

A note book for the elements of the comparative anatomy of invertebrates.

Contributors

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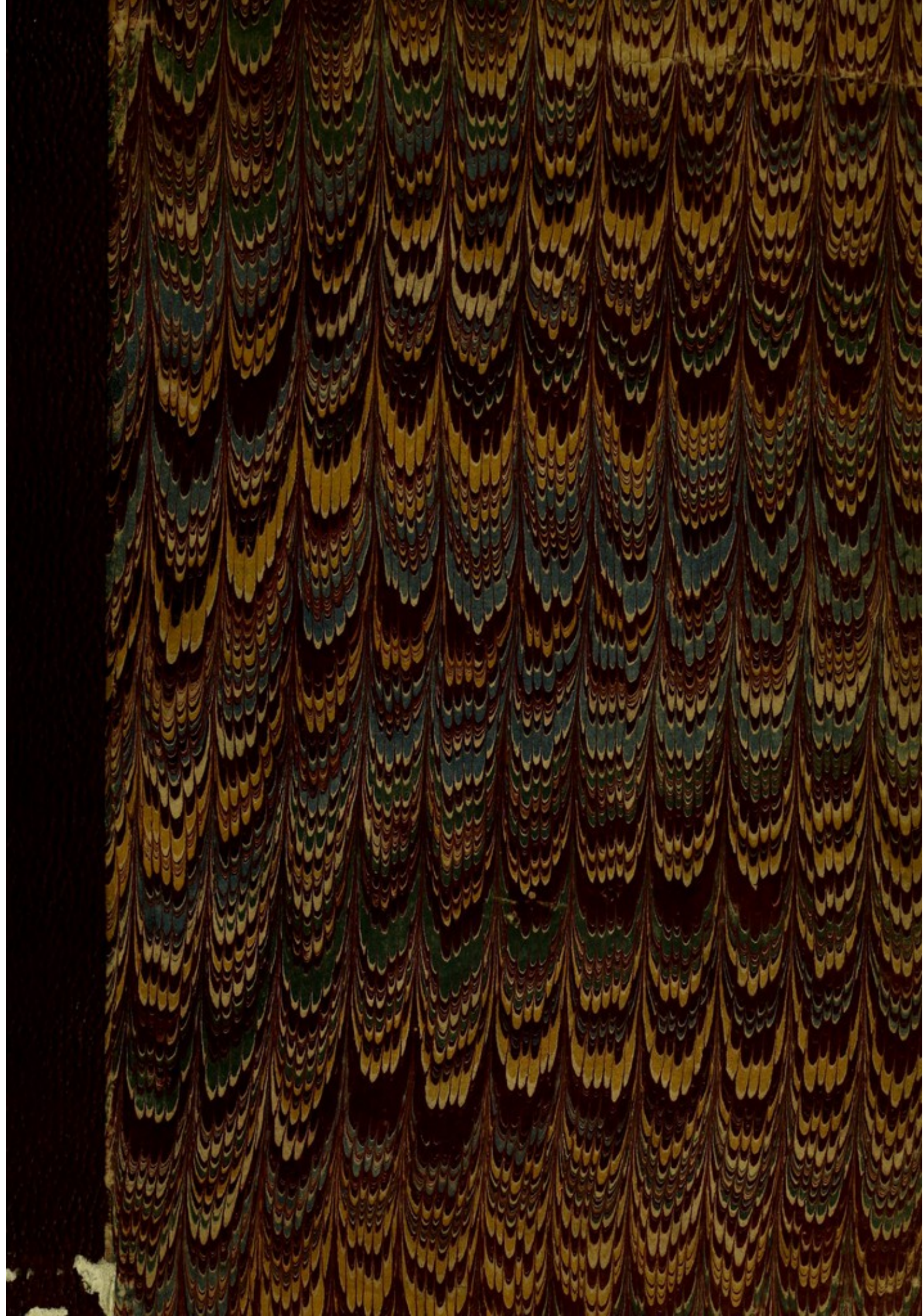
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A NOTE BOOK
FOR THE
ELEMENTS OF THE COMPARATIVE
ANATOMY OF INVERTEBRATES

FOURTH EDITION

EDITED BY

DR A. E. SHIPLEY

AND

MR F. A. POTTS

CAMBRIDGE

PRINTED AT THE UNIVERSITY PRESS

1911

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TABLE OF CONTENTS AND CLASSIFICATION
OF INVERTEBRATA.

		PAGE
INTRODUCTION		v
LABORATORY METHODS		vii
PROTOZOA		1-11
I. RHIZOPODA.	1. Amoebina. <i>Amoeba, Arcella, Diffugia</i>	1
	2. Foraminifera. <i>Polystomella</i>	2
	3. Heliozoa. <i>Actinosphærium, Actinophrys</i>	3
	4. Radiolaria	4
	5. Mycetozoa	4
II. MASTIGOPHORA.	1. Flagellata. <i>Polytoma, Euglena, Volvox</i>	5, 6
	2. Dinoflagellata	
	3. Cystoflagellata	
III. SPOROZOA.	1. Gregarinida. <i>Monocystis, Clepsidrina</i>	7, 8
	2. Coccidia	
	3. Hæmosporidia	
IV. CILIOPHORA.	1. Ciliata. <i>Paramæcium, Opalina, Nyctotherus, Balantidium, Vorticella</i>	9
	2. Suctoria	
CŒLEENTERATA		12-24
I. HYDROZOA.	1. Hydrida. <i>Hydra</i>	
	2. Hydromedusæ. (i) <i>Calyptoblastea (Leptomedusæ). Obelia, Sertularia, Antennularia</i>	12, 13
	(ii) <i>Gymnoblastea (Anthomedusæ). Pennaria, Tubularia, Lizzia, Geryonia</i>	13-16
	3. Siphonophora	17
II. ACALEPHÆ.	1. Aurelia	18, 19
III. ACTINOZOA.	1. Alcyonaria. <i>Alcyonium</i>	20, 21
	2. Zoantharia. <i>Peachia</i>	22, 23
IV. CTENOPHORA		24
ANNELIDA		25-31
I. POLYCHÆTA. <i>Nereis, Arenicola</i>		25-27
II. OLIGOCHÆTA.	1. Terricolæ. <i>Lumbricus</i>	
	2. Limicolæ. <i>Nais</i>	
III. HIRUDINEA. <i>Hirudo</i>		29-31
ARTHROPODA		32-59
I. CRUSTACEA.	1. Trilobita	
	2. Phyllopoda. <i>Apus, Daphnia</i>	32, 33
	3. Ostracoda	
	4. Copepoda. <i>Cyclops</i>	34
	5. Cirripedia. <i>Lepas</i>	35
	6. Leptostraca. <i>Nebalia</i>	
	7. Eumalacostraca. (i) Amphipoda. <i>Gammarus</i>	37
	(ii) Isopoda. <i>Asellus</i>	38
	(iii) Decapoda. <i>Astacus, Carcinus</i>	39

	PAGE
II. ONYCHOPHORA. <i>Peripatus</i>	42
III. MYRIAPODA. 1. Diplopoda. <i>Julus</i>	43
2. Chilopoda. <i>Lithobius</i>	43
IV. INSECTA	44-56
1. Aptera (spring-tails, silver-fish)	
2. Orthoptera (earwig, cockroach, stick and leaf insects, locusts, crickets). <i>Periplaneta</i>	44-49
3. Termitidæ (white "ants")	
4. Ephemeroidea (may-flies)	
5. Odonata (dragon-flies)	
6. Neuroptera (lacewings, antlions)	
7. Trichoptera (caddis-flies)	
8. Lepidoptera (butterflies and moths)	51, 52
9. Coleoptera (beetles)	
10. Hymenoptera (ants, bees, sawflies, etc.)	51
11. Diptera (flies)	50
12. Hemiptera (bugs)	50
V. ARACHNIDA. 1. Scorpionidea (Scorpions)	57
2. Xiphosura. <i>Limulus</i> (The King Crab)	58
3. Araneida. (Spiders)	59
4. Acari. (Mites)	59
MOLLUSCA	60-84
I. GASTROPODA. 1. Isopleura. <i>Chiton</i>	65
2. Anisopleura. (i) Streptoneura. <i>Haliotis, Patella, Buccinum</i>	66, 67
(ii) Euthyneura. a. Opisthobranchiata. <i>Aplysia, Doris, Eolis</i>	68
b. Pulmonata. <i>Helix</i>	60-64
II. LAMELLIBRANCHIATA. 1. Protobranchiata. <i>Nucula</i>	74
2. Filibranchiata. <i>Mytilus, Pecten</i>	74, 75
3. Eulamellibranchiata. <i>Anodonta</i>	69-73
III. CEPHALOPODA. 1. Dibranchiata. (i) Decapoda. <i>Sepia</i>	77-82
(ii) Octopoda	
2. Tetrabranchiata. <i>Nautilus</i>	84
ECHINODERMATA	85-91
I. ASTEROIDEA. <i>Asterias, Solaster</i>	85-87
II. ECHINOIDEA. <i>Echinus</i>	88
III. OPHIUROIDEA	
IV. HOLOTHUROIDEA	
V. CRINOIDEA	
TUNICATA. <i>Ciona</i>	92-95
HEMICHORDATA. <i>Balanoglossus</i>	96
PLATYHELMINTHES	97-103
I. TURBELLARIA. <i>Dendrocalum</i>	97, 98
II. TREMATODA. <i>Distoma</i>	99, 100
III. CESTODA. <i>Tenia</i>	101-103
NEMATODA. <i>Ascaris</i>	104-106

INTRODUCTION.

AN Elementary Notebook for the practical study of Invertebrates must necessarily be incomplete in many of its details. Some whole Phyla of the specialised organisms have to be omitted, such as Polyzoa, Brachiopoda, etc. Within Phyla many classes cannot be mentioned. Thus, of 22 orders of Insects given by Professor Adam Sedgwick in his "Students Textbook of Zoology," only 12 are enumerated. Indeed, we have to restrict ourselves to the more dominant and conspicuous forms of life on the globe, to such other forms as are of high theoretical importance in considering the question of evolution, and, lastly, to such forms as affect man himself, by being parasitic. Organisms included in the *Biology Notebook* are omitted.

In each sub-division of animals so far as possible one or two examples are studied. Most of these have to be examined from preserved specimens. The anatomy has to be studied, but it is essential that the student should consider where and how each organism lives, and how its anatomy is adapted to that mode of life. In examining each organism the external features should be carefully studied, the hand-lens and the microscope being freely used.

