and **tail flukes.**
(6) Whale contains fringed **baleen** consisting of two rows of transverse plates of keratin for filtering planktones.

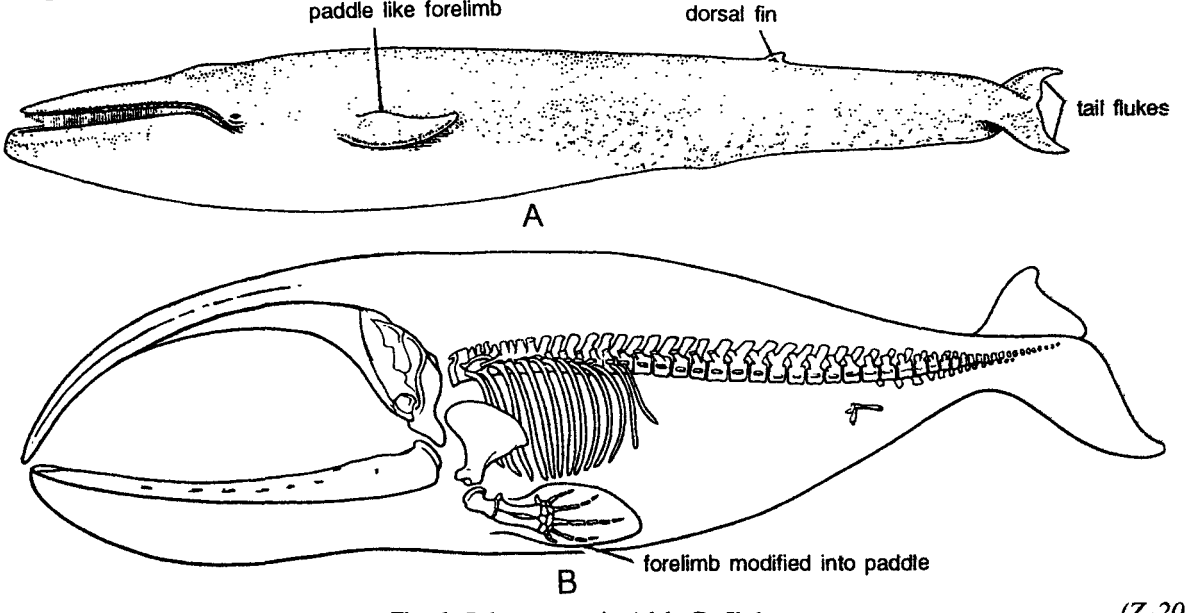


Fig. 6. *Balaenoptera.* **A.** Adult, **B.** Skeleton.

(7) Tail flukes are like two forked lobe of tail fin of fish. They provide strong propulsive thrust allowing upward movement of flukes which cause farward movement of whale. Tail flukes are operated by strong muscles inserted into hind most vertebrae of tail fluke.
(8) Stability and balance is provided by the **paddle like forelimbs** acting as **hydroplanes**.
(9) Tail flukes and dorsal fins are **neomorphus** i.e., they are only folds of skin without any skeletal support but guided by strong muscles.
(10) Paddle-like forelimbs are adapted for swimming.

Identification : Since the animal contains tail fluke and above features, hence it is **whale**.

13. *Equus caballus* : Horse

Classification : Same as that of ***Talpa***.

Order..... **Perissodactyla** → Odd-toed hoofed mammals.
Genus..... ***Equus***
Species.....***caballus***

Geographical distribution : Eocene to Recent. Found in Eurasia, Africa, and tropical America. Cosmopolitan.

Habit and **habitat :** Horses live in herds in open plains and grasslands. Wild Przewalski's horses live in deserts between Mongolia and China. Horses are domesticated. One of the fastest running animals.

Comments :

(1) Commonly called as **modern horse**.
(2) Horses support their entire body weight on the third toe of each foot. Other toes have atrophied to rudimentary **splints**. This is excellent adaptation for swift running on the open plains.
(3) Body of horse is massively built and divided into **head**, **neck**, **trunk**, **chest**, **abdomen** and **tail**.
(4) **Head** is small and characteristic. Teeth adapted for grazing and specialized for grinding course siliceous grasses. Jaws are elongated typically 'horse' like. Ears shorter.
(5) **Neck** is long and mobile. Mane longer and pendant.
(6) **Trunk** is large.
(7) Each foot ends in a large hoof. Metatarsals and tarsals fused. Hind legs and fore legs well developed and adapted for fast running.
(8) Tail is bushy completely covered with long hairs.

Special features : Horse shows following features—(i) Horse is a very familiar animal to man. (ii) It provides excellent evidence for organic evolution. It has been very useful animal to mankind, used in wars and transport. (iii) Horse racing is most commercial and ammusing game. ***Equus przewalskii*** of Mongolia is the only surviving wild horse from which nearly 50 to 60 domesticated horses have been derived. (iv) Horse symbolizes truth and secrecy. Very familiar saying that from '**Horses mouth**'. (v) Horse also symbolizes **strength** or **power** of heavy machines such 2 **horse power**, 5 **horse power** etc. Horses also form part of Army for wars.

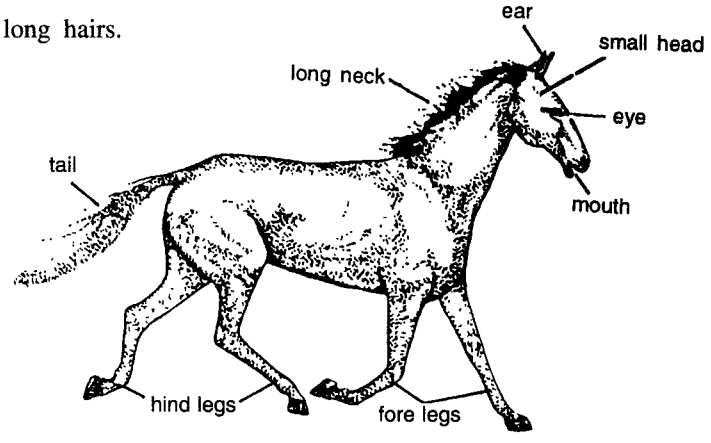


Fig. 7. *Equus caballus* (Horse).

Identification : Since the animal has peculiar jaws and above feature, hence it is ***Equus caballas***.

14. *Ichthyophis*

Classification :

Phylum..... Chordata	→	Dorsal tubular nerve cord, notochord and gill-slits present.
Group..... Craniata	→	Definite head. Cranium with brain present.
Sub-phylum..... Vertebrata	→	Vertebral column present.
Division..... Gnathostomata	→	Jaws and paired appendages present.
Superclass..... Tetrapoda	→	Paired limbs, lungs, cornified skin and bony skeleton.
Class..... Amphibia	→	Cold blooded. Scaleless glandular skin. Can live both in water and on land.
Order..... Gymnophiona or Apoda	→	Two occipital condyles. Heart three-chambered.
Genus.....*Ichthyophis*	→	Vermiform Amphibia without limbs or limb girdles.

Geographical distribution : ***Ichthyophis*** is distributed in tropical regions and found in Sri Lanka, Philippines, Borneo, Java, Scychelles, Mexico to Argentina and India (Mysore) and is the only representative of Gymnophiona living today in tropical countries.

Habit and habitat : ***Ichthyophis*** lives in **burrows** and leads a fossorial life in moist ground. The animal is blind and adapted for burrowing life. It feeds on invertebrates.

Comments :

(1) Commonly called as **caecilian.**

(2) Animal is worm-like and slender, measuring about 30 cm in length. Body divided into **head, trunk** and **tail.**

(3) Body is covered with a smooth, slimy and transversely ringed skin consisting of small calcified scales arranged in transverse rows. **Squirt glands** in skin discharge an irritating fluid.

(4) **Head** contains **eyes, nostrils** and a pair of **sensory tentacles.** Tympanic membrane, tympanic cavity and columella absent.

(5) **Eyes** small, functionless and covered by skin. Though reduced but contain all the parts. A small protrusible tentacle is present between eye and nostril.

(6) Skull compact, roofed with bone.

(7) Limbs and limb girdles absent. Vertebrae **amphicoelous.**

(8) Laryngotracheal chamber is prolonged into a distinct trachea. Right lung elongated, while left lung is reduced. Anus is sub-terminal.

(9) Males are provided with **eversible copulatory organ,** which shows advanced characters. **Fertilization internal.** Male's cloaca is everted like copulatory organ. Eggs are laid in moist burrows. Mother coils around eggs till they hatch into tadpoles.

Special features : ***Ichthyophis*** resembles Amphibia in having a 3-chambered heart, conus arteriosus and brain like Amphibia. But it differs from living Amphibia in having scales in dermis and meroblastic eggs. The animal also shows parental care, as the

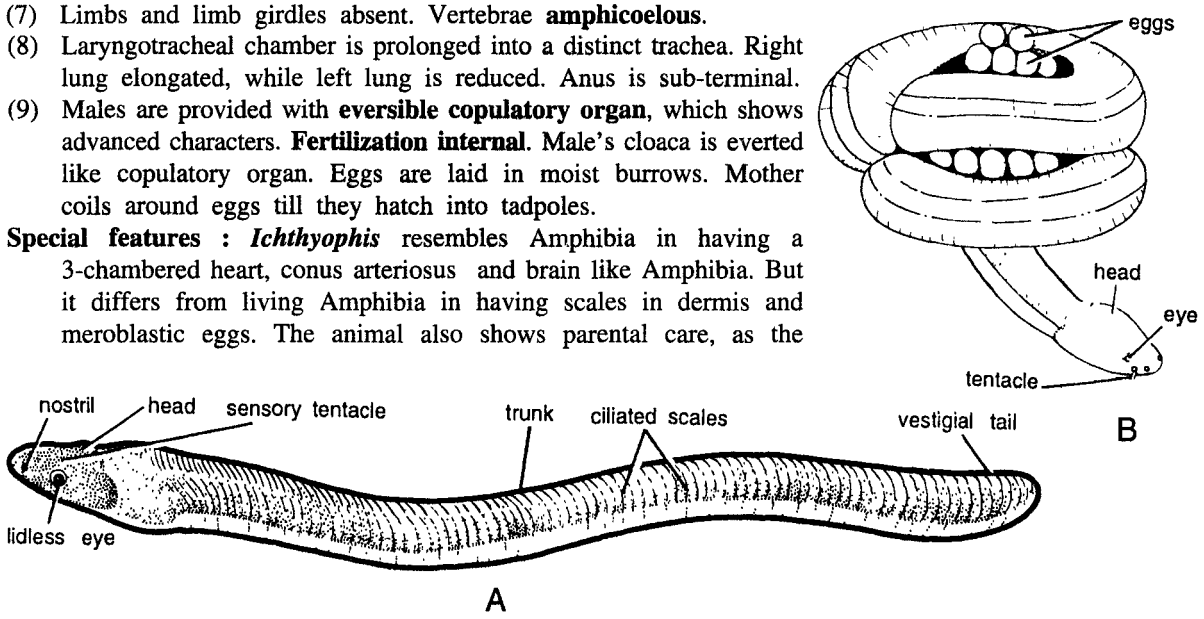


Fig. 8. *Ichthyophis* : **A.** Male, **B.** Coiled female containing eggs.

females take care of the eggs by keeping them in the coils of the body, till they hatch. It shows combination of primitive and advanced characters. The former characters include dermal scales in the skin and number of dermal bones in the skull. Loss of limbs, short post-anal part and copulatory organs are specialized characters.

Identification : Since the animal is **limbless**, contains calcified scales and vestigial tail and above features, hence it is ***Ichthyophis***.

15. *Uraeotyphlus*

Classification : Same as that of ***Ichthyophis***.

Genus..... ***Uraeotyphlus***

Geographical distribution : ***Uraeotyphlus*** has been reported from India, Malayasia, South Africa and South America.

Habit and habitat : ***Uraeotyphlus*** also **burrows** in moist ground. It feeds on small worms.

Comments :

(1) ***Uraeotyphlus*** is **worm-like** and elongated.

(2) Limbs are reduced due to burrowing habit.

(3) Body elongated, vermiform and covered with naked skin in which small **dermal scales** are embedded. Body divided into **head**, **trunk** and **tail**.

(4) Colour of body is brown or black above and white below.

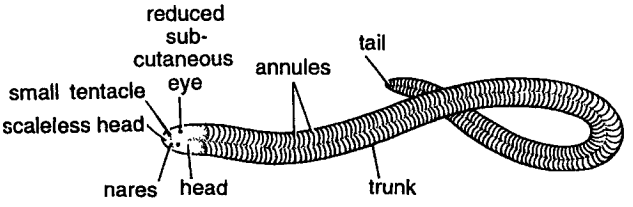


Fig. 9. *Uraeotyphlus.*

(5) Small scaleless **head** contains **eyes** and **nares**.

(6) Eyes are **non-functional**, indistinct and concealed beneath the slimy skin.

(7) It has a peculiar sensory tentacular apparatus consisting of protrusible flap-shaped or globular soft tentacle lodged in a groove of maxilla between eye and nostril.

(8) Respiration through lungs. Right lung is exceptionally large and sac-like.

(9) **Tail** is extremely short. Anus sub-terminal.

Special features : This Apoda also reveals combination of **primitive** and **advanced** characters. The presence of dermal scales in the skin and number of dermal bones in the skull are primitive characters. While specialized characters are loss of limbs, very short post-anal part and copulatory organs.

Identification : Since the animal is limbless, slender and has above features, hence it is ***Uraeotyphlus***.

16. *Typhlops* : Blind Snake

Classification :

Phylum..... Chordata	→	Dorsal tubular nerve cord, notochord and gill-slits present.
Group..... Craniata	→	Definite head. Cranium with brain present.
Sub-phylum..... Vertebrata	→	Vertebral column present.
Division..... Gnathostomata	→	Jaws and paired appendages present.
Super-class..... Tetrapoda	→	Paired limbs, lungs, cornified skin and bony skeleton.
Class..... Reptilia	→	Scaly vertebrates with right and left aortic arches. Single condyle. Pulmonary respiration. Embryo with amnion and allantois.
Sub-class..... Diapsida	→	Skull with two temporal openings separated by postorbital and squamosal.
Order..... Squamata	→	Lizards and snakes with horny epidermal scales or shields. Quadrate bone movable. Vertebrae procoelous. Anal opening transverse.
Sub-order..... Ophidia	→	Snakes. Limbs, feet, ear openings sternum and urinary bladder absent. Mandibles jointed anteriorly by ligament. Tongue slender, bifid and protrusible. Left lung reduced.
Family..... Typhlopidae	→	Eyes vestigial under opaque scales.
Genus..... *Typhlops* (Blind snake)		

Geographical distribution : ***Typhlops*** is widely distributed in Europe, Asia, Africa, America, Australia, India, tropics and sub-tropics of both hemispheres.

Habit and habitat : It is a **burrowing** snake feeding on small insects, earthworms and soft larval insects.

Comments :

(1) Commonly known as **blind snake**. Body divided into **head**, **neck**, **trunk** and **tail**.

(2) Body is elongated, cylindrical, measuring about 175 to 180 mm and covered by thin **overlapping cycloid scales** in multiple rows over whole body.

(3) Animal looks like earthworm and is of dark chocolate colour.

(4) There is no **distinct head** and also there is no differentiation between dorsal and ventral scales which are in **multiple rows** over whole body. Head contains mouth nostril and eye.

(5) Lower jaw without **teeth**, maxilla toothed and transversely placed, ectopterygoid and squamosal absent and pterygoid separate from quadrate.

(6) **Rostral**, **nasal**, **ocular** and **pre-ocular shields** are larger.

(7) Eyes are indistinct and covered with scales. They are immobile and **without eyelids**.

(8) **Limbs**, **feet**, **ear openings**, **sternum**, **urinary bladder absent**. Mandibles join anteriorly by ligament. Tongue slender, bifid, protrusible. Left lung reduced.

Identification : Since this snake contains indistinct head and eyes and above features, hence it ***Typhlops***.

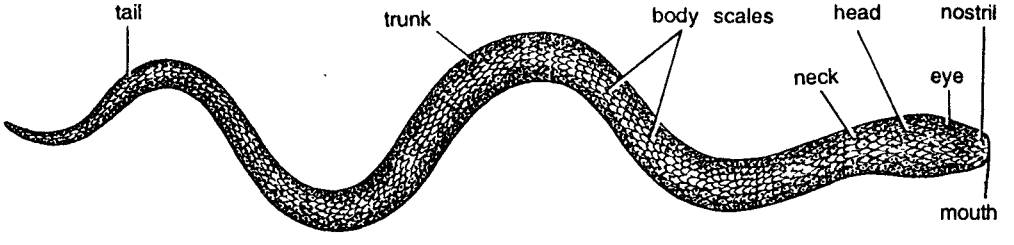


Fig. 10. *Typhlops.*

C. ADAPTIVE MODIFICATION OF FEET OR CLAWS IN BIRDS

17. Types of Feet or Claws in Birds

The feet of birds are also modified variously in accordance with the character of the environment and the manner of locomotion. For illustration see figure 11.

1. **Cursorial or running feet.** In **running birds**, the legs are powerful and the number of toes is reduced. Hind toe may be elevated, reduced or absent. In **bustards**, **coursers** and ratites such as **emu**, **rhea** and **cassowary**, only 3 toes directed forwards are present. **Ostrich** [Fig. 11 (1)] has only 2 toes, of which the outer one is smaller and without a nail.
2. **Perching feet.** Majority of birds belong to the category of **perching birds** or **such as finche** [Fig. 11 (3)], **sparrows**, [Fig. 11 (2)] **crows**, **bulbuls**, **robins**, **mynahs**, etc. Toes are anterior and slender, while one toe or hallux is posterior, strongly built and apposable, so that they can securely fasten the foot to a branch or a perch.
3. **Scratching feet.** Feet of **fowls**, [Fig. 11 (7)] **quails** and **pheasants**, etc. are stout, with strongly-developed claws and well **adapted for running** as well as **scratching** the earth. Foot of male bird is usually provided with a pointed bony spur of offence and defence.
4. **Raptorial feet.** Predatory or carnivorous birds, such as **eagles**, **kites**, **vultures** and **owls**, [Fig. 11 (4)] etc. have strongly taloned feet for **striking** and **grasping** their prey. Toes have strongly developed, sharp and curved claws. Large and fleshy bulbs, called **tylari**, are found on the undersurface of the toes, especially developed in the **sparrow-hawk**. In **osprey** [Fig. 11 (5)] and **Ketupa**, tylari are absent but horny spines are present, which help in gripping slippery preys such as fish.
5. **Wading feet.** Legs and toes are exceptionally long and slender in **wading** or **marshy** birds such as **herons**, [Fig. 11 (11)] **snipes**, **jacana**, [Fig. 11 (6)] **lapwing**, etc. These serve to **walk over** aquatic vegetation or marshes. Web is absent or feebly developed.
6. **Swimming feet.** In **swimming birds**, the **toes** are **webbed**, partially or completely. In diving birds, like **coots** [Fig. 11 (9)] and **grebes**, [Fig. 11 (10)] the web is lobate and the toes are free. In swimming and paddling birds, such as **ducks** [Fig. 11 (12)] and **teals**, **avocet** [Fig. 11 (8)] only the anterior 3 toes are united in a web. In **pelican** and **cormorant** [Fig. 11 (13)] all the 4 toes are enclosed in the web.
7. **Climbing feet.** In **parrots** [Fig. 11 (17)] and **woodpeckers** [Fig. 11 (14)] the feet are used as **grasping organs** and especially adapted for **climbing vertical** surfaces. Second and third toes point in front, while the first and the fourth toes point backwards.
8. **Clinging feet.** In **swifts**, **martinets** [Fig. 11 (15)] **king fisher** [Fig. 11 (16)] and **humming birds**, all the 4 toes point forwards and serve to cling to steep faces of cliffs or under caves of houses, etc.

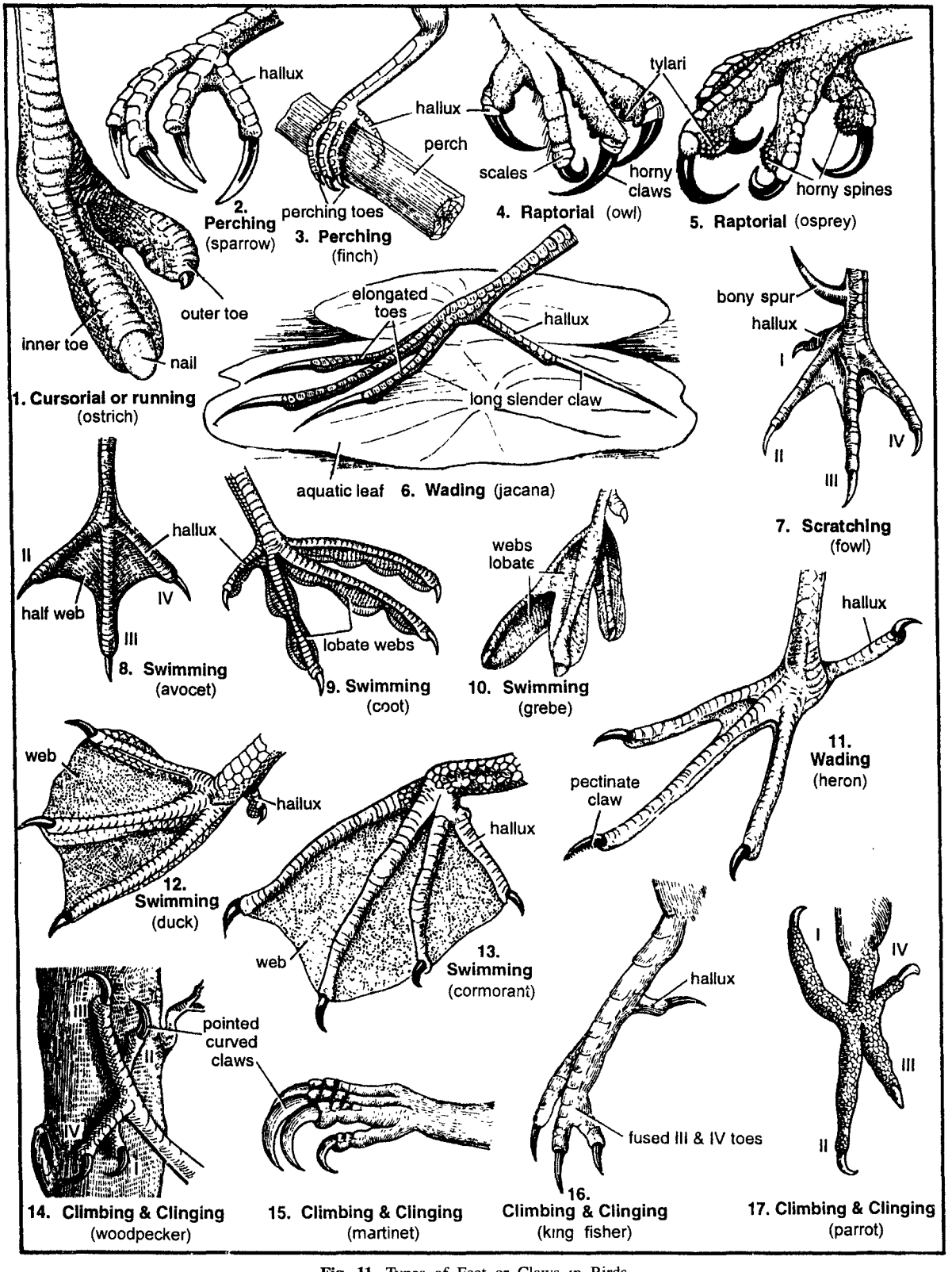


Fig. 11. Types of Feet or Claws in Birds.

D. ADAPTIVE MODIFICATION IN MOUTH PARTS OF INSECTS

18. *Culex* : Male : Head and Mouth Parts

Comments :

(1) **Head** and the **mouth** parts are seen clearly under low magnification of the microscope.
(2) **Body** is differentiated into **head, thorax** and **abdomen** (Fig. 12).
(3) In male ***Culex***, **maxillary palps** are longer than **labium** and **antennae** possess long and bushy delicate hairs in bunches as joints.
(4) **Head** is freely movable on a narrow neck, having large **black compound eyes** and **antennae** and **clypeus articulates** with **labrum-epipharynx.**
(5) Mouth parts contain **labrum-epipharynx, needle shaped mandibles** and **maxillae, hypopharynx, maxillary palps** and **labium** with tactile hairs.
(6) **Mouth parts** are of **sucking** type.
(7) It communicates **filariasis** (causing **elephantiasis).**

Identification : Since the mouth has long maxillary palps, hence it is **head** and **mouth parts of male *Culex*.**

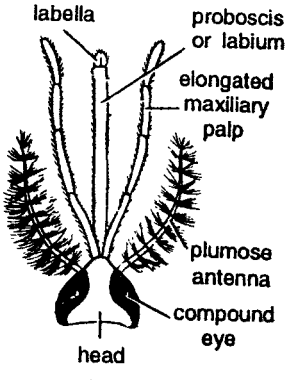


Fig. 12. *Culex*. Head and mouth parts of male.

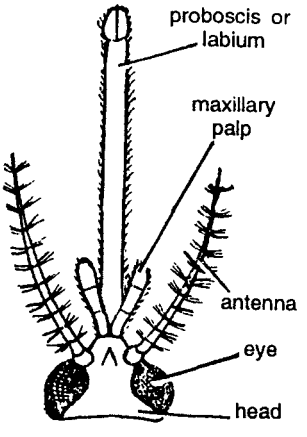


Fig. 13. *Culex*. Head and mouth parts of female.

19. *Culex* : Female : Head and Mouth Parts

Comments :

(1) In female ***Culex***, **maxillary palps** are exceedingly short and **antennae** contain a few short hairs at joints (Fig. 13).
(2) **Head** is freely movable on a slender neck, having large black compound eyes and antennae.
(3) **Clypeus articulates** with **labrum-epipharynx.**
(4) **Mouth parts** are of **peircing** and **sucking type**, composed of **labrum-epipharynx, needle-like mandibles** and **maxillae** and **hypopharynx. Maxillary palps** are three-jointed.
(5) **Maxillary palps** and **labium containing tactile hairs** forming **proboscis sheath.**
(6) It helps in transmission of **elephantiasis** disease.

Identification : Since the mouth has short maxillary palps, hence it is **head** and **mouth parts of female *Culex*.**

20. *Anopheles* : Male : Head and Mouth Parts

Comments :

(1) **Head** and its **mouth parts** are distinct, which can be observed under dissecting microscope and in low magnification of the microscope (Fig. 14).

(2) **Head** is freely movable on a slender neck, having large black compound eyes and antennae.

(3) **Clypeus** articulates with **labrum** and **epipharynx**.

(4) Mouth parts are **piercing** and **sucking type** composed of **labrum-epipharynx, needle-shaped, mandibles.** and **maxillae hypopharynx, maxillary palps** and **labium. Maxillary palps** are **club-shaped** and are nearly equal to labium or **proboscis**; and **antennae** have long, bushy hairs at their joints.