Drawings, in the first instance, should be sketched lightly in pencil to admit of corrections. These outlines may then be rendered more permanent. Shading, as a rule, is inadvisable; colours are valuable, but should be used with judgement. The left-hand pages in the Notebook are left blank. They may be used for additional drawings of and notes on demonstration specimens, etc., but places will be found in the Notebook for many of the latter.

The demonstration specimens placed out from time to time should be carefully examined. Students should visit the Museum and make themselves further acquainted with the variety of organisms found in the different Phyla.

This is the Fourth Edition of the Laboratory Notebook, the three former having been prepared under the direction of Professor Adam Sedgwick, formerly Lecturer, Reader, and Professor of Zoology in the University.

J. STANLEY GARDINER.

ZOOLOGICAL LABORATORY,
CAMBRIDGE,
August, 1911.



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LABORATORY METHODS FOR THE PREPARATION OF MICROSCOPIC SPECIMENS.

1. Fixation. The living tissues of an animal must be killed as quickly as possible by some *fixative agent* in order that their natural form shall be preserved without distortion and that the protoplasm shall behave properly with stains. The best general fixative agent is a saturated solution of *corrosive sublimate* in water, with 5 per cent. of *acetic acid* added to increase the power of penetration. For animals of small bulk 3—5 minutes in such a solution is sufficient: for larger objects which are intended to be cut in section (e.g. embryos of rabbit, etc.) 10—15 minutes should be allowed. After this period of fixation the specimen must be thoroughly washed in water [changed several times] to remove the excess of sublimate which would otherwise interfere with the action of stains.

For Protozoa a solution of $\frac{1}{4}$ per cent. *osmic acid* is best, fixation being effected on the slide under control of the microscope. The animal should not remain for more than 1 minute in contact with this reagent, which should be drawn off with blotting paper, a drop of water being placed on the far side of the coverslip.

Another method for staining and mounting Protozoa and other delicate organisms is to keep them in the one watch-glass until they reach the glycerine or the oil of cloves, after being treated with the various fluids as given subsequently. The separate reagents should be drawn from the watch-glass with a fine pipette, leaving the specimens at the bottom of the watch-glass each time. This prevents a considerable amount of damage being done to small and delicate organisms.

In examining many living Protozoa the method adopted is to transfer the living animal from the watch-glass by means of a fine pipette on to a slide; then to use a small piece of paper or a piece of thin glass to support the coverslip, thus preventing the compression of the specimen by the coverslip.

2. Staining. Two of the most convenient and reliable stains are picrocarmine and boraxcarmine. Of other stains the uses of paracarmine, hæmatoxylin and picric acid should be subsequently mastered.

Picrocarmine is dissolved in water, so that as soon as the animal has been washed after fixation, it may be placed in the stain. Here it should remain for 5—15 minutes according to size, being then thoroughly washed in water to remove the excess of stain.

Boraxcarmine is dissolved in 50 per cent. alcohol so that it is employed when the specimen is to be permanently mounted in canada balsam. It should stay in the stain from 15—20 minutes and must then be washed in 70 per cent. alcohol with a few drops of nitric acid (acid alcohol).

Both these stains combine especially with the *nucleus* of the animal cell so that when the excess stain has been removed by washing there is a strong contrast between the deeply stained *nucleus* and the lightly stained *cytoplasm*. A certain class of stains like *eosin* colour the cytoplasm and do not combine with the nucleus, so that double staining e.g. with boraxcarmine and eosin still further emphasises the distinction between nucleus and cytoplasm.

Paracarmine is dissolved in 70 per cent. alcohol and is used extensively for small animals and larvae. Such objects should not have an alkaline reaction nor contain carbonate of lime. The method is similar to that described for boraxcarmine.

Hæmatoxylin is a powerful nuclear and a selective plasma stain dissolved in about 25 per cent. alcohol. It may be diluted with 50 per cent. alcohol. It is used instead of boraxcarmine, and in the same way, giving a blue colouration. The object must be washed with acid alcohol for 1—2 minutes to remove the superfluous stain. It should then be washed in 70 per cent. alcohol.

Picric acid dissolved in alcohol or water is useful for staining chitin (the exoskeleton of Crustacea etc.). It may be used for suitable objects after any of the carmine stains.

3. Mounting in Glycerine. Specimens stained in picrocarmine can, after washing with water, be transferred at once to dilute glycerine and a few minutes afterwards to a drop of pure glycerine on a slide. Care must be taken that too much glycerine is not used. The coverslip is prevented from slipping on the slide by painting a solution of *gold size* in xylol round the edges of the coverslip. With the evaporation of the xylol the gold size hardens. Only animals or tissues of slight thickness should be mounted in glycerine, for the reagent clears slowly. It must however always be used when the preparation is intended to show objects of high refractive index like spicules or setæ.

4. Mounting in Canada Balsam. This is the more permanent method of mounting. It entails the removal of all water from the specimen by passing it through a series of alcohols of graduated strength. In the case of a small object which has already been fixed but not stained, *dehydration* may be effected by passing the following succession of fluids into the watch glass :

30	per cent.	alcohol	3	minutes.
50	”	”	”	”
70	”	”	5	minutes.
90	”	”	5	minutes.
		Absolute alcohol	5	minutes.

The still opaque object is then treated with *oil of cloves* as a *clearing agent*, in which it remains till it is entirely transparent. If dehydration is not complete, a milky precipitate is formed in the oil of cloves and the specimen should be returned to absolute alcohol for a few minutes.

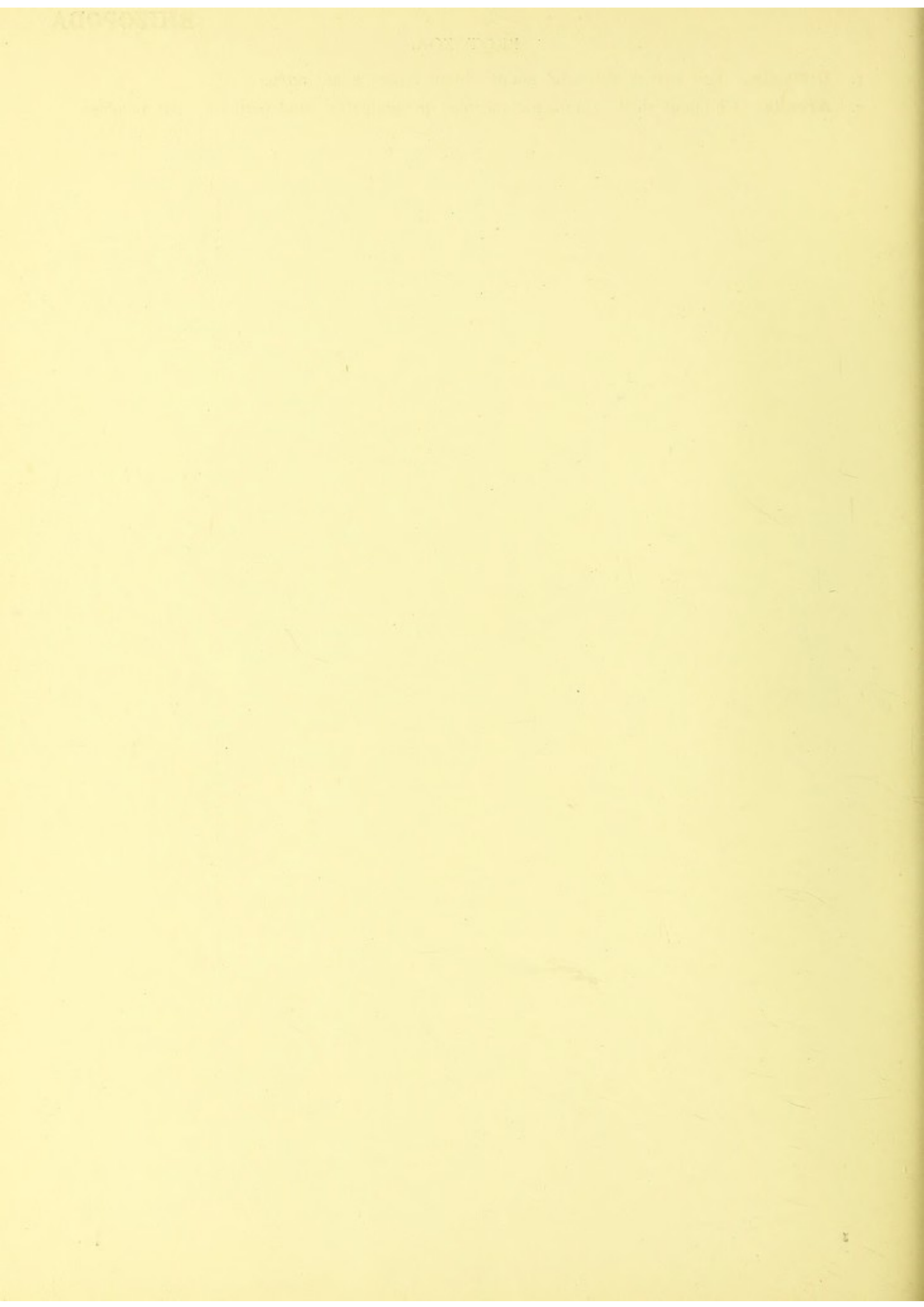
From oil of cloves the specimen may be transferred to a drop of *Canada balsam* on a slide and a coverslip then placed on top. The balsam is dissolved in xylol and, as this solvent evaporates, sets hard so that the coverslip remains permanently fixed without employing gold size. The process of evaporation can be accelerated by leaving the slide on a hotwater-bath for a day.

PROTOZOA.

1. **Diffugia.** Test coated with sand grains: blunt forked pseudopodia.
2. **Arcella.** Chitinous shell; contractile vacuole; pseudopodia; food particles; gas vacuoles.

ADOPTEE

ADOPTEE



3. **Polystomella.** Examine (*a*) alive in watch-glass, to see the external protoplasm and the pseudopodia, (*b*) transferred to slide using the high power of the microscope. Then kill with osmic acid, decalcify in 5 p.c. acetic acid, stain with picocarmine and mount permanently, to see nuclei and cell-chambers.

4. Shells of Foraminifera. Calcareous.

5. **Actinosphærium.** (*a*) Examine floating in water in watch-glass. Low power. (*b*) Mount on slide, supporting coverslip by two narrow strips of gummed paper. High power. (*c*) Kill with osmic acid and stain with picocarmine to show nuclei. Ectoplasm; endoplasm; pseudopodia; contractile vacuole; axes of pseudopodia; granular cortex of pseudopodia; vacuoles of ectoplasm; food balls in endoplasm.