(5) It does not help in transmission of **malarial disease** and feeds on plant juices.

Identification : Since the mouth has club-shaped maxillary palps, hence it is **head** and **mouth parts of male *Anopheles***.

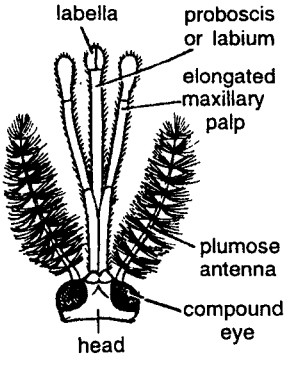


Fig. 14. *Anopheles*. Head and mouth parts of male.

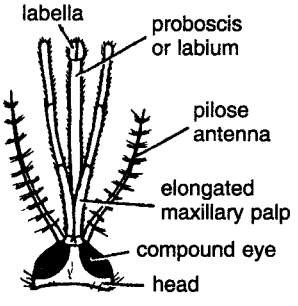


Fig. 15. *Anopheles*. Head and mouth parts of female.

21. *Anopheles* : Female : Head and Mouth Parts

Comments :

(1) **Head** and its **mouth parts** are clearly seen under dissecting microscope under low magnification of compound microscope (Fig. 15).

(2) **Antennae** possess a few short hairs at joints.

(3) **Head** is freely movable on a delicate and slender neck, having large black **compound eyes** and **antennae.**

(4) **Clypeus** articulates with **labrum** and **epipharynx**.

(5) **Mouth parts are piercing** and **sucking type**, composed of **labrum-epipharynx, needle-shaped mandibles** and maxillae, **hypopharynx, maxillary palps** and **labium. Maxillary palps** are simple and equal to labium or proboscis.

(6) It transmits **malarial disease** and acts as **intermediate** host for ***Plasmodium***.

Identification : Since the mouth contains simple maxillary palps, hence it is head and mouth parts of female ***Anopheles***.

22. *Musca domestica* : Housefly : Head and Mouth Parts

Comments :

(1) ***Musca domestica*** or **housefly** belongs to order **Diptera** and contains **sponging** mouth parts, adapted for **sucking** liquid food (Fig. 16).

(2) These insects lack the cutting apparatus.

(3) Head bears **Ocelli** on ocular plate and large compound eyes and mouth parts. Antennae are aristat.

(4) **Mouth parts** are composed of **proboscis, short maxillary palps, labrum-epipharynx** and **hypopharynx. Mandibles** are absent.

(5) **Maxillae** are represented by short and unjointed **maxillary palps** before the rostrum.

(6) **Labrum** is fused with the epipharynx and forms a narrow slender tube opening ventrally.

(7) **Hypopharynx** is narrow structure. Containing salivary duct and fits into the tube constituted by labrum-epipharynx.

(8) **Proboscis is retractile, fleshy** and differentiated into **basal rostrum, middle haustellum** and **upper labellum. Labellum** contains **pseudo-tracheal, canals,** bounded by **pseudo-tracheal membrane.** Labium forms a tube and encloses **labrum-epipharynx** and **hypopharynx.**

(9) **Hypopharynx** and labrum constitute the food channel. Other structures seen are **gene, epistome, apodeme, discal sclerite** and **hyoid sclerite.**

Identification : Since the mouth contains pseudo-tracheae in labellum, and all above features, hence it is **W.M. head and mouth parts of *Musca domestica*.**

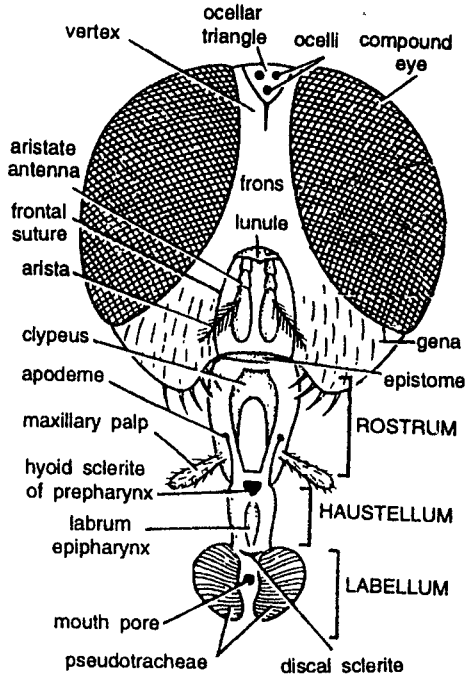


Fig. 16. Head and mouth parts of housefly.

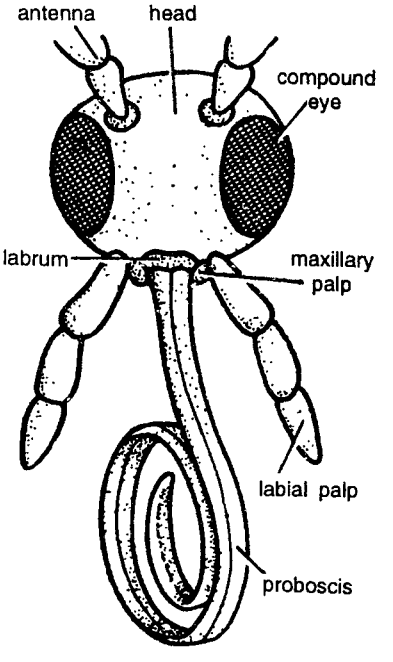


Fig. 17. Head and mouth parts of butterfly.

23. Butterfly : Head and Mouth Parts

Comments :

(1) Butterfly, belonging to order **Lepidoptera**, contains siphoning or **sucking mouth parts**. Head may be examined under binocular microscope for mouth parts (Fig. 17).
(2) **Head** of butterfly is composed of large **compound eyes** and **antennae**. It is broad and **contains siphoning** type of **mouth parts**.
(3) **Mouth parts** are composed of small labrum in front of **clypeus**, **triangular labium** and **coiled proboscis**.
(4) **Mandibles** are absent.
(5) Proboscis is composed of elastic cuticle and greatly elongated **galeae of maxillae**, **grooved internally forming food canal for nectar**.
(6) **Proboscis** lies in **coiled stage**, but it immediately uncoils and protrudes in response to a food stimulus, due to rise in blood pressure.
(7) **Labium** is triangular and plate-like containing labial palps.
(8) Other joints of maxillae and maxillary palps are reduced or vestigial.
(9) Head contains ventral groove for proboscis.

Identification : Since the mouth contains coiled proboscis, hence it is the mouth parts of **butterfly**.

24. *Apis* : Honey-bee : Mouth Parts of Worker

Comments :

(1) **Honey-bee** belonging to the order **Hymenoptera**, contains **rasping** and **lapping** mouth parts, adapted for collection of **nectar** and **pollen** (Fig. 18).
(2) **Head** is triangular, containing large **compound eyes**, 3 **ocelli antennae** and **mouth parts**.
(3) Mouth parts are composed of **spoon-shaped mandibles**, **labrum** and **maxillae** devoid of lacinia.
(4) **Mandibles** are smooth and **spatulate type**, found on either side of the labrum.
(5) It contains **vestigial maxillary palps** and **blade-like galea**.
(6) Labellum is **spoon-shaped**, **grooved internally** forming a tube and is called as tongue.
(7) **Epipharynx** is soft and triangular lying below the **labrum. Cardo** and **stipes** are well developed.
(8) Liquid food taken along tongue is converted into honey in honey-sac by enzymes from salivary glands.
(9) **Prementum** contains segmented **labial palps**, **paraglossae** and **glossae**.
(10) Honey-bee also **moulds waxes** in its hive.

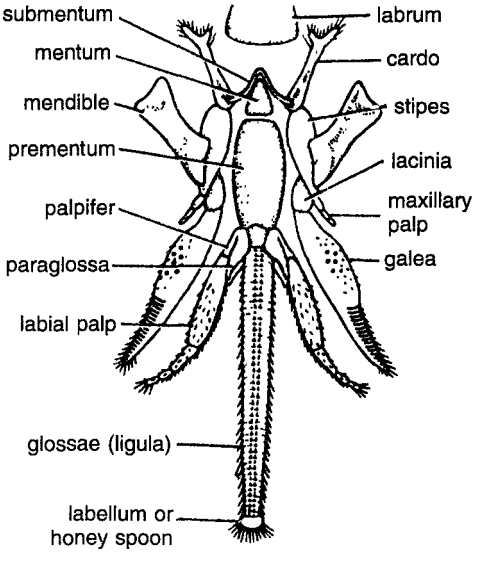


Fig. 18. Honey-bee. Mouth parts of worker.

Identification : Since the mouth contains spoon-shaped labellum, hence these are **mouth parts of worker**, honey-bee.

E. SERIAL HOMOLOGY

25. *Palaemon* : Prawn : Appendages

Instructions : *Study and draw the following appendage (19 pairs) as shown serially in figure. 19.*

A. Cephalic Appendages

(1) **Antennule** : It is sensory and tactile in function and contains inner and outer feelers, **basis, coxa, precoxa** and **stylocerite**. Precoxa contains statocyst and is large. The basis is longer than coxa and carries 2 long sensory feelers. Outer feeler is divided into 2 unequal branches (Fig. 20).

(2) **Antenna** : It is sensory, excretory and balancing, and it consists of **coxa** and **basis** which bears an expanded leaf-like exopodite, called as **squama**, and a long narrow feeler.

(3) **Mandible** : Mandibles are short and stout, lying one on each side of the mouth. It is masticatory in function and consists of coxa. The coxa is densely calcified to form powerful jaws. Its proximal part is spoon-shaped, having cavity for muscle insertion and is called as apophysis, while the distal part is called as head. Head contains stout molar process and a flat plate-like incisor process. It outer border also contains a 3-jointed **mandibular palp**.

(4) **Maxillula** : It also helps in **manipulation of food** and consists of **coxa, basis, gnathobases** and **endopodite**.

(5) **Maxilla** : This manipulates food and is composed of **coxa, basis, gnathobases** and **endopodite.**

B. Thoracic Appendages

It comprises of anterior 3 pairs of **maxillipedes** and **posterior** 5 **pairs of walking legs** (Fig. 21).

(1) **First maxillipede** : (i) It is formed by flattened, leaf-like **coxa** and **basis**. (ii) Coxa contains a bilobed leaf-like **epipodite**. (iii) **Endopodite** is small and unsegmented. (iv) The **exopodite** is also unsegmented but is elongated, with a basal plate-like expansion.

(2) **Second maxillipede** : (i) It comprises of **coxa** and **basis**. It is not so flattened. (ii) Coxa is short and contains a small **epipodite** and **gill** on outer side and setae on inner side. (iii) Basis is jointed to ischium of endopodite. (iv) Endopodite comprises of 5 **segments** namely **ischium, merus, carpus, propodus** and **dactylus**. (v) **Exopodite** is elongated and contains **setae**.

(3) **Third maxillipede** : (i) It is leg-like and comprises of **coxa** and **basis**. (ii) Coxa has a small epipodite

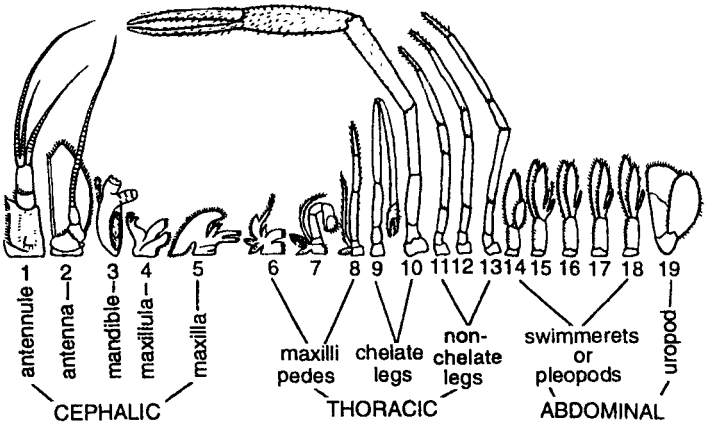


Fig. 19. *Palaemon* : Prawn. Serial arrangement of appendages (19 pairs).