6. Demonstration specimen of **Actinophrys** to show the single nucleus.

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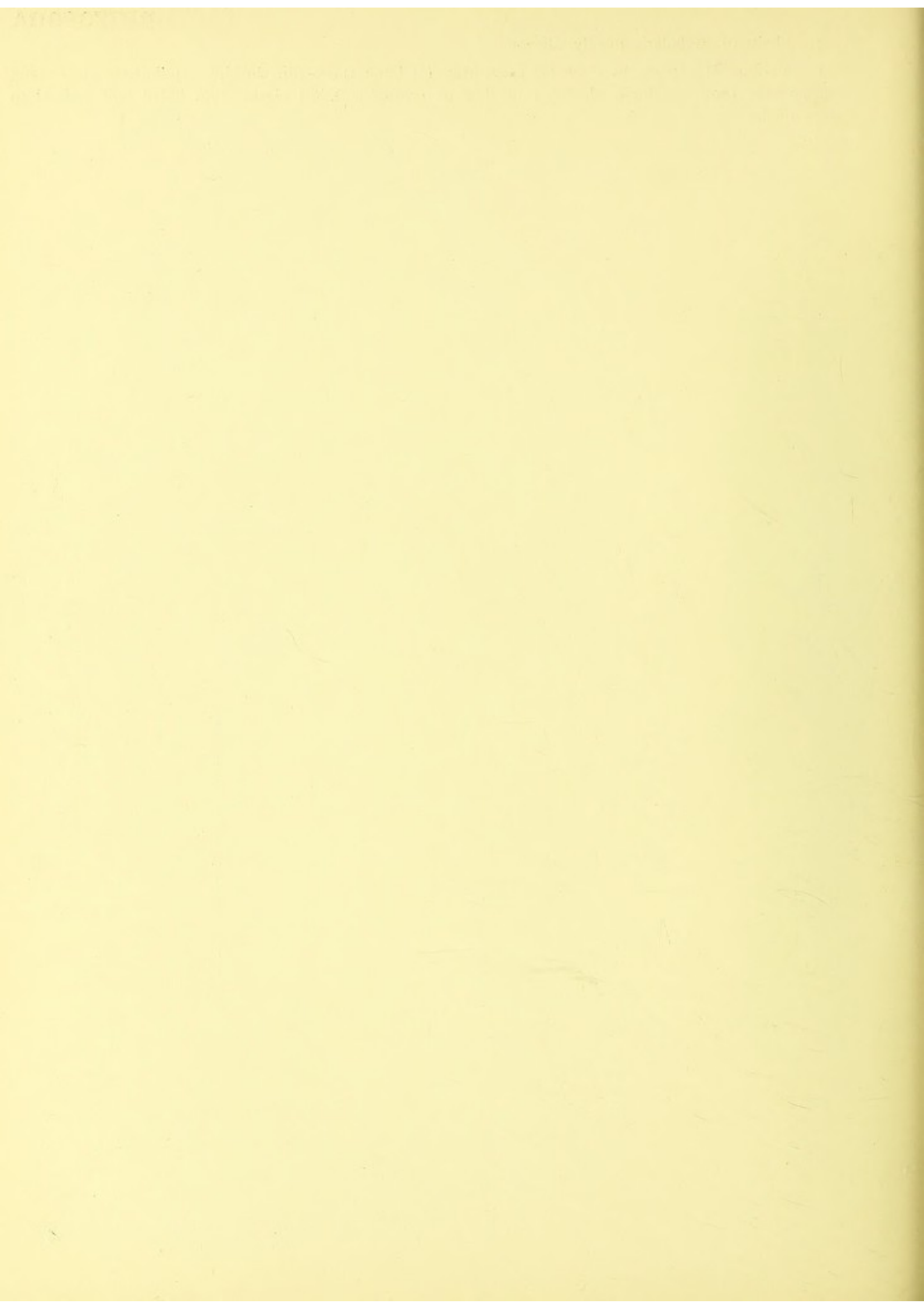
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7. Shells of Radiolaria mostly siliceous.
8. Various Mycetozoa to show (*a*) spore-fruit, (*b*) burst spore-fruit showing capillitium, (*c*) creeping plasmodium (note rhythmic character of flow of protoplasm), (*d*) plasmodium killed and stained to show nuclei.



MASTIGOPHORA

9. **Polytoma.** Smear a drop of the fluid over the slide and examine the drying edges, where the animals will be more or less still. Flagella; contractile vacuoles; nucleus.

Look for forms undergoing fission.

Add iodine. The flagella are seen more distinctly.

10. **Euglena.** Gullet, pigment spot, flagellum, contractile vacuole, nucleus.

Kill with iodine.



MASTIGOPHORA

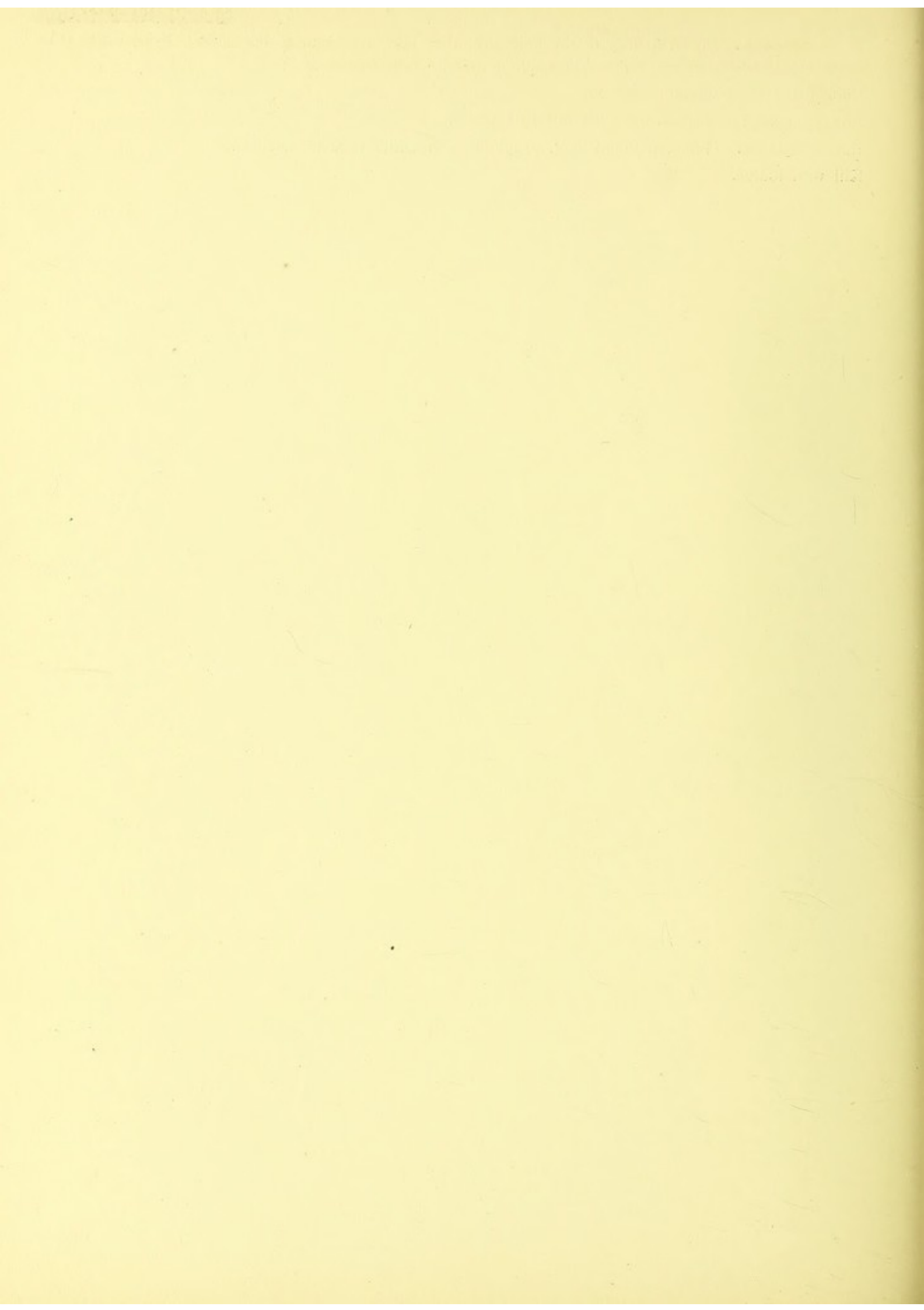
9. **Polytoma.** Smear a drop of the fluid over the slide and examine the drying edges, where the animals will be more or less still. Flagella; contractile vacuoles; nucleus.

Look for forms undergoing fission.

Add iodine. The flagella are seen more distinctly.

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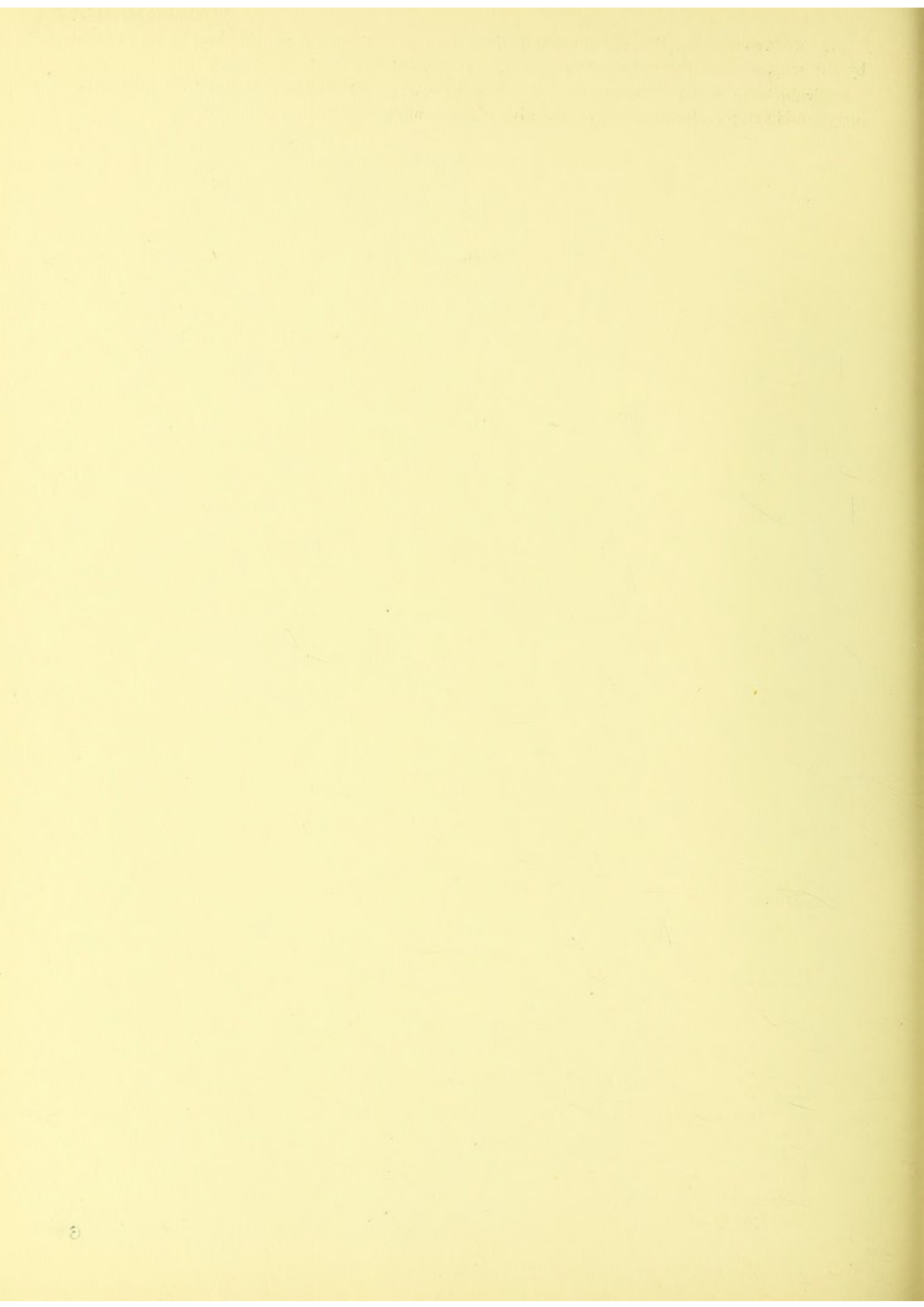
Kill with iodine.



MASTIGOPHORA

11. **Volvox.** (*a*) Alive and rotating in the water. (*b*) Removed to slide and slightly compressed by coverslip, supported on strips of paper. (*c*) Killed with iodine.

Individuals of colony; connecting threads; flagella; parthenogonidia; female reproductive cell (megagonidium); male reproductive cell dividing into microgonidia.



SPOROZOA

12. Free **Monocystis** from the sperm rosettes in the vesicula seminalis of the Earthworm. High power. Cortical substance; medullary granular substance; nucleus; successive changes of form of the Gregarine.

13. Cysts from amongst developing spermatozoa in the lateral vesiculæ seminales. (a) With two unbroken individuals; (b) the encysted individuals fused and more or less broken up; (c) with young lemon-shaped pseudonavicellæ; (d) with complete pseudonavicellæ; (e) enlarged drawing of a single pseudonavicella seen under the highest available power.

N.B. *Open the Earthworm from the dorsal side in salt solution. Remove alimentary canal carefully and open median vesiculæ seminales. Note white threads streaming from the sperm rosettes which are the Monocystis. Cut off small part of rosette with attached parasite and examine in .75 p.c. salt solution.*

SPOROZOA

14. **Clepsidrina** from the chylific ventricle of the cockroach; anterior chamber (protomerite); posterior chamber (deuteromerite); anterior knob for attachment (epimerite) generally absent; nucleus; nucleolus; cortical substance; medullary substance.

1850
The following is a list of the names of the persons who have been admitted to the membership of the Society since the last meeting.

CILIOPHORA

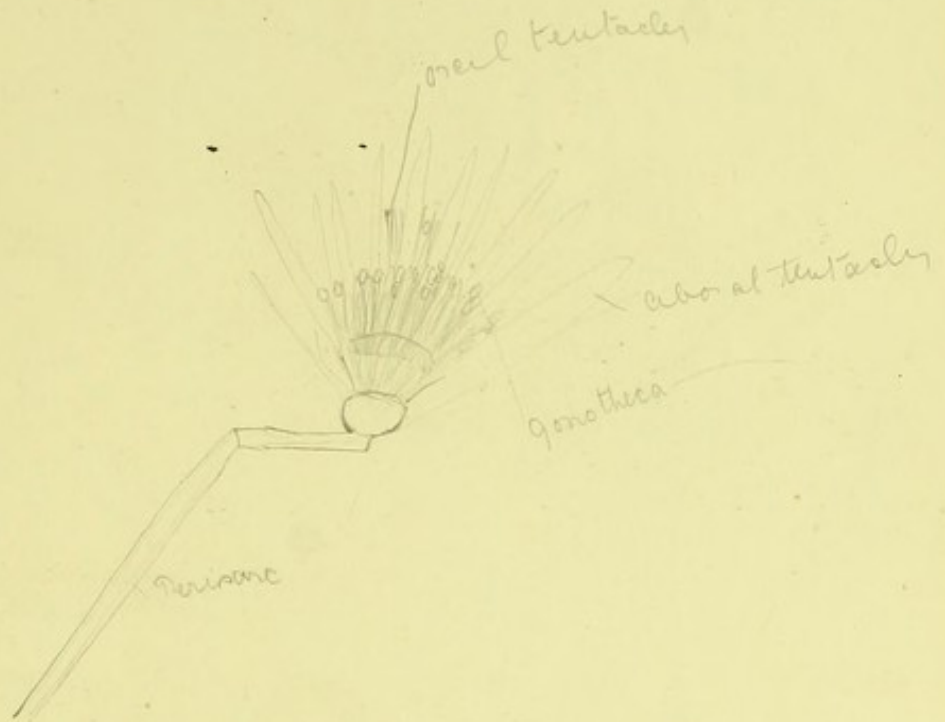
15. Ciliata from the rectum of the frog. **Opalina.** A mouthless holotrichous form. **Nyctotherus.** A heterotrichous form. Pharynx; contractile vacuole; nucleus; anus (permanent). **Balantidium.** A heterotrichous form. Four contractile vacuoles; mouth; nucleus.
- Examine (*a*) alive in a drop of the rectal fluid, (*b*) stained with picocarmine after osmic acid.
16. Examples of free-living Ciliates.

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COELENTERATA.

The material of **Obelia** and other hydroids is given to the student preserved in 70 p.c. alcohol. It should be stained in borax carmine (in 50 p.c. alcohol), dehydrated and mounted in Canada balsam.

1. Colony of **Obelia** (as type of Calyptoblastic Hydroid). Cœnosarc; perisarc; hydrotheca; gonotheca; blastostyle; medusa-bud.
2. Medusa of **Obelia** (type of Leptomedusæ). Tentacles of edge of umbrella; manubrium; the four gonads; the four radial canals; the eight otocysts.



panularia Vesticillata occurs in a similar manner to panularia Vesticillata



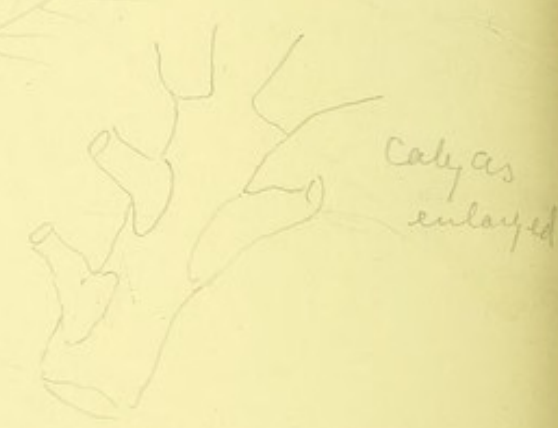
panularia pinnata

portion of stem enlarged



panularia abietina

on shells, stones etc. at 30 fathoms, very common
with channel



HYDROZOA

3. Colonies of other Calyptoblastea. (a) **Sertularia**, sessile polyps on both sides of branch.
(b) **Antennularia**, sessile polyps on one side of branch; nematocalyces.
4. **Pennaria**. A colony of Gymnoblasic hydroids.
5. **Lizzia**. (Type of the Anthomedusæ.) Manubrial gonad; groups of marginal tentacles; ocelli.



HYDROZOA

6. A single polyp of **Tubularia** (Gymnoblasic Hydroid) removed from the colony and examined with a simple lens.

Oral tentacles; gonophores, on branched processes of the body wall; aboral tentacles; cœnosarc; perisarc.

7. Longitudinal section through a polyp of **Tubularia**. (Low and high powers.) Mouth; ectoderm; endoderm of enteron; solid axis of the tentacle, consisting of modified, much vacuolated endoderm cells; oral tentacles; gonophores and stalk of gonophores; aboral tentacles; globular swelling; cœnosarc septum between cavity of polyp and cœnosarc.



8. Transverse section of a **Tubularian polyp** near the mouth. (Low power.) Axes of oral tentacles prolonged for a short distance down the body; ectoderm; endoderm.

9. Bunch of female gonophores of **Tubularia** stained slightly. In ripe gonophores observe umbrellar cavity; rudimentary tentacles; manubrium with gonad; embryo in sub-umbrellar cavity. Look out for stages showing development of gonophores.