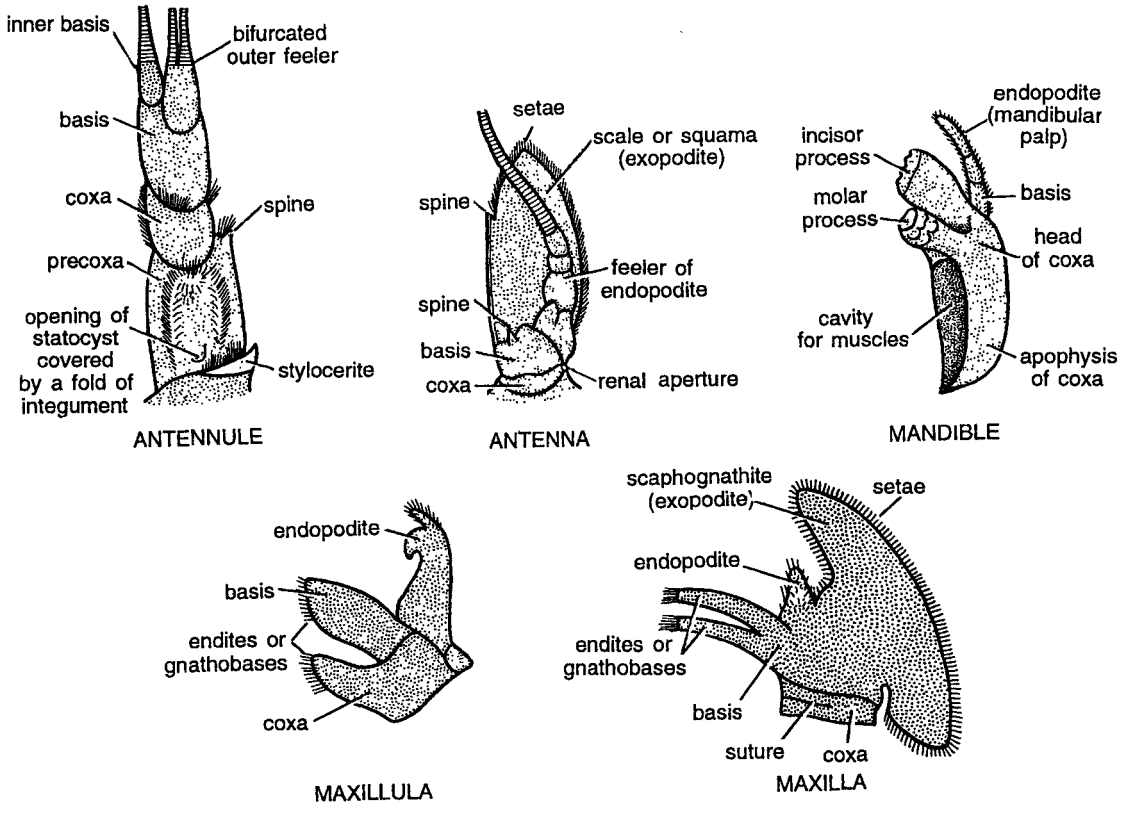


Fig. 20. *Palaemon* : Prawn. Cephalic appendages.

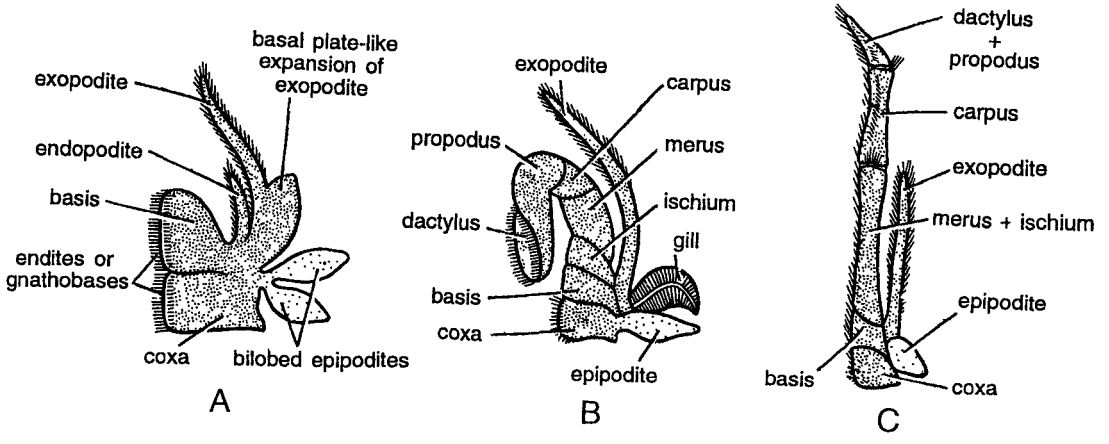


Fig. 21. *Palaemon* : Prawn. Maxillipedes.

on its outer side and basis bears a slender unjointed **exopodite** and an elongated **endopodite.** (iii) The endopodite is composed of 3 podomeres, proximal podomere fused with merus, middle carpus and terminal one fused with dactylus. (iv) Setae are found all along exopodite and on inner margin of **endopodite.**

(4) **Typical leg :** (i) There ar 5 pairs of walking legs differing from maxillipedes in the absence of exopodite and endopodite and also greater in size. (ii) A typical leg or 4th leg consists of 2-jointed

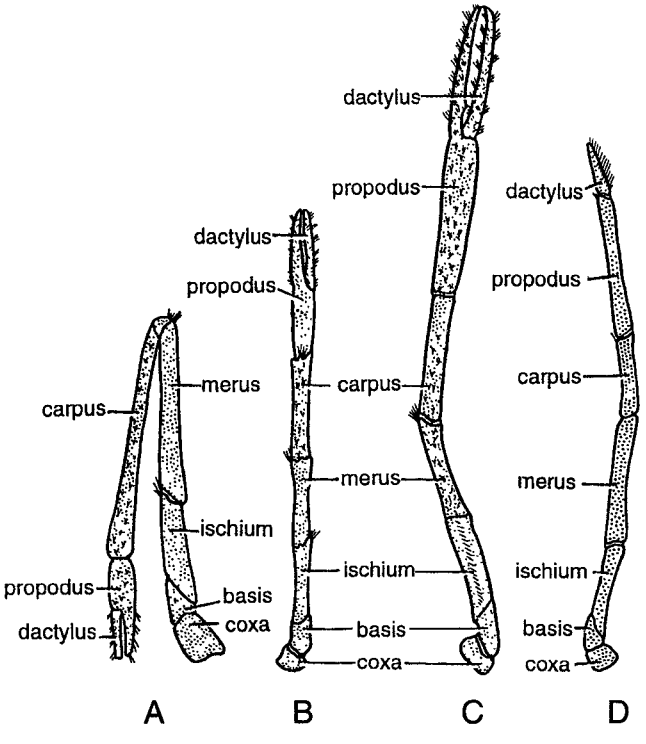


Fig. 22. *Palaemon* : Prawn. Walking legs. **A.** Typical (4th) non-chelate legs, **B.** Ist chelate leg, **C.** 2nd chelate leg of female, **D.** 2nd chelate leg of male.

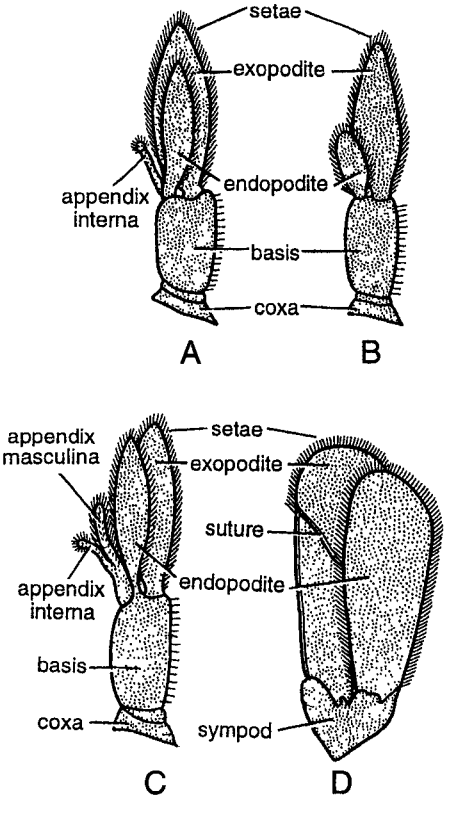


Fig. 23. *Palaemon* : Prawn. Abdominal appendages (pleopods). **A.** Typical, **B.** First, **C.** 2nd of male, **D.** Uropod.

protopodite and **a 5-jointed endopodite**. (iii) All the seven podomeres namely **coxa**, **ischium**, **merus**, **carpus**, **propodus** and **dactylus**, are arranged in linear series and hinged together (Fig. 22).

(5) **First chelate leg :** (i) In this, the propodus is prolonged beyond its articulation with the dactylus, so that 2 podomeres work one against the other like forceps blades forming chela or pincer and such legs are called as cheliped or chelate legs. (ii) Setae cover entire surface.

(6) **Second chelate leg :** (i) All podomeres are considerable elongated. (ii) In males, it is more powerful than in female. Third, fourth, and fifth pairs of legs are **non-chelate** and typical. In males, each fifth leg bears a male genital aperture on the arthrodial membrane between leg and thorax. In female, the genital aperture is found on the inner side of the coxa of third leg.

C. Abdominal Appendages

There are **six pairs of abdominal appendage**. These are typical **biramous appendages**, one pair in each abdominal segment. They help in **swimming** and hence called as swimmerets or **pleopods** (Fig. 23).

(1) **Typical abdominal appendages** (3rd appendages) : (i) The **protopodite** has ring-like coxa and a **cylindrical basis**, (ii) The basis bears flattened leaf-like smaller **endopodite** and a larger **exopodite**. (iii) From inner basal margin of endopodite, a small knob-headed rod-like structure arises, called as **appendix interna**. (iv) In female, the appendix interna of opposite appendages articulate with each other forming bridges to carry the eggs. (v) The outer surface of basis and margins of exopodite and endopodite contain several setae. (vi) Remaining appendages slightly differ from typical ones.

(2) **First abdominal appendage :** Appendix interna absent and endopodite greatly reduced.

(3) **Second abdominal appendage :** In males only, in addition to appendix interna, there is additional **rod-like** and **setae-bearing process called as appendix masculina**, found between appendix interna and endopodite.

(4) **Uropods :** Sixth pairs of appendages are called **uropods** lying one on either side of telson. In each uropod, coxa and basis are fused together to form a triangular sympod. **Endo** and **exopodites** are **oar-like** and their margins bear setae. Exopodite is bigger than endopodite and incompletely divided in the middle by a transverse suture.

Instructions : *Draw the diagrams of the appendages with help of the practical book.*

EXPERIMENTS ON ANIMAL BEHAVIOUR

Practicals on animal behaviour have been designed for the first time in this book for the under graduate students. The experiments are based on various aspects of animal behaviour such as learning, conflict, predation, signalling, courtship and phototaxis and toxic effects on behaviour etc.

The practical exercises are of two types (A) Photographs and designs/figures depicting various aspects of animal behaviour and (B) Phototaxis and Toxicological responses.

A. STUDY OF PHOTOGRAPHS

Study of photographs deals with **Conflict behaviour**, **Predation pressure**, **Fixed Action Pattern** (FAP), **Courtship and Territorial Behaviour of the birds.**

26. Conflict Behaviour

Comments :

(1) Conflict behaviour is considered to have been originated from some stereotyped display behaviour.

(2) Conflict behaviour arises as an incidental effect of the neural system, controlling attack and escape behaviour.

(3) In Herring gulls, the conflict behaviour accurately signals to attack and stopping one male from entering into the territory of other males.

(4) In above, 3 birds have been shown in which 2 male birds are opposite each other dose to the territory, the female bird is behind the male bird.

(5) Both above male birds are motivated by aggression and fear.

(6) One male bird responds by pulling grass within safe zone of territory.

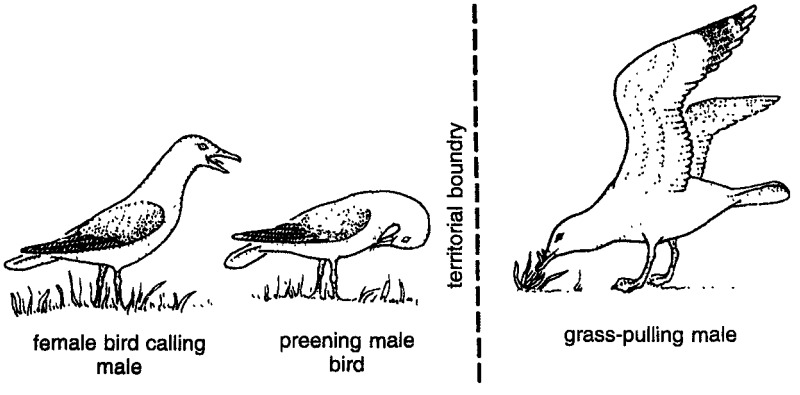


Fig. 24. Conflict behaviour of herring gulls.

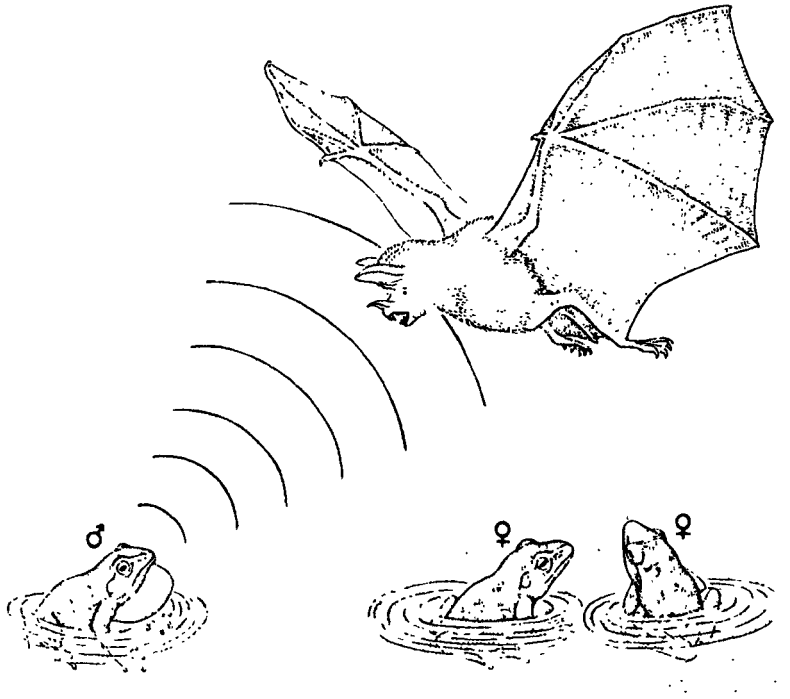


Fig. 25. Predation behaviour.

(7) The other male bird responds by preening its feathers with a bent head rather than attacking the other. The female bird calls behind the preening bird.