SENSE ORGANS OF HYDROZOA

10. View of part of margin of disc of **Geryonia** showing tentaculocyst.

11. Transverse section through the edge of the disc of **Geryonia**. (High power.)

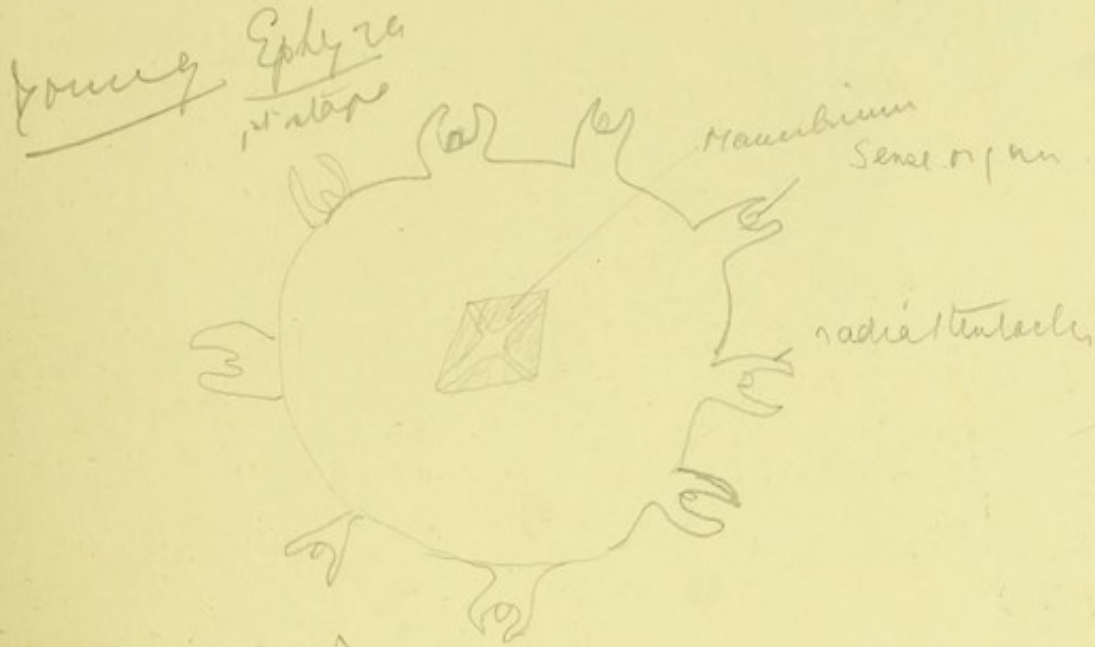
Thickened ectodermal ring; velum; tentaculocyst; upper and lower nerve-rings; circular canal; sub-umbrellar ectoderm; mesogloea.

12. Examine demonstration specimens of the Siphonophora illustrating the development of polymorphism in the group.

ACALEPHÆ

13. **Aurelia.** Small marginal tentacles; 8 sense tentacles; 4 sub-genital pits and 4 groups of gastral filaments in the radii of four of the sense tentacles; 4 oral arms in the radii of the other four sense tentacles; the pseudo-velum; 16 radiating canals, those in the radii (radial) of the 8 sense tentacles branch, the others (adradial) do not; circular canal.

14. Examine a sense tentacle first *in situ*, and then in watch glass with low-power to see protective folds of umbrella; otoliths.



Sense organ of Aurelia



crystalline otoliths
they are in number 4 lie on the edge of the umbrella. The distal end consists of mass of otoliths formed from endoderm

Section of Sense organ



endo dermal canal

Showing the endo dermal lining of tentaculocyst

distal portion of tentaculocyst containing otoliths

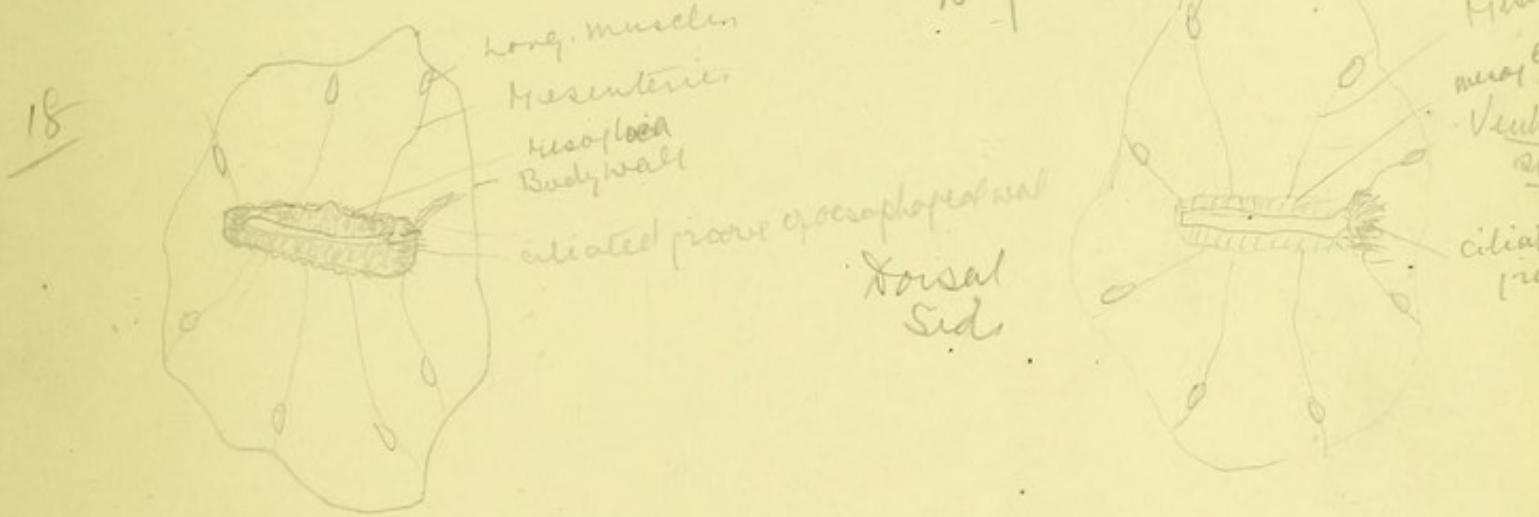
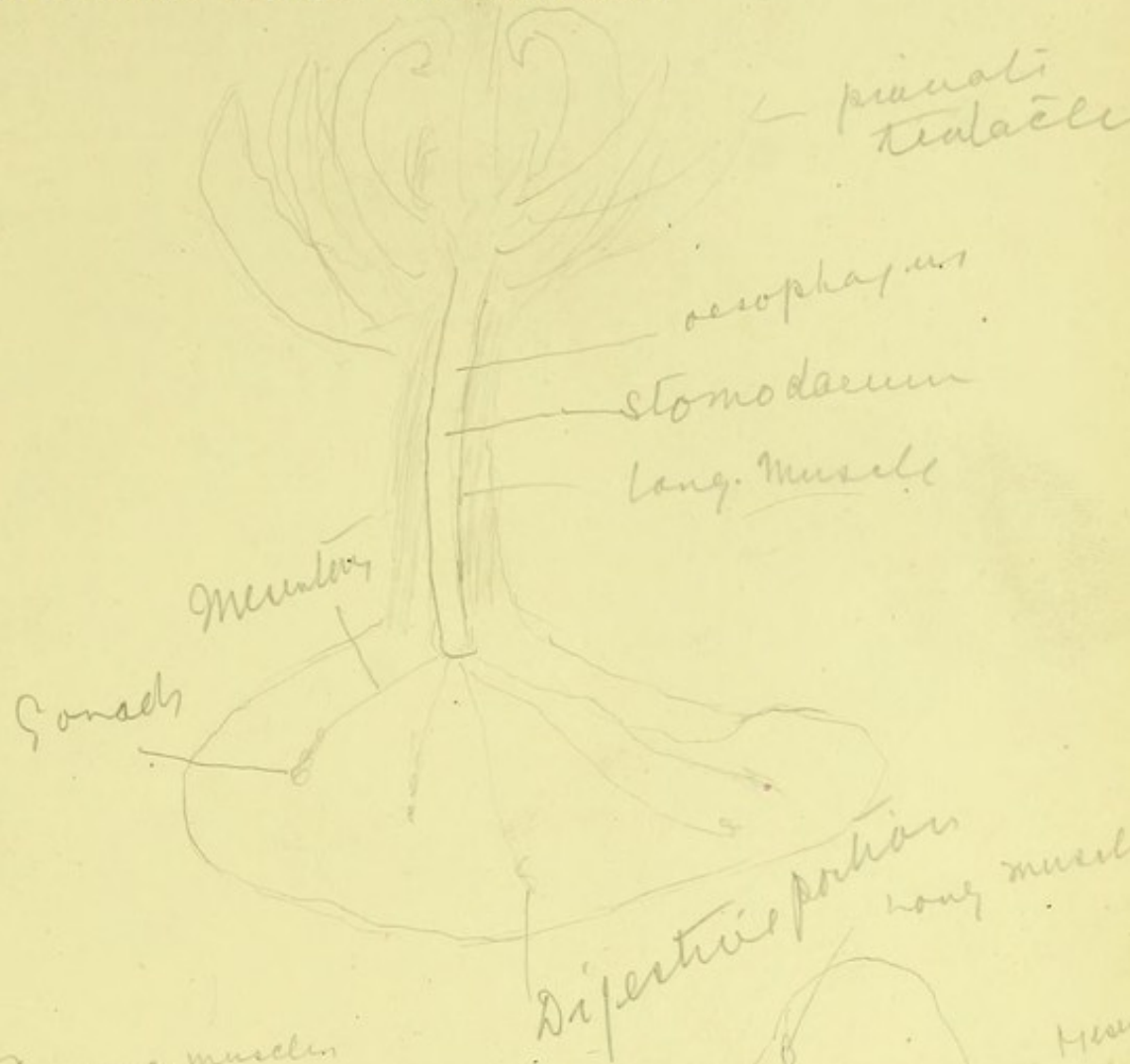
15. **Hydratuba** or **Scyphistoma** stage of **Aurelia**.
16. Demonstration specimens of other Acalephæ.



ACTINOZOA

17. **Alcyonium.** Single extended polyp from a colony stained and mounted. Pinnate tentacles; oesophagus; mesenteric filaments; part of coenenchyma; spicules.

18. Transverse sections through a polyp (a) at the oesophageal region. Body-wall; oesophageal wall; ciliated groove of latter; mesenteries; mesogloea of oesophagus with spicules; longitudinal muscles of mesenteries; (b) below the end of the oesophagus. Mesenteric filaments.



19. **Alcyonium.** Section of undecalcified cœnenchyma made by hand; spicules; polyp tubes with mesenteries [and gonads].

20. Demonstration specimens of other Alcyonaria.

20 Tubipora. The organ pipe coral.
The spicules of the body wall of the zooid fuse to form perforated calcareous tubes. The adjacent zooids are connected to each other by horizontal plates.

Heliopora. The Blue coral of coral reefs. Notice the large & small pores of the autozooids & ectodermal canals respectively.

ACTINOZOA

21. **Peachia**. View of animal opened along one side. Tentacles partly or entirely retracted. Body-wall; mesenteries (twelve); secondary mesenteries; mesenteric filaments; gonads; œsophagus laid open; œsophageal groove, projecting lip of same.

View of the face of a mesentery. Gonads; filament; longitudinal muscle of mesentery.