27. Predation Pressure

Comments :

(1) Above photograph depicts predation pressure involving male Tungara frog and illigitimate call receiver bat (Fig. 25).
(2) Male frog calls loudly at night to attract female frog for mating.
(3) Call of male frog also attracts nocturnal bat which is illigitimate call receiver. The bat sweeps through water to catch, kill and eat the frog (prey).
(4) Frog avoid predation risk by stopping the calls when it detects a flying bat.
(5) Frog produce very narrow frequency calls by which they may not mate but survive and may mate at next opportunity and thus fulfil their reproductive requirement.

28. Fixed Action Pattern (FAP) Behaviour : Courtship Behaviour

Comments :

(1) Fixed Action Pattern) (FAP) behaviour or courtship behaviour is mediated by genes and exhibited automatically by animals without seeing or learning (Fig. 26).
(2) Above behaviour is observed even if the animal is developed in isolation.
(3) **Courtship** is a good example of Fixed Action Pattern behaviour.
(4) During courtship behaviour the male peacock spreads its wings and dances during rain to attract its mate.

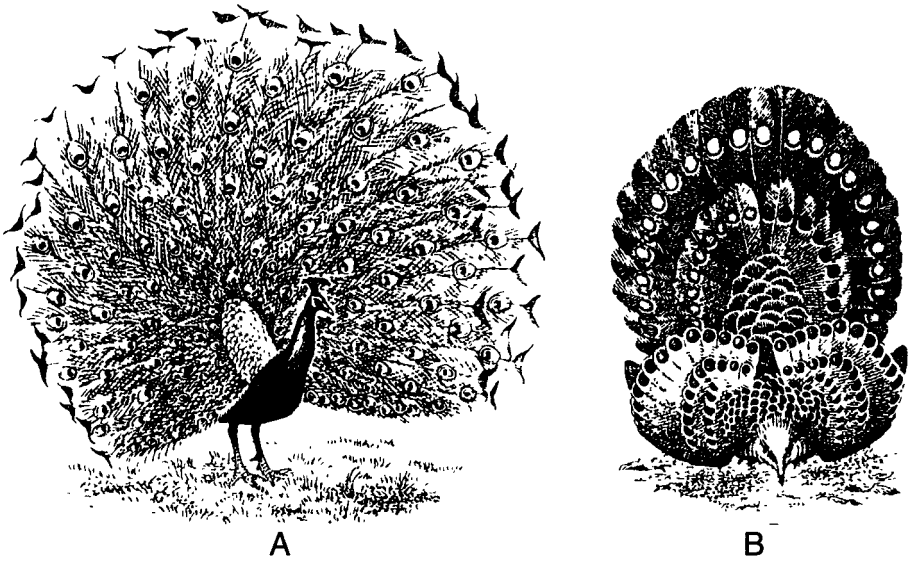


Fig. 26. Courtship behaviour : **A.** Common peacock, **B.** Burmese peacock.

29. Territorial Behaviour in Birds

Comments :

In 1941, **Nice** divided the territories of birds into 6 types.

(1) **First type** of territory is very wide and it is the place of all feeding and reproductive behaviour including of pairing and sexual display.

(2) **Second type** of territory is used only for reproductive behaviour, it is used by grebes, surans, swallows and some sparrows.

(3) **Third type** of territory is used for display grounds by grouse, manakins and Prairie hen.

(4) **Fourth type** of territory is used for reproductive behaviour and it is extremely small in size. It consists of nests and immediate surroundings. It includes social weavers, penguins, pelicans and monk parakeets.

(5) **Fifth type** of territory consists of separate nesting and food gathering areas. This territory is shown by seaside sparrow and rock thrush.

(6) **Sixth type** of territory is occupied by non-migratory birds and that is only for breeding season.

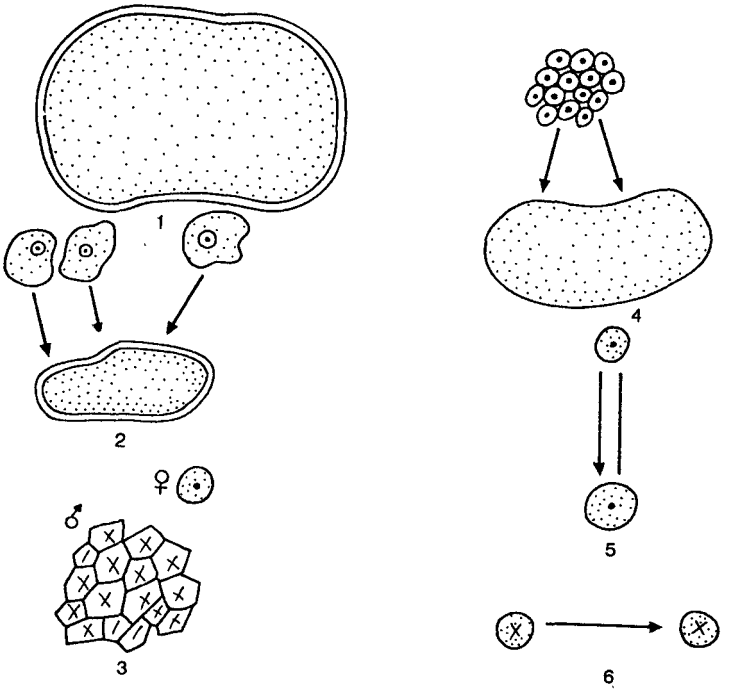


Fig. 27. Territorial behaviour of birds.

B. PHOTOTAXIS OR PHOTORECEPTION AND TOXICOLOGICAL RESPONSES

Phototaxis and photoreception exercise, could be done with earthworms or frogs while toxicological responses could be studied with fishes using any pollutant like cadmium acetate.

30. Phototaxis/Photoreception Behaviour of Earthworms

Phototaxis i.e. attraction towards light in darkness is well known phenomenon for insects. Other animals also show phototaxis or photorecepter. Phototaxis can be observed on earthworms in rainy season when earthworms are available in large number.

Procedure :

(1) Make a rectangular 12" × 6" wooden box with a partition in the center. The base of the box should be sliding and the partition should be made such, as to allow only earthworms to wriggle from one chamber to another. One chamber should be completely dark and in another chamber fix a small zero watt white bulb with a small glass window in the chamber with bulb.

(2) Keep the box on experimental table and slide the base of wooden box closer towards you, keep 25 earthworms in the dark side of the box, push the base to close it and switch on the bulb and observe. Observe the movement of earthworm through a glass window. Earthworms are attracted towards the lighted chamber, this reveals phototaxis in earthworm.

31. Toxicological Response of Fish : Operculum Movement and Surfacing

In fishes movement of operculum and surfacing (emergence of fish on the surface of water) is interesting behaivour of the fishes to be observed. Movement of operculum and emergence depend on conditions of water, such as dissolved oxygen, dissolved toxicological substances such as cadmium acetate, zinc, lead etc. The following experiment has been designed using cadmium acetate as a heavy metal toxicant.

Procedure : Cadmium acetate, distilled water, two large glass troughs and a medium size living fish are required for the experiment.

(1) Take two glass troughs, label them as A and B.

(2) In glass trough A fill it with water upto 3/4 label. Keep glass trough on the laboratory table. Observe the movement of fish and also the movement of operculum in one minute and emergence of fish on the surface of water. In case of common aquarium Gold fish the movement of operculum is 60 to 61 per minute and surfacing 6 to 7 times in 5 minutes. Take at least 5 readings and calculate the average value.

(3) Take glass trough B for studying toxicological responses. First determine LD_{50}. In case of cadmium acetate prepare LD_2 solution. Fill the glass trough with cadmium acetate solution and leave a fish in it. Observe the movement of operculum and surfacing of fish in one minute and five minutes respectively. Take 5 readings and calculate the average value.

Precautions : The above experiment must be done with concentration and care.

17 Viva Voce

QUESTIONS & ANSWERS

(Questions are addressed to students and answers to teachers)

Question

1. **What do you mean by the word Zoology ?**
   Sir, Zoology is **Greek** word which means Zoo = animals and **logos** = discourse or discussion or study. Hence study of animals is called as **Zoology**.
2. **What do you mean by term Fauna ?**
   Sir, Study of various groups of animals is called as **Fauna**.
3. **What are two broad divisions of animals?**
   Sir, Entire animals living or dead have been divided into following two groups :
   (1) **Non-chordates** or **Invertebrates**. All those animals devoid of **notochord** or **vertebrae** are called as **Invertebrates.**
   (2) **Chordates**. All the animals having notochord are called as **Chordates**.

   The Viva voce questions are categorised under different heads as per evolutionary sequence and under different phylum wise.

Fundamental Zoology

4. **What do you understand by the Proterostome or Protostome and Deuterostome concept ?**
   Sir, The above two words Proterostome and Deuterostomes are associated with origin of **mouth** and **blastopore**.

   In **Proterostomes** mouth originates from **blastopore**. This group includes **helminthes (Platyhelminthes**, and **Nemathelminthes)**, **Phoronida**, **Brachiopoda**, **Annelida**, **Mollusca** and **Arthropoda**. In these groups **cleavage** is **spiral** and **determinate** and Coelom is **Schizocoelus**.

   In **Deuterostomes** blastopore closes and a fresh another opening originates called as mouth. **Stoma means mouth**, Deutero means twice. In the embryonic stage openings formed two times are referred as **deuterostome**. Coelom is **enterocoelus**. It includes **Echinoderms** and all **chordates** upto **man**. Cleavage is indeterminate. All vertebrates including man are enterocoelus deuterostome. **Deuterostome is higher character**.

5. **What is Symmetry ?**
Sir, Disposition or arrangements of various parts of the body both external and internal in a definite pattern is called as symmetry.
6. **What is radial symmetry ?**
Sir, Arrangement of body parts along radii is called as **radial symmetry**.
For example—radial, inter-radial, per-radial and adradial tentacles in ***Obelia*** medusa.
7. **In which groups you find radial symmetry?**
Sir, Radial **symmetry** is found in Coelenterates and Echinoderms.
8. **Is radial symmetry primitive or advanced character ?**
Sir, Radial symmetry is primitive character because most of the animals having radial symmetry belong to **Coelenterates**.
9. **What is bilateral symmetry ?**
Sir, If any animal is cut along the **median vertical longitudinal plan**, then two halves would be **mirror image** of each other. All animals from Platyhelminthes upto man are bilaterally symmetrical animals except Echinoderms.
10. **Is bilateral symmetry a primitive or advanced character ?**
Sir, Bilateral symmetry is advanced character because man belong to bilateral symmetry group.
11. **What is radio-bilateral symmetry ?**
Sir, In nematodes (Aschelminthes) certain organs are disposed on radial patterns, such as lips and cephalic papillae and certain organs on bilateral plane such as cervical papillae and lateral alae. This is called as **radio-bilateral symmetry**.
12. **What is a coelom or true body cavity ?**
Sir, The cavity present between body wall and alimentary canal is called as **Coelom** or true body cavity.
13. **What are characters of a true coelom ?**
Sir, The true coelom has following characters :
(i) Coelom is lined by 2 coelomic epithelial linings. Towards body wall coelom is lined by **parietal coelomic epithelial** lining. Towards intestine coelom is lined by **visceral coelomic epithelial** lining.
(ii) Coelom develops either from mesoderm, then it is called as **Schizocoelus** coelom or from **enteron** or archenteron, then it is called as **Enterocoelus coelom**.
(iii) Excretory organs open into the coelom. For example—nephrostome of septal nephridia of Earthworm opens in coelom.
(iv) Sex-cells originate from coelomic epithelium.
14. **In which group you find true coelom for the first time ?**
Sir, In Phylum Annelida.
15. **Are you Coelomate or Acoelomate ?**
Sir, Truely coelomate.
16. **Which are acoelomate animals?**
Sir, Helminthes, Turbellarians, Trematodes and Cestodes are Acoelomate. Space between body wall and alimentary canal is filled with mesenchyma or **parenchyma**. In these groups there is no cavity between body wall and alimentary canal.
17. **What is pseudocoelom or false body cavity and in which group you find pseudocoelom?**
Sir, Pseudocoelom is found in **Round worms** or **nematodes**. Although in these animals the cavity originally develops from mesoderm but it disorganizes. The body cavity losses all the characters of true coelom (1). It is not lined by parietal and visceral epithelial layer, sex cells do not arise from the coelomic epithelium and excretory organs do not open into coelom, hence coelom of nematodes is called as **pseudocoelom**. Nematodes are called as pseudocoelomates animals.
18. **What is metameric segmentation?**
Sir, Serial repetition of body parts both externally and internally is called as **metameric segmentation**. For example in earthworm a pair of setae, a nerve ganglion, a part of blood vessels, excretory duct are found in each segment.
19. **Which group of animal is called as metamerically segmented ?**
Sir, Phylum – Annelida.
20. **Which Phylum is truely coelomate and metamerically segmented ?**
Sir, Phylum – Annelida.

21. What is true segmentation ?
Sir, When external segmentation corresponds to internal segmentation also then it is referred as **true segmentation** as in Earthworm.

22. What do you mean by Superficial segmentation ?
Sir, In leach each segment is divided into 4 to 6 superficial segments, hence it is called as **superficial segmentation.**

23. What is protonephridia and in which group you find them ?
Sir, Protonephridia is primitive **closed** nephridia found in acoelomate group, for example flame-cells in ***Fasciola hepatica.***

24. Why protonephridia is a closed nephridia ?
Sir, Protonephridia is closed because there is no coelom in Helminths or acoelomates. Excretory products diffuse into flame-cells and then passed to the exterior by net work of excretory tubules and then main excretory canal to outside by excretory pore.