22. Transverse sections of **Peachia** (a) at the level of the œsophagus, (b) below the end of the œsophagus.



23. Demonstration specimens of various Zoantharia.

ZOANTHARIA - MADREPORARIA

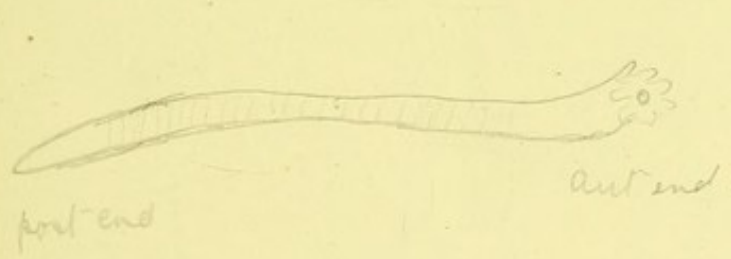
Fungia a solitary coral. The fertilised egg develops into a polyp (A) resembling a Caryophyllia. By a process of resubbling, strobilisation the anterior end of the polyp becomes free & develops into the adult form shown here. The adult also divides by transverse fission.



CARYOPHYLLA



EDWARDSIA lives buried in the sand. Body is divided into 3 regions. An Anterior & Posterior end are retractile within central portion.



Here at 8 mesenteries
The 6 rayed Actinians, probably derived from similar polyps of Edwardsia.

24. Demonstration specimens of Ctenophora.

ANNELIDA.

1. **Nereis**. Dorsal view of head. Prostomium, with eyes, tentacles and palps; tentacular cirri (cirri of 1st and 2nd segments fused with head).
2. Parapodium. Notopodium and neuropodium, each with two lobes; notopodial cirrus; neuropodial cirrus; acicula; setæ.
3. **Heteronereis** (sexual) form. Enlarged eyes: modified posterior segments; gonads.
4. Parapodium of **Heteronereis** form: flattened expansions of parapodia: oar-shaped setæ.

5. **Arenicola.** External features side view. Proboscis with buccal papillae; prostomium, peristomium and first achaetous body segment; segments with parapodia but no gills; segments with parapodia and gills; tail segments without setæ and gills. Parapodia consisting of notopodium with capillary setæ and a transverse neuropodial ridge with crotchet-like setæ. Segments divided into a number of annuli (generally five).

6. Internal organs displayed by a mid-dorsal incision. Body cavity divided anteriorly by three septa: septa also in the tail region (but absent in all intermediate segments); alimentary canal consisting of pharynx, œsophagus, stomach and intestine; single pair of œsophageal glands; dorsal blood vessel, single pair of hearts; lateral gastric vessel and ventral vessel.

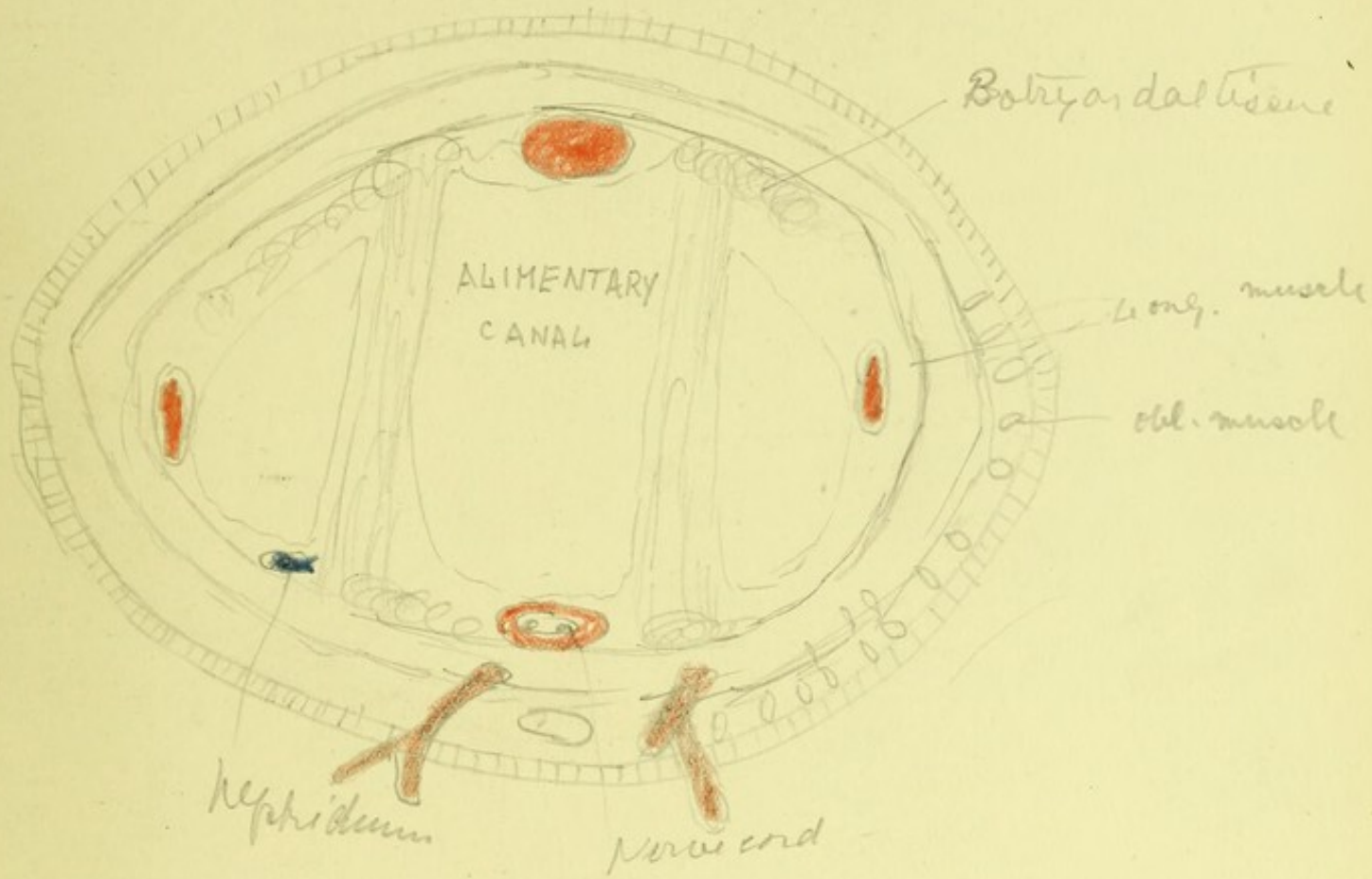
7. **Arenicola.** Remaining organs seen after removal of the alimentary canal. The oblique muscles must also be cut to exhibit the six pairs of nephridia: ventral non-ganglionated nerve cord: œsophageal connectives and brain.

8. Single nephridium seen under lens. Large nephrostome with ciliated dorsal lip: gonad: secreting portion and bladder.

9. Demonstration specimens of various forms.

HIRUDINEA

10. **Hirudo.** A dorsal, and B ventral aspect. Annuli (103, counted dorsally), superficial constrictions, of which five, except towards the extremities, correspond to one segment or metamere as indicated by the deep-lying organs. Oral sucker perforated by the mouth; posterior sucker and anus dorsal to it; penis issuing from its opening between annuli 31 and 32, in segment xi; female opening five annuli behind the male, in segment xii; five pairs of eyes situated respectively on annuli 2, 3, 4, 6 and 9.



amoeboid

Dora to show asexual reproduction in Oligochaeta



→ Simple fission

Branchiura

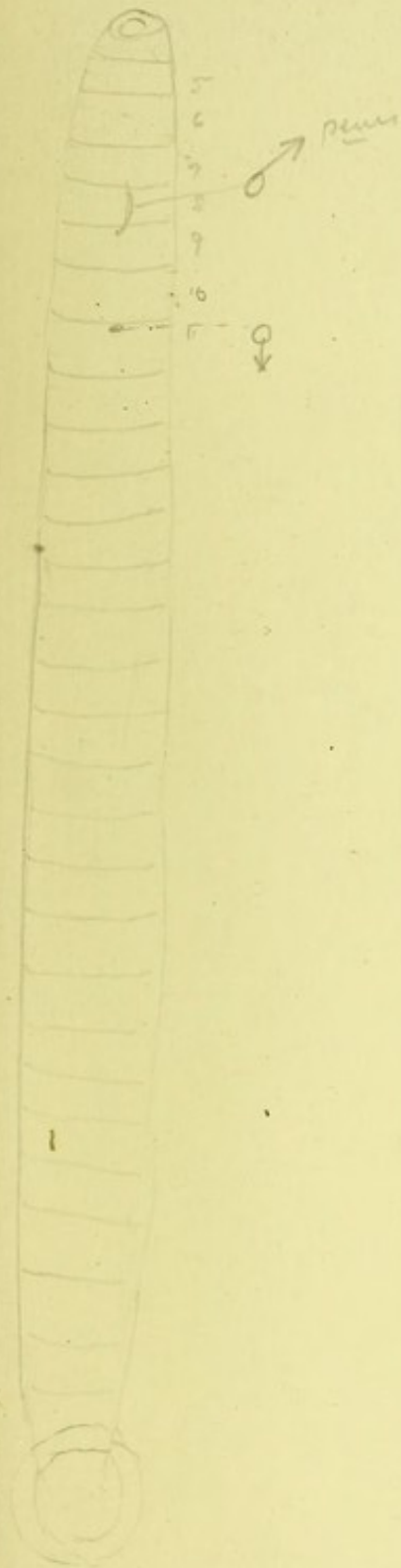


bifex



HIRUDINEA

11. The leech opened by a dorsal incision, made slightly to one side of the median line so as to avoid the dorsal vessel, and extending from the last pair of eyes to the anus. Muscular sucking pharynx; crop with eleven pairs of cæca, the last and longest pair extending backwards on either side of the median stomach and intestine; vessels (dorsal and lateral trunks) containing blood, coloured red with hæmoglobin; 17 pairs of nephridia situated respectively in segments vii—xxiii.



HIRUDINEA

12. Remove the alimentary canal and expose the nephridia, generative organs and nerve cord. Double nerve cord with circum-pharyngeal ring of 5 fused ganglia, terminal posterior ganglionic mass of 7 fused ganglia, and the 21 free ganglia lying between them; penis sac opening to the exterior in the middle line behind the 5th free ventral ganglion, the pair of coiled epididymes communicating with it and extending backwards on each side into a vas deferens with which are connected by short ducts (vasa efferentia) the 9 pairs of testes; the pair of ovaries, the glandular enlargement (albumen gland) of the oviducts, which unite to form a median vagina opening to the exterior behind the 6th free ventral ganglion; the 17 pairs of nephridia numbered.

13. Turn the leech over, slit up the pharynx by means of a short ventral median cut and expose the 3 jaws (one dorsal median and two ventro-lateral). Remove one of the jaws and examine under a low power in water the serrated row of teeth upon its free edge.

ARTHROPODA.

1. **Apus.** Dorsal view. Carapace; backwardly projecting free portion of same; transverse groove marking junction of these two parts; eyes; externally segmented posterior part of body; terminal setæ.

Ventral view. Notice that the anterior legs are pediform and stout, the posterior foliaceous and delicate. The posterior six segments are without appendages. Shell glands in the carapace.

2. Appendage (typical Phyllopod appendage). Corm or axis, bearing 6 endites, and 2 exites—the flabellum and bract. In some legs there is an apical lobe beyond the endite 6.

3. **Daphnia.** Mount on slide, and keep in place by supported coverslip. Low power. Head; fused compound eyes; median simple eye; first pair of antennæ (rudimentary but seen with high power); second pair of antennæ, large and biramous with long bristles bearing delicate hairs; mouth; hepatic diverticula of anterior part of alimentary canal; heart; brood-pouch, probably containing ova or embryos; thoracic appendages; abdomen curved ventralwards within the valves of the shell, which is formed by the prolonged lateral halves of the carapace; anus terminal and slightly dorsal; terminal setæ.

Notice the circulation of the blood as shown by the movement of the corpuscles.

CRUSTACEA

4. **Cyclops**, dorsal view. (Low power.) Carapace including head and first two thoracic segments; median eye; 1st and 2nd pairs of antennæ (uniramous); four appendage-bearing thoracic segments behind the cephalo-thorax; generative segment (last thoracic); three abdominal segments of which the last bears the caudal fork; genital gland in the thorax; alimentary canal.

CRUSTACEA

5. **Lepas.** Side view of whole animal. Scutum; tergum; carina; opening of shell; peduncle.
 6. With shell and mantle of one side removed. Oral cone; gills attached to base of anterior thoracic legs; thorax with six pairs of biramous legs; abdomen rudimentary and with penis as ventral appendage, just dorsal to root of which is anus; testicular follicles, on sides of thorax.
- Cut open peduncle and observe ovaries. Examine the inner side of the uninjured mantle for ovigerous frenum, to which may be attached the ovarian lamella.

CRUSTACEAN LARVÆ

7. **Nauplius larva** with three pairs of appendages, the future 1st antennæ (uniramous), 2nd antennæ and mandibles (biramous); the single median eye. The unjointed carapace may be prolonged into long spines.

8. **Zoæa larva**, cephalothoracic shield with spines; free abdominal segments; forked telson; compound stalked eyes.

The appendages in a typical Zoæa are:

Two pairs of antennæ.

Mandibles without palp.

Two pairs of maxillæ.

Two pairs of maxillipeds, large, biramous, and used for swimming.

CRUSTACEA

9. **Gammarus.** Side view. 1st antenna; 2nd antenna; head (with which the 1st thoracic segment is fused); oral appendages; eyes; the seven free thoracic segments; the abdominal segments, the three anterior with swimming limbs, the three posterior with limbs adapted for springing.

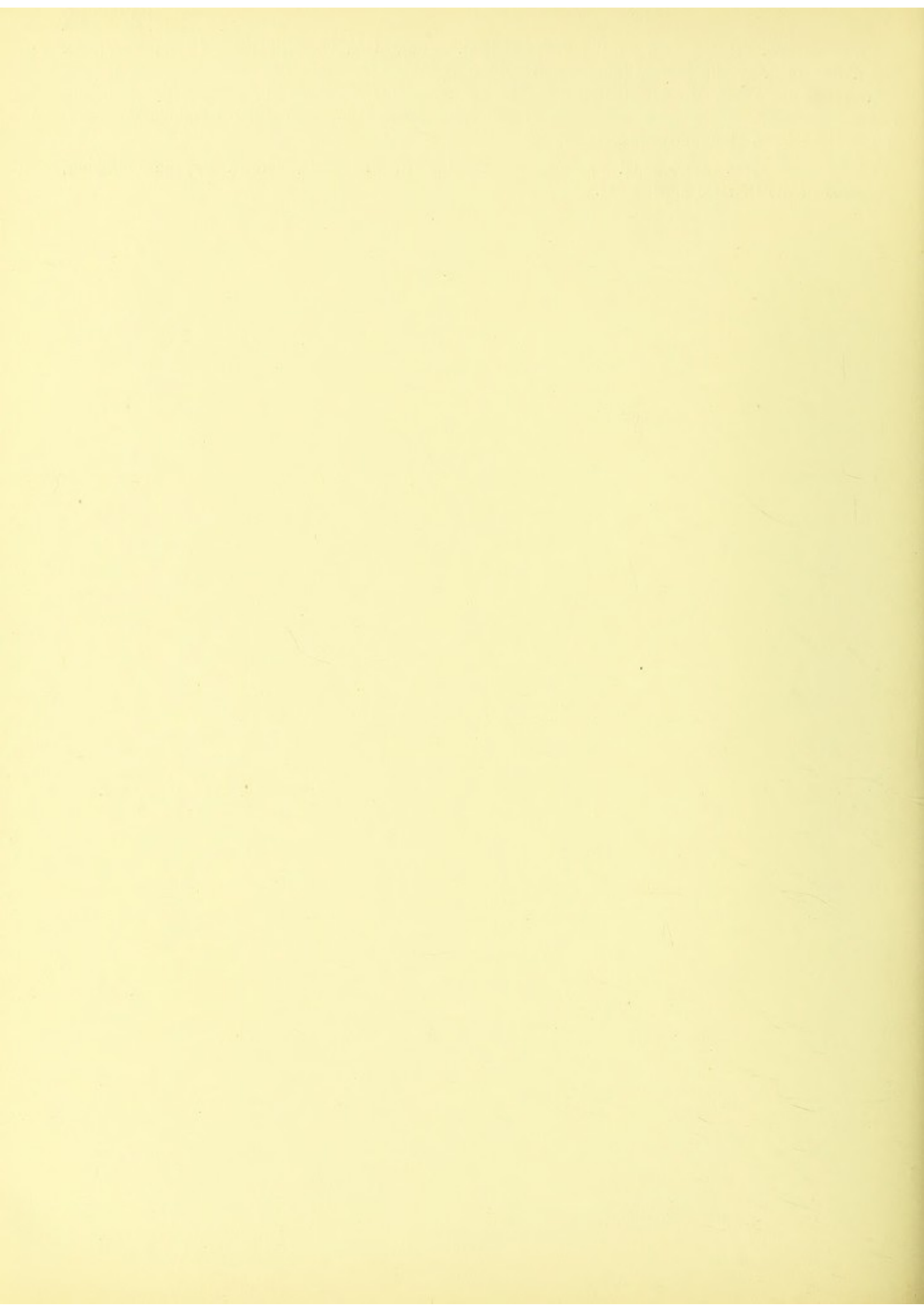
10. Thoracic segment detached to show limbs, branchiæ usually springing from coxopodite and (in the female) oostegites forming brood-pouch.



CRUSTACEA

11. **Asellus.** Dorsal view of the entire animal, examined in a watch-glass. Head; eyes; the seven free terga of the thorax (the tergum of the 1st thoracic segment is obsolete); single piece representing the fused abdominal segments (the 1st abdominal segment may perhaps be seen as a minute free ring); 1st antennæ; the much longer 2nd antennæ; the seven pairs of ambulatory limbs; the bifurcated 6th abdominal appendages.

12. Ventral view. Abdominal appendages; brood-pouch in female, formed by the oostegites, processes of the thoracic appendages.



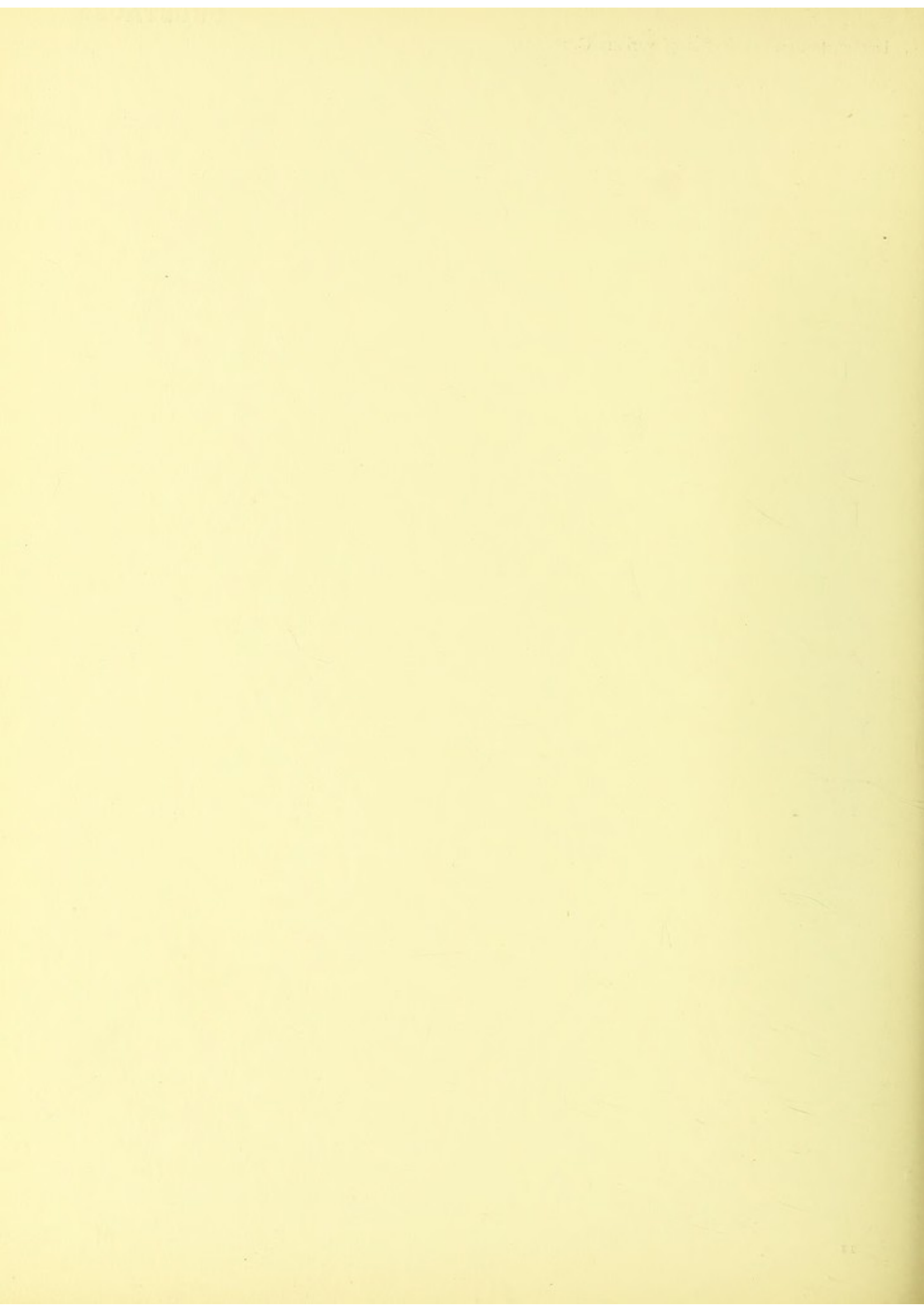
CRUSTACEA

13. **Carcinus**, common shore crab. Note the folded 1st antennæ, small 2nd antennæ, wide 3rd maxilliped, and reduced abdomen, wide in the female with four pairs of biramous ovigerous appendages, narrow in the male with two pairs of appendages only, forming copulatory styles. The last abdominal segment is without appendages in both sexes.