25. Enumerate different phyla of invertebrates or non-chordates.
Sir, Different phyla are as under :
1. PHYLUM – **PROTOZOA**
2. PHYLUM – **PORIFERA**
3. PHYLUM – **COELENTERATA**
4. PHYLUM – **PLATYHELMINTHES**
5. PHYLUM – **NEMATHELMINTHES**
6. PHYLUM – **ANNELIDA**
7. PHYLUM – **MOLLUSCA**
8. PHYLUM – **ARTHROPODA**
9. PHYLUM – **ECHINODERMATA**

26. Give Phylum characters of each phyla in Invertebrates.
Sir, the Phylum characters are as under :
1. **Phylum protozoa** – Unicellular animals.
2. **Phylum porifera** – Cellular grade animals.
3. **Phylum coelenterata** – Tissue grade animals.
4. **Phylum platyhelminthes** – Organ grade animals.
5. **Phylum nemathelminthes** – Pseudo-coelomate animals.
6. **Phylum annelida** – Truly coelomate and metamerically segmented animals.
7. **Phylum mollusca** – Shell and mantle containing animals.
8. **Phylum arthropoda** – Jointed appendages containing animals.
9. **Phylum echinodermata** – Spiny skinned animals.

27. What do you mean by Minor Phyla ?
Sir, During evolution certain group of animals showed divergent evolution and they deviated from main lines. Such groups have been divided into (i) **Coelomate** minor phyla and (ii) **Acoelomate** minor phyla. **Coelomate** minor phyla consists of following :
1. Phylum – Brachiopoda.
2. Phylum – Phoronida.
3. Phylum – Ectoprocta.
4. Phylum – Sipunculida.
5. Phylum – Echiuridea.
6. Phylum – Tardigrata.

Acoelomate minor phyla are as follows :
1. Endoprocta
2. Gastrotrichia
3. Kinorhyncha
4. Nemertinea
5. Rotifera
6. Acanthocephala

28. Why they are called as Minor Phyla ?
Sir, The animals belonging to coelomate and acoelomate groups are called as minor phyla as they consist of very few species and each group shows separate identity in their structure and development. For example, ***Magillania*** of Phylum brachiopoda apparently looks like bivalve molluscs ***(Unio)***, but in brachiopods the two shells are unequal and one shell is produced into beak. These groups do not fit into direct line of dissendency along any of regular Phylums. If some similarity is found in structure, they widely differ in development. Hence they are referred as minor phyla. But now the trend is to treat each minor phyla as independent Phylum.

PHYLUM–PROTOZOA

29. Why they are called as Unicellular animals?
Sir, Since all the physiological and metabolic activities are performed within a single cell and hence they are called as unicellular animals.

30. Give diagnostic characters of Phylum Protozoa.

Sir, Phylum protozoa has the following diagnostic characters.

1. Unicellular and eukaryotic.
2. Cytoplasm is composed of **ectoplasm** and **endoplasm.**
3. Both ectoplasm and endoplasm contain several cell organelles. Different cell organelles perform different functions and they differ in their structures.
4. Protozoans are free-living and parasitic.
5. Protozoans may be terrestrial and fresh water (aquatic).

31. What do you mean by cell-organelles ?

Sir, Specialized parts of cytoplasm for specialized functions are called as cell-organelles.

32. Enumerate different cell organelles in *Amoeba* along with their functions.

Sir, Different cell organelles in ***Amoeba*** are as under along with their functions :

1. **Plasma membrane** — Protection and permeability.
2. **Glycocalyx** — Fuzzy layer outer to plasma membrane for ionic exchanges, osmosis and diffusion is called glycocalyx.
3. **Endoplasm** has following organelles :
   (i) **Nucleus** — Reproduction and physiology,
   (ii) **Endoplasmic reticulum** — Support, storage, transport of nutrients,
   (iii) **Ribosomes** — Protein synthesis,
   (iv) **Mitochondria** — Oxydative phosphory -lation and energy production,
   (v) **Contractile vacuoles** — Osmo-regulation and excretion,
   (vi) **Fibrils** — Support.
   (vii) **Golgi body**— Entire internal secretion.
   (viii) **Lysosome** — Proteolytic activities and phagocytosis,
   (ix) **Pseudopodia** — Locomotion. Cilia, flagella — Locomotion.

33. Can you classify protozoans ?

Sir, Phylum protozoa is divided into 2 sub-phyla—

(1) **Sub-phylum** – Plasmodroms having **pseudopodia** and **flagella** and (2) **Sub-phylum - Ciliophora** having **cilia**. Further sub-phylum plasmodroma is divided into 3 classes :

1. **Class - Mastigophora** - Locomotion by flagella — Example : ***Euglena Trypanosoma*** and ***Leishmania***.
2. **Class - Sarcodina** - Locomotion by pseudopodia — Example : ***Amoeba***, ***Entamoeba histolytica***, etc.
3. **Class - Sporozoa** - No locomotionary organelles - includes parasitic protozoans -such as ***Plasmodium*** covering malaria, *coccidiasis* and PAM disease due to free-living pathogenic amoebae - such as ***Acanthamoeba*** and Hartmanialla.

34. Can you name rectal ciliates?

Sir, The rectal ciliates comprise the following parasites obtained from rectum of frog.

1. ***Balantidium***, 2. ***Opalina***, 3. ***Nyctotherus***.

35. Can you tell me important parasitic protozoans and diseases caused by them ?

Yes Sir, Important parasitic protozoans along with the diseases caused by them are as under :

1. ***Plasmodium vivax***,
2. ***Plasmodium ovale***,
3. ***Plasmodium falciparum***,
4. ***Plasmodium malariae.***

   All the above four species cause malaria disease in man.
5. ***Entamoeba histolytica*** — Causing amoebiasis in man.
6. ***Trypanosoma*** — Causes trypanosomiasis (African sleeping sickness and death also). Different species cause different disease such as — ***Trypanosoma gambiense*** causes **African sleeping sickness**, ***Trypanosoma rhodesiense*** causes **Rhodesian sleeping sickness**, ***T. bruci*** causes **Nagana** fatal disease in cattles, ***T. cruzi*** causes **Chaga's** disease in central America.

36. How sleeping sickness disease is transmitted to new host ?

Sir, Sleeping sickness disease is transmitted by contaminated **tse tse fly**.

37. What do you know about Kala-azar disease in man ?

Sir, Kala-azar is caused by another protozoan parasite ***Leishmania donovani*** in which fever occurs. ***L. donovani*** also causes visceral leishmaniasis and also cutaneous lesions.

38. What is post Kala-azar dermal *Leishmania* ?
Sir, It is caused by ***L. donovani.*** After Kala-azar ***Leishmania*** causes **dermal leishmanoid** in which disfiguration of face occurs due to formation of blister like lesions over the face.

39. What do you know by Oriental sore ?
Sir, It is caused by ***Leishmania tropica. L. tropic*** causes cutaneous lesions.

40. What is giardiasis ?
Sir, It is caused by a protozoan parasite. ***Giardia*** which causes **enterocolitis, anaemia** and **allergy.**

41. What do you know about *Trichomonas* ?
Sir, ***Trichomonas*** is a flagellate parasite. ***Trichomonas vaginalis*** is found in vagina of woman causing inflammation.

42. What is amoebiasis ?
Sir, The adult Trophozoite parasites of ***Entamoeba histolytica*** are tissue invading parasites. They are found in intestine causing **ulceration** and **amoebic dysentery.** The infective stage is tetranucleate cyst transmitted by house fly.

43. How *Paramecium* reproduces ?
Sir, ***Paramecium*** **reproduces by binary fission, conjugation, endomixis, hemixis and automixis.**

44. What do you know about Kappa particles ?
Sir, T.M. Sonneborn (1938) reported that *P. aurelia* occurs in two strains. One with Kappa particles kills the other sensitive strain without Kappa particles.

PHYLUM-PORIFERA

45. Give diagnostic characters of Phylum Porifera.
Sir, Phylum porifera has following features :
1. Cellular grade organization.
2. Surface of the body contains several pores and hence the name **Porifera.**
3. Commonly called as **sponges.**
4. Presence of **canal system** for feeding and nutrition.

46. How many types of canal system in Porifera ?
Sir, Canal system of 3 kinds mainly (1) **Asconoid,** (2) **Syconoid** and (3) **Leuconoid.**

47. What do you mean by cellular grade ?
Sir, In Porifera different cells perform different functions. For example **Choanocytes** (feeding), **Amoebocytes** (storage of food reserve), **Mesenchyma** (support) and **Archaeocytes** (reproduction), hence cellular growth.

48. What is the social and mythological significance of *Euplectellal* ?
Sir, In ***Euplectella*** a pair of shrimps become imprisoned and dried skeleton contains these shrimps, signifies permanent association of shrimps and ***Euplectella.*** The animal is presented to newly married couples in Japan.

49. What is common name of *Euplectellal ?*
Sir, Common name of ***Euplectella*** is **Venus flower basket.**

50. Which sponge is Dead man's finger as Mermaid's gloves ?
Sir, The above sponge is ***Chalina.***

51. What do you mean by Asconoid or Ascon type of canal system ?
Sir, Ascon type is **simplest** canal system called as **Asconoid** canal system with **Ostia**-Spongocoel-Osculum arrangement.

52. What is syconoid canal system ?
Sir, In ***Sycon*** the radial canals become finger like hence canal system becomes modified and is called as **Syconoid** canal system. Water flow is through **Ostia**-internal canal, prosopyles, radial canals - apopyle -spongocoel - Osculum-exterior.

53. What is leuconoid canal system ?
Sir, In leuconoid type body is further folded and water root comprise **Ostia**-Incurrent canal, prosopyles, flagellated chambers, apopyle-excurrent canal-outside. This type of canal system is found in **spongilla.**

54. What do you know about reproduction in sponges ?
Sir, In sponges two types of reproduction occurs : (1) **Sexual** by sperm ova, and (2) **asexual** by **budding, fission** and **gemmule** formation.

55. What is gemmule ?
Sir, Gemmule is asexual reproductive body found in ***Spongilla*** and ***Ephydatia.*** In suitable months (April or May) gemmules internally contains a living substance called **histoblasts,** which amount through micropyle and develop into new sponge.

56. What do you know about Amphiblastnla larva ?

Sir, In many calcareous sponges zygote after embryonic development gives rise to **Amphiblastula** larva. It contains flagellated cells in one half (anterior) and non-flagellated in posterior half.

PHYLUM-COELENTERATA (=CNIDARIA)

57. Enumerate diagnostic features of Phylum-coelenterata.

Sir, Coelenterates are characterized by following features :

1. They have **tissue-grade organization**.
2. **Diploblastic-** made up of **ectoderm** and **endoderm** with intervening mesoglea.
3. Show division of labour.
4. Coelenterates contain nematocyst, polyp and medusa.
5. Reproduce by sexual and asexual methods.
6. Solitary, colonial, fresh water and marine.

58. What do you know about tissue ?

Sir, Tissue is a collection of cells performing the same function. For example, Testis of ***Hydra*** has number of cells but their function is to produce sperms.

59. What do you know about division of labour in *Hydra* ?

Sir, ***Hydra*** has different tissues performing different functions. For example, Tentacles are meant for feeding, gastrovascular cavity for intracellular digestion. Testes producing sperms, ovary producing ova and nematocyst for capture of prey.

60. Do you find coelom in *Hydra* ?

No Sir, ***Hydra*** has coelenteron or gastrovascular cavity but no coelom.

61. Tell different cells in *Hydra.*

Sir, ***Hydra*** contains ectoderm cells, endoderm cells, epithelio-muscular cells, gland cells, interstitial cells, cnidoblast cells, nerve cells and germ cells in ectoderm. Endoderm contains endothelio muscle cells, gland cells, nerve cells and interstitial cells.

62. What is polyp ?

Sir, Polyp is a feeding zooid.

63. What is medusa?

Sir, Medusa is a reproductive zooid.

64. What do you know about metagenesis ?

Sir, The life-cycle of ***Obelia*** has been considered a case of metagenesis or alternation of generation but no true alternation is there between haploid or diploid stages, hence in ***Obelia*** metagenesis term is not considered true phenomenon.

65. Which coelenterate shows regeneration ?

Sir, It is ***Hydra.***

66. What is common name of *Aurelia* ?

Sir, Common name of ***Aurelia*** is **Jelly fish.**

67. What are different life-cycle stages in *Aurelial ?*

Sir, Different life-cycle stages are **zygote, Planula larva, Scyphistoma larva, Ephyra larva** and **adult.**

68. How will you differentiate between classes Hydrozoa, Scyphozoa and Actinozoa ?

Sir, In hydrozoa both polyp and medusa are present in scyphozoa only medusoid forms exist and actinozoans are exclusively polypoid.

69. What is phenomenon of Polymorphism ?

Sir, The existence of the same animal in different forms or zooids (Poly = many, morpha = forms) is known as Polymorphism.

70. In which group it is best developed ?

Sir, Polymorphism is best developed in **Siphonophores** and the animal showing best illustration of polymorphism is ***Physalia.***

71. Why *Physalia* is called as Portuguese man of war ?

Sir, Like submarines of which suddenly appear or disappear in Portugal, ***Physalia*** can also suddenly come over the surface because air filled float but it can go in deep water by suddenly pushing air through pneumatopore. Therefore, like Portuguese warships behaviour it is commonly called as Portuguese man of war.

72. Name different corals.

Sir, Different corals are ***Tubipora*** (organpipe coral), ***Alcyonium*** (soft coral), ***Astrea*** (stony coral). ***Madrepora*** (brain coral) and ***Fungia*** (Mushroom coral).

PHYLUM-PLATYHELMINTHES

73. What do you mean by platyhelminthes ?
Sir, The name of the Phylum is derived from a Greek word (Platy = Flat, Helminth = worm).

74. Tell diagnostic characters of Phylum. Platyhelminthes ?
Sir, The diagnostic features of Phylum platyhelminthes are as under :
1. **Organ grade animals.**
2. **Acoelomate bilateria** without definitive anus.
3. **Triploblastic** (ectoderm, mesoderm and endoderm). **Mesoderm** has given different **organs.**
4. **Germarium** and **Vitellaria** separate structures.
5. Excretory organs **protonephridia.**
6. Free-living and parasitic. Parasitic ferus cause various diseases.

75. Classify Platyhelminthes.
Sir, Phylum platyhelminthes has been divided into 3 classes :
Class 1. Turbellaria (Planarians)
Class 2. Trematoda (Flukes)
Class 3. Cestoda (Tape worms).

76. How will you distinguish between Turbellaria, Trematoda and Cestoda ?
Sir, Turbellarians are mostly free–living and first bilaterally symmetrical animals called as planarians. Body is covered by ciliated and syncytial epidermis containing rhabdites. Rhabdites are organs of defense and offense. **Trematodes** are called as **Flukes** including **ectoparasites** and large number of **endoparasites.** Body is covered by **Tegument. Cestodes** are called as **Tapeworms,** which include exclusively intestinal **endoparasites.** These parasites have **complete absence of intestine** or **alimentary canal.** Body is covered, by tegument.

77. How tegument of Trematodes differ from tegument of Cestodes ?
Sir, In case of Trematodes, tegument contains scales while in cestodes tegument has **microvilli** called as **micro-stitches.**

78. What special aspects are denoted by Turbellarians ?
Sir, In planarians evolution of genital organs have taken place for the first time. The yolk producing (vitelline glands) and egg producing structures (ovary = germarium) are separate structures—planarians (**Dugesia**) have been extensively used for **regeneration** and **grafting** experiments.

79. Can you name important trematode parasites and diseases caused by them ?
Sir, Out of about more than 75 dozen families only few families show parasitism in man and his animals.
1. ***Fasciola hepatica*** — causing **fascioliasis** in man and his animal.
2. ***Fasciola gigentica*** — **fascioliasis** in sheep.
3. ***Fasciola indica*** — **fascioliasis** in buffalo,
4. ***Fasciola magna*** — **fascioliasis**
5. ***Fasciolopsis buskii*** — fasciolopsis in pig.
6. ***Schistosoma mansonii*** — commonly called as blood.
7. ***Schistosoma haematobium*** — flukes causing **Schistosomiasis.**
8. ***Schistosoma japonicum*** — in man.

80. Tell different life-cycle stages found in *Fasciola hepatica*.
Sir, Various life-cycle stages are **egg. Miracidium larva, sporocyst larva, redia larva, cercaria larva** and **metacercaria larva.** Adult parasites are found in the bile duct of liver of sheep (**definitive host, *Limnea limnea trucatula*** acts as intermediate host containing **sporocyst stage.**

81. What disease liver fluke causes in sheep ?
Sir, In sheep liver fluke causes **anaemia, eosinophilia, diarrhoea,** dysentery, ulcers, pain, bottle jaw disease and **liver rot.**

82. What do you know about Taeniasis disease ?
Sir, Taeniasis is caused by ***Taenia solium***. It is commonly called as Pork Tapeworm. Adults are in the upper part of intestine of man. Another Tapeworm ***Taenia saginata*** is also found in the lower part of intestine of man.

83. Where do you find *Taenia solium* and *Taenia saginata* infections ?
Sir, ***Taenia solium*** is found in pig eating population and ***Taenia saginata*** is found in beef eating population.

84. How the life-cycle of *Taenia solium* is completed ?
Sir, The life-cycle of ***T. solium*** is digenetic—completed in two hosts. Man as definitive host and pig as intermediate host. Eggs or

oncospheres are passed outside the intestine. Human faeces containing onchosphores is eaten by pig and pig becomes infected. Pig contains **Cysticercus larvae**, encysted in muscles. Whenever man eats such port, he becomes infected.

85. What is measly pork ?
Sir, The pig muscles containing encysted **cysticercus larvae** are called as **Measly pork.**

86. What harms are caused by Tapeworm in man ?
Sir, Infection of Tapeworm ***T. solium*** causes diarrhoea, dysentery, abdominal and intestinal pain. Scolex attached with intestinal mucosa causes necrosis of brush border, intestinal villi are destroyed resulting into malabsorption.

87. What is cysticercosis ?
Sir, Whenever cysticercus larvae reach brain they form cyst or nodules causing headache, nervous disorders and epileptic disturbance. The presence of cysticercus larvae in brain is called as **Cysticercosis**. The disease could be detected by ultrasound studies.

88. What do you mean by *Cysticercus cellulose* and *Cysticercus bovis* ?
Sir, The encysted larva in pig is called as ***Cysticercus cellulose*** while that of beef is called as ***Cysticercus bovis***.

89. What is Dwarf Tapeworm ?
Sir, ***Echinococcus granulosus*** is called as dwarf tapeworm.

90. What is structure of *E. granulosus* ?
Sir, ***E. granulosus*** contains scolex with suckers and hook, neck, immature segment, mature segment and only one gravid segment.

91. What is hydatid worm ?
Sir, ***E. granulosus*** is called as **hydatid worm** because its infective stage causes hydatid formation in man.

92. Describe briefly life-cycle of *E. granulosus* ?
Sir, The infection is maintained in two hosts. Dog as definitive host harbouring adult hydatid worms (***E. granulosus***) and man or sheep intermediate hosts. Man becomes infected by eating contaminated oncospheres through food stuffs or through contaminated water. Man is **dead end intermediate host**. When dog eats offal (post-mortem) muscles of contaminated of sheep, then it becomes infected.

93. What is hydatidiasis ?
Sir, The encysted stages of ***E. granulosus*** **broad capsules** in liver of man is called as **hydatidiasis**.

94. What do you know about parasitic adaptations ?
Sir, Parasitic adaptations consists of 3 kinds of adaptations (1) **Morphological**, (2) **Physiological** and (3) **life- cycle stages.**

95. What do you know about morphological adaptations in parasites ?
Sir, Morphological adaptations are as under :
1. **Attachment organs :** Adhesive organs like suckers and spines and hooks as found in scolex of ***Taenia solium*** and acetabulum or ventral suckers in ***Fasciola hepatica***.
2. Shape in leaf like in ***Fasciola*** and ribbon like in Tapeworms.
3. Outer covering **Tegument** is found in trematode and cestodes.
4. Genital organs are such which give rise to large number of eggs.

96. What do you know about physiological adaptations ?
Sir, The parasites are adapted to adjust in different organs of the host. For instance ***Taenia solium*** occupies coils of the intestine and nutrition is absorbed through the general surface of the body. Leaf like body of ***Fasciola hepatica*** fits into bile ducts and biliary passages in liver. Digestion in parasites is intracellular. **Respiration** is **anaerobic**.

97. What do you know about anaerobic respiration ?
Sir, All the inter and intracellular parasites have anaerobic respiration, i.e. in the absence of free-oxygen. The parasites depends on the oxygen available in the cells and tissues.

98. What is the most peculiar aspect of parasite ?
Sir, The parasites are best animals evolved so far because they are so perfect and meticulous in their life and life-cycle that they have not faced extinction so far. Since their evolution the eukaryotic parasites are successfully continuing their genetic population. Adaptability is most peculiar aspect of the parasites.

99. What is parasitism ?
Sir, According to Cheng (1987) parasitism is defined as "an intimate and obligatory

relationship between two heterospecific organisms during which the parasite, the smaller of the two is metabolically dependent on the host". Besides, metabolic dependency parasite also induces immunological response in the host.

100. What do you mean by prokaryotic and eukaryotic parasites ?

Sir, Prokaryotic parasites are those in which nucleus is without nuclear membrane and eukaryotic parasites in which nucleus has nuclear membrane.

101. What are microparasites ?

Sir, All the viruses, bacteria and protozoans are microparasites because they can only be seen through the microscope. For example, cow pox virus, typhoid virus, influenza virus, **herpes virus, hepatitis virus**, etc. Bacterial diseases comprise all the cocci infections like **cholera, tuberculosis, leprosy**, etc.

102. What are macroparasites ?

Sir, Macroparasites are larger parasites which could be seen by naked eye such as ***Ascaris lumbricoides***, ***Fasciola hepatica***, ***Taenia solium***. Although among macroparasites these are smaller parasites like plant nematodes. Pinworms and larval stages which could be seen through microscope for their structures although, they are also visible through the naked eyes.

103. What is commensalism ?

Sir, Eating on same table by different persons is known as commensalism. In this kind of association all the associates are benefited by each other. But there is no metabolic dependency and there is also no morphological, physiological and organic relationship between associates. For example,

1. Sea anaemone and mollusc shell.
2. Sea anaemone and clownfish (Kentocapros). Both sea anemone and clownfish share their food and fish is protected by enemies by nematocysts. Fishes protect from nematocysts by secreting a layer of mucous around them.

104. What is phoresis ?

Sir, Term phoresis means to carry. No physical relationship or metabolic dependency is involved. For example, carrying of bacteria on the legs of housefly.

105. What is mutualism or symbiosis ?

Sir, In this kind of association the mutualist or symbiont and the host are metabolically dependent and they both benefit each other. For example, intestinal flora, i.e. ***Escherichia coli*** and intestinal lumen. ***E. coli*** derives nutrition from the host and in turn produces certain molecules (enzymes and vitamins), beneficial to the host. Classic example of mutualism is those of **lichens** representing a certain species of algae and fungi. Alga produces certain organic compounds which is used by fungus. Fungus in turn provides Alga mineral water and protection. Another classic example is those of flagellate protozoans in the gut of **woodroaches** and termites. Woodroaches zoologically known as ***Gyptocercus punctuatus*** provide wood chips to flagellate protozoans, because they entirely depend on carbohydrate diets, while in turn flagellates synthesize cellulose enzyme in excess to be used by woodroaches in their digestion of cellulose.

106. What is facultative parasite ?

Sir, A parasite does not depend on parasite way of life but it can adapt parasitic life is called as facultative parasite.

107. What is obligatory parasite ?

Sir, A parasite completely depending on its host is called as obligate parasite.

108. What is incidental parasite ?

Sir, If an organism accidentally infects unnatural host, then it is called as : **Incidental parasite.**

109. What is erratic parasite ?

Sir, A parasite living in another organs in which it is not found is called as **erratic parasite**.

110. What is sporadic parasite ?

Sir, An organism visiting its host intermittently for its some metabolic requirements is called as **sporadic parasite**.

111. What is ectoparasite ?

Sir, When parasite living outside the body of the host on surface. For example, ***Pediculus humonia***.

112. What is endoparasite ?

Sir, When parasite living inside the body of the host.

113. What is pathogenic parasite ?
Sir, When a parasite causes disease and clinical symptoms, then it is called as **pathogenic parasite**.

114. What is definitive host ?
In definitive host parasites sexually reproduce and adult parasite live in it.

115. What is intermediate host ?
Sir, The host in which part of life-cycle of the parasite take place.

116. Enumerate diagnostic characters of Phylum Nemathelminthes ?
Sir, Phylum nemathelminthes are characterized by following characters :
1. Pseudocoelomate round worms.
2. Body covered by tough transversally striated outside.
3. Radially symmetrical.
4. Unisexual but sexual dimorphism exhibited by posterior region only.
5. Free-living, plant parasitic and zooparasitic. Free living forms may be terrestrial, fresh water or marine nematodes.

117. Give the names of five nematode parasites and diseases caused by them ?
Sir, Following nematodes cause diseases in man :
1. ***Ascaris lumbricoides*** - Ascariasis in man.
2. ***Wuchereria bancroftii*** causing Elephantiasis in man.
3. ***Ancylostoma duodenale*** causing **Ancylastomiasis** in man.
4. ***Dracunculus medinensis*** causing **Dracunculiasis** in man.
5. ***Trichiuris trichura*** causing **Trichuriasis** in man.

118. How infection ascariasis occurs in man?
Sir, Man becomes infected by eating contaminated vegetables (vegetables containing infective eggs) or contaminated water (water containing infective eggs of ***Ascaris lumbricoides***). **Mode of infection is oral.**

119. Which one is first animal parasite to be discovered ?
Sir, It is ***Dracunculus medinensis.***

120. Enumerate certain plant nematodes ?
Sir, ***Meloidogyne*** is found in tomato, ***Anguina tritici*** in wheat, ***Heterodera*** in potato and ***Pratylenchus*** in wheat and maize. ***Anguina tritici*** found in wheat plant is the first plant parasitic nematode to be discovered.

PHYLUM-ANNELIDA

121. Enumerate the diagnostic characters of Phylum Annelida.
Sir, Annelids are distinguished by following features :
1. Truely coelomate and **metamerically** segmented.
2. **Triploblastic** and body covered with thin cuticle.
3. Coelom **Schizocoelus**.
4. Excretory organs **metanephridia**.
5. **Hermaphroditic, larva** is **Trochophore**.

122. What is metameric segmentation ?
Sir, Serial repetition of body parts is known as metameric segmentation. For example, each segment of earthworm contains parts of nephridia, blood vessels, nerve ganglion and setae, etc.

123. What is metanephrid ?
Sir, Open nephridia which open in coelom. As septal nephridia by its nephrostome opens in coelom.

124. What are clam worm and sea mouse ?
Sir, ***Nereis*** and ***Aphrodite*** are called as **clam worm** and **sea mouse** respectively.

125. What is botryoidal tissue and where it is found ?
Sir, In case of leeches, the coelom or body cavity is reduced and filled with a spongy tissue called as **Botryoidal** tissues. The coelom is reduced to four haemocoelomic channels (dorsal, ventral and 2 laterals).

126. Which annelid is ectoparasite ?
Sir, Leeches (***Hirudu medicinalii***) and (***Hirudinaria granulosa***) are ectoparasitic leeches.

127. Which annelida is most modified ?
Sir, ***Chaetopterus*** is highly modified **Tubicolous** animal.

128. What is importance of earthworms ?
Sir, Earthworms have following 3 significances and importance :
1. Earthworms have agricultural importance. They make soil fertile.

2. They have great educational importance as they are used to study invertebrate anatomy.
3. They are used as bait for catching fishes by fish catchers.

PHYLUM - MOLLUSCA

129. Give diagnostic features of Phylum Mollusca.
Sir, Phylum mollusca is characterized by following features :
1. Shell, mantle, visceral mass and foot present.
2. Circulatory system open.
3. Unsegmented except monolacophora.

130. What is Elephant's Tusk shell ?
Sir, ***Dentalium*** having shape of tusk of elephant is called as Elephant's tusk-shell.

131. Which is slowest moving animal ?
Sir, ***Pila globosa*** **(Apple snail)** is the slowest moving animal.

132. What is Torsion ?
Sir, Gastropod molluscs exhibit phenomenon of torsion. According to Garstang's hypothesis (1928), torsion is twisting of the internal organs and nervous system through 180°.

133. What is the advantage of twisting ?
Sir, By twisting the pallial complex (head, tentacles and eyes) are able to withdraw inside the body in times of danger and cover the internal structure by operculum.

134. What is zoological name of the pearl oyster ?
Sir, ***Pinctata vulgaris.***

135. What is Sepia Ink ?
Sir, Sepia, a cephalopod mollusc secretes rather ejects blue colour secretion when irritated. The secretion is called as Sepia ink. The secreted ink defends the animal.

136. What is devil fish?
Sir, Octopus is called as devil fish.

PHYLUM–ARTHROPODA

137. What is parasitic castration?
Sir, A parasitic crustacean called as **Root headed barnacle** or ***Sacculina*** infects another crustacean crab. ***Sacculina*** sends root like processes into the body of the crab destroying host's sex organs and the crab is unable to reproduce. This phenomenon is called as **parasitic castration.**

138. Which crustacean leads commensale life ?
Sir, ***Eupagurus*** (Hermit crab). The crab occupies coils of the gastropod mollusc-shell. It undergoes modification. It protrudes its walking legs. It moves carrying molluscs shell.

139. What are peculiar features of peripatus ?
Sir, Peripatus has few peculiar features : (1) It is called as living fossil. (2) It has annelidan and arthropodan characters. **Annelidan** characters include dermo-muscular body wall, simple eyes and unjointed stumpy appendages. Arthropodan features include antennae, chitin in cuticle, haemocoel, trachae and salivary glands like arthropods. (3) It is said to be connecting link between Annelida and Arthropoda.

140. Why limulus is called as king crab?
Sir, Because of its majestic look, it is called king crab.

141. What is common name of *Lepisma*?
Sir, It is **silver fish.** It destroys books and papers.

142. What are different life-history stages of honey bee?
Sir, Different life-history stages in honey bee are **queen, worker, drone, larva, pupa,** and egg ?

143. What is zoological name of silk worm?
Sir, It is **Bombyx morii.**

144. Name the useful products derived through insects.
Sir, Honey, lac, and silk.

PHYLUM–ECHINODERMATA

145. What is most peculiar features of Echinoderm ?
Sir, Echinoderms have **mesodermal calcareous endoskeleton.**

146. Why echinoderms are at the top of invertebrates even if they do not have head ?
Sir, Since echinoderms have calcareous endoskeleton hence they are at the top of invertebrates because no other invertebrate has endoskeleton.

147. Tell different larval stages of Echinoderms?
Sir, Different larval stages are **Bipinnaria larva, Brachiolaria larva, Cystidean larva, Pentacrinoid larva, Doliolaria larva, Ophiopluteus larva** and **Echinopluteus larva.**

EXPERIMENTAL CYTOLOGY

148. Which is smallest cell ?
Sir, ***Mycoplasma gallisepticum.***

149. How will you differentiate between prokaryotic and eukaryotic cells ?
Sir, In prokaryotic cells nucleus and nuclear membrane are absent while in eukaryotic cells distinct nucleus with nuclear membrane present.

150. What are different cell organelles ?
Sir, **Plasma membrane, mitochondria, endoplasmic reticulum, ribosomes, nucleus, nucleolus, Golgi body** and **lysosomes** etc. are different cell organelles.

151. By which methods chromosomes can be studied ?
Sir, The chromosomes can be studied by **squash method** and by **heat dry Giemsa method.** Heat dry Giemsa method is better for animal chromosomes.

152. From which animal tissues can you study chromosomes ?
Sir, Chromosomes could be studied from **testis of frog, grasshopper**, ***Gryllus*** and ***Ascaris*** and ***Ascaridia galli.***

153. What are different stages in Mitosis?
Sir, Different stages in mitosis are **interphase, prophase, metaphase, anaphase** and **telophase.**

154. How will you recognize metaphase stage ?
Sir, In metaphase chromosomes are arranged at the **equatorial plate.**

155. In anaphase stage how can you divide chromosomes on the basis of position of centromere?
Sir, Depending on the position of centromeres chromosomes may be **Metacentric, Sub-metacentric** and **Acrocentric**, i.e. they may be **V-sbapcd, J-shaped** or **I-shaped.**

156. What are two stages in Meiosis ?
Sir, The two stages are (1) first meiotic division or **reduction** division, and (2) second meiotic division or **mitotic** division.

157. What are various stages of first meiotic divisions ?
Sir, Various stages of first meiotic divisions are :
(1) Interphase and (2) First prophase.

(A) First prophase consists of following stages:
1. **Leptotene** or **Leptonema** — Interwoven thread like chromosomes.
2. **Zygotene** or **Zygonema** — Pairing of homologous chromosomes.
3. **Pachytene** or **Pachynema** — Chromosome become tetrad, bivalents, condensed, shortened and coiled, crossing over takes place at thin stage.
4. **Diplotene (diplonema)** — Separation of homologous chromosomes take place and chromosomes move towards ends called terminilization.
5. **Dikinesis** - Chromosomes undergo further contraction.

(B) First metaphase — Bivalent chromosomes appear at equatorial plate. Nuclear membrane disappears.

(C) First anaphase — The sister chromatids separate and go to same pole and it is called as reduction division. After anaphase I each pole has haploid number of chromosomes.

(D) First telophase and **interphase** - During this stage nuclear membranes are formed around chromosomes. First telophase is followed by second meiotic division.

(E) Second meiotic division - It includes following stages :
Second prophase — Chromosomes become already double.
Second metaphase — Chromosomes arrange along equator.
Second anaphase — Chromatids separate and chromosomes reach at poles.
Second telophase and cytokinesis - In which four haploid cells are formed.

EXPERIMENTAL ECOLOGY

158. Give names of certain animals which show ecological modifications or adaptations.
Sir, ***Chaetopterus***, **blood flukes,** ***Taenia solium.*** **hermit crab** and **sea anemone,** ***Exocoetus***, ***Draco*** and bat show different modifications according to their mode of living.

159. What do know about biotic factors ?
Sir, Biotic factors include **autotrophs, heterotrophs, producers** and **consumers.**

160. What are abiotic factors ?
Sir, These factors include : (a) **Inorganic substances** like chlorides, sulphates, phosphorus, sulphur, nitrogen and hydrogen, etc. (b) **Organic substances** — Such as carbohydrates, proteins and lipids. (c) Climatic condition such as rains, temperature, light, humidity, pH value and moisture.

BIOSTATISTICS

161. What do you mean by application of statistics in biological sciences ?
Sir, All the data work such as population dynamics, length and breadth of animals are statistically analysed to know whether the data is significant or insignificant.

162. What test you apply to analyse the data?
Sir, Students t-test, Chi-square (χ^2) test and Anova-two way test.

163. What is arithmatic mean ?
Sir, Arithmatic mean is the average obtained by dividing the sum of values of a series of items divided by their number.

164. What is median ?
Sir, If observations in a population or sample are arranged in order of magnitude from smallest to largest represented by y(l), y(2), ... y(n), the bracketed figures show that are arranged in order. The middle value (when n = odd number) gives the median value.

165. What is mode ?
Sir, Mode is that observation which occurs most frequently.

166. What is range ?
Sir, The range of a distribution signifies difference between the highest and lowest values of the variables.

167. What is standard deviation ?
Sir, The standard deviation is actually a square root of the mean squared deviation and also called as root mean squared deviation.

168. Can you enumerate basic discoveries based on the work with invertebrates ?
Sir, The following discoveries are based on invertebrates :

1. Word **cancer** come from crab (as crab grasps his prey till it dies, similarly cancer kills the patient).
2. **Neoplasia** has its origin in hydrozoan colonies.
3. One cannot conceive the idea of genetics without ***Drosophila.***
4. **Muscle nerve interaction** cannot be complete without understanding axons of squids.
5. Developmental biology originated from the experiments done on sea urchin eggs.

169. Can you enumerate some estimated species in different groups.
Sir, Some estimated number of species and species living are as under :

Group	No. of species	Species living
1. Mesozoa	85	500
2. Ctenophora	80	130-500
3. Gnathostomula	80	1000
4. Gastrotrichia	450	1000
5. Rotifera	1800	2500-3000
6. Kinorhyncha	125	500
7. Priopulida	10	15, 25
8. Nematoda	10,00,000	?
9. Nemertinsa	800	3000 +
10. Pogonophora	120	500
11. Sipuncula	320	330
12. Tardigrade	550	1000 +
13. Echiura	130	140
14. Insecta	—	10,000,000
15. Crustacea	75,000	90,000
16. Phoronida	13	20
17. Brachiopoda	330	400-500
18. Hemichordata	100	150 +

170. Tell us the classification in which animals and other organisms have been divided into 5 kingdoms ?

Sir, Whittaker (1969) divided whole organisms into FIVE Kingdoms :

1. **Monera** – Prokaryotic organisms without organized nucleus – Bacteria, blue green algae, viruses.
2. **Protista** – Unicellular eukaryotic organisms – with organized nucleus Never beyond unicellular organisations -include **Protozoans**, **Protophytons** and **Protofungii.**
3. **Plantae** – Multicellular organisms with cellulose in cell wall – Photosynthesizing, organisms with photoautotrophic nutrition.
4. **Fungi** – Multicellular organisms with cell having chitin – Nourishment derivation by chemical breakdown of materials.
5. **Animalae** – Multicellular organisms without cellulose with heterotrophis nutrition.

171. Give recent most characters of each invertebrates phyls ?

Sir, The characters are as under :

1. **PROTOZOA** – Unicellular eukaryotes with different cell organelles for different functions.
2. **PORIFERA** – Cellular grade – Multicellular and multinucleate syncytial forms - Body pierced by pore.
3. **COELENTERATA = (CNIDARIA)** Tissue grade, radial, biradial or radiobilateral with oral aboral axis.
4. **PLATYHELMINTHES** – Acoelomate bilateria without definition anus and with little cephalizaion.
5. **NEMATHELMINTHES** Pseudocoelomate, spindle shaped with radial symmetry.
6. **ANNELIDA** – Truely coelomate and metamerically segmented.
7. **MOLLUSCA** – Fully cephalized with outer shell and mantle-shell for protection.
8. **ARTHROPODA**– Bilaterally symmetrical, segmented and equipped with jointed appendages.
9. **ECHINODERMATA** – Spinny skinned, uncephalized, radially or biradially symmetrical animals with as **oral aboral** axis and with mesodermal endoskcleton.

172. Give the names of authors and books by foreign authors in Zoology.

Sir, The authors and books are as under :

1. Parker and Haswell – Vol. I-Invertebrates Vol. II – Vertebrates.
2. Paul A. Meglitsch – Invertebrate Zoology.
3. Cleon Harn – Concepts in Zoology.
4. Storer and Usinger – General Zoology.
5. Sedgwick – Vol. I – Protozoa – Annelid and Minor phyla.
   Vol. II – Chordata.
   Vol. Ill —
   Arthropoda, Crustacea and Xiphosura.
6. Elliot – Zoology.
7. Hyman —
   Vol. I – Protozoa through Ctenophora. Vol. II – Platyhelminthes and Rhyncocoela.
   Vol. III – Acanthocephala, Aschelminthes and Rhyncho Entoprota. Vol. IV - Echinodermata. Vol. V – Smaller Coelomate groups. Vol. VI – Mollusca.
8. Barner – Invertebrate Zoology.
9. Carter, G. S. – General Zoology of Invertebrates.
10. Hegner, R.W. and Engenmann, J.G. – Invertebrate Zoology.
11. Boradaile, L.A., Potts. F.A. Invertebrates.
12. Russel-Hunter, W.D. – A Biology of Lower Invertebrates.
13. Russel-Hunter, W.D. – A Biology of Higher Invertebrates.

173. Tell us the Indian Zoological memoirs written so far ?

Sir, These memoirs are as under :

1. K.N. Bahl – ***Pheretima.***
2. M.L. Bhatia – ***Leech.***
3. Beni Prasad – ***Pila.***
4. S.M. Das – ***Herdmania.***

174. Tell the name of nematode whose complete genome has been worked out.

Sir, *Caenorhabdits elegems.*

175. Which invertebrate phylum has potential to evolve into a new group of animal?

Sir, Echinodermata when ever bilaterally symmetrical echinoderm larvae get suitable environment to develope into bilateral adult, they would evolve into new gorup of animals.