In specimen with branchiostegite removed note the spacious gill chamber and structure and arrangement of gills.

14. Demonstration specimens of various Crustacea.

Demonstration specimens of various Crustacea.



1. **Peripatus.** Ventral view.

Antennæ; oral papillæ; mouth; lips; jaws; the seventeen pairs of legs; generative opening; anus.

2. Dorsal view of head to show the eyes. (Simple lens.)



MYRIAPODA.

1. **Lithobius.** Ventral view. Antennæ; head; 1st body segment, with poison claws; broad sterna of body segments; ambulatory appendages.

In side view note stigmata in alternate segments.

2. JAWS of same. Mandibles; 1st maxillæ united in the median line; 2nd maxillæ; poison claw (appendage of 1st post-cephalic segment).

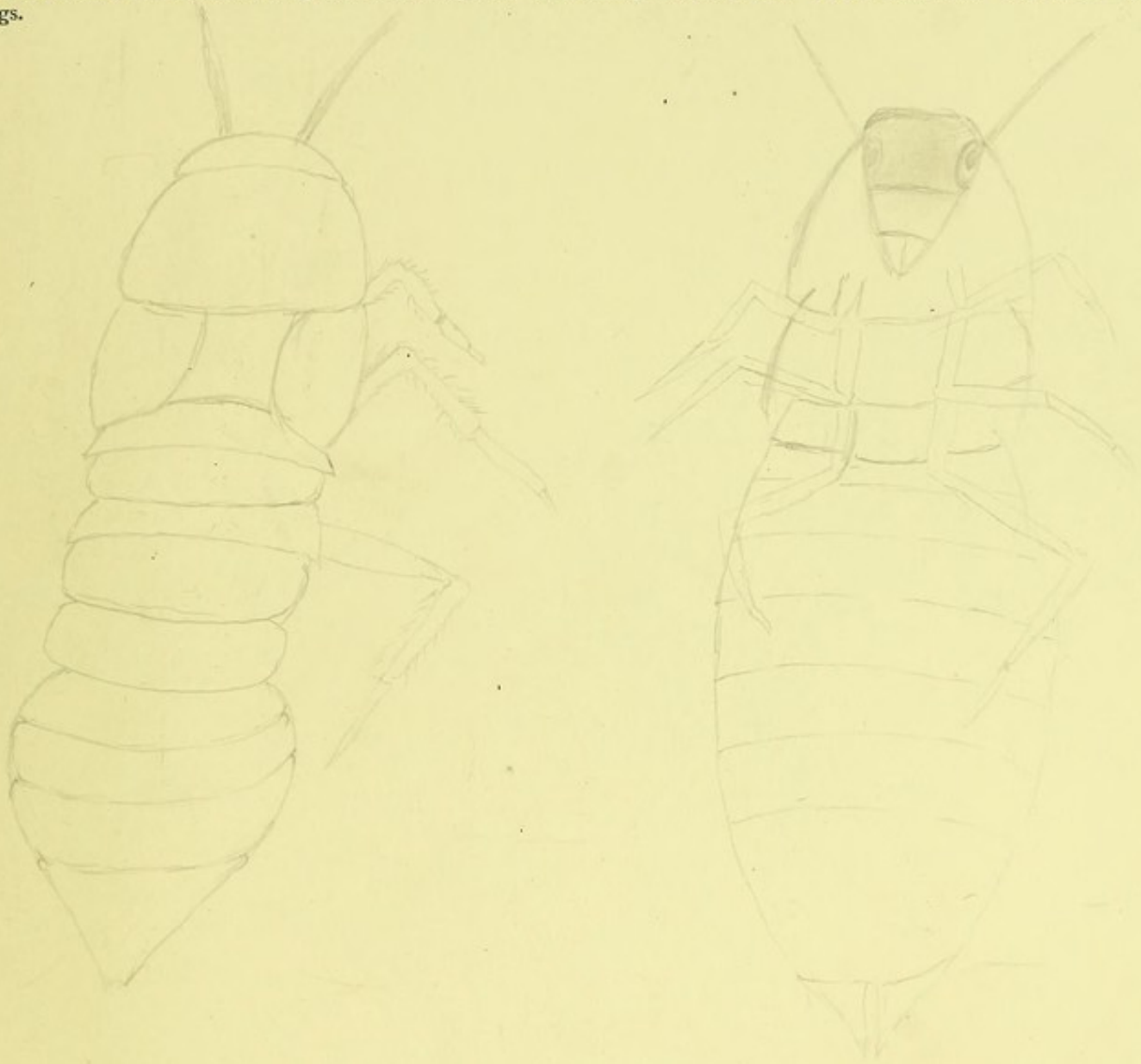
3. **Julus.** Note short antennæ, cylindrical body, narrow sterna, numerous legs (two to each segment of the body).

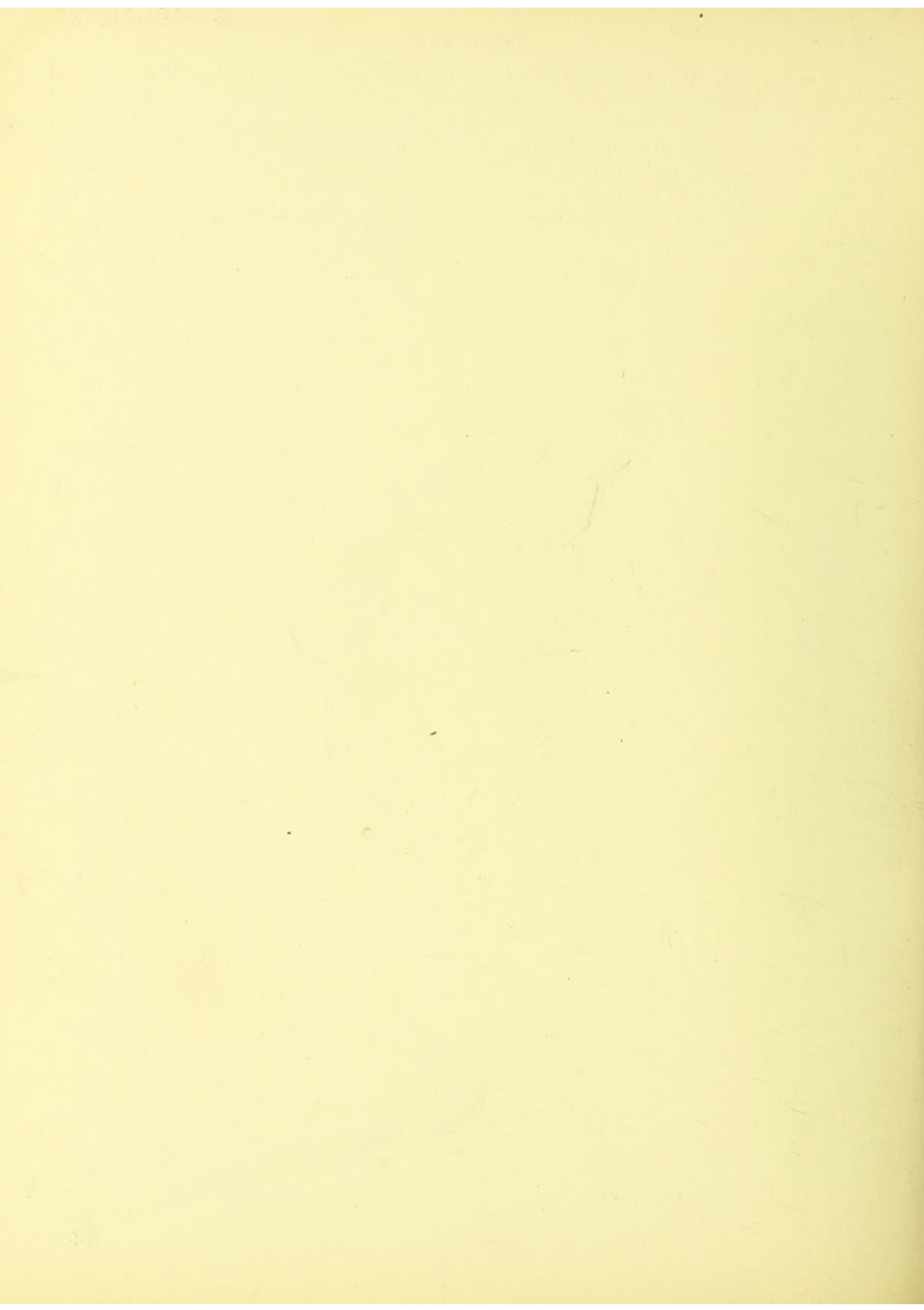
4. JAWS of same. Mandibles; maxillæ as a four-lobed plate.

INSECTA.

1. **Periplaneta.** Dorsal or tergal aspect of a full grown male or female pinned by the base of the legs. Head; thorax; abdomen; antennæ; prothorax; mesothorax; metathorax; mesothoracic and metathoracic wings, pinned forward. 1st to 7th abdominal segments or somites. Terga of the 8th and 9th somites overlapped by the 7th. Tergum of the 10th somite. Right and left styles attached to sternum of the 9th somite in male, *absent in female*. Right and left jointed cerci anales attached to the tergum of the 10th somite.

In *P. orientalis*—the common species—the wings are rudimentary in the female. In *P. americana*, both sexes have wings.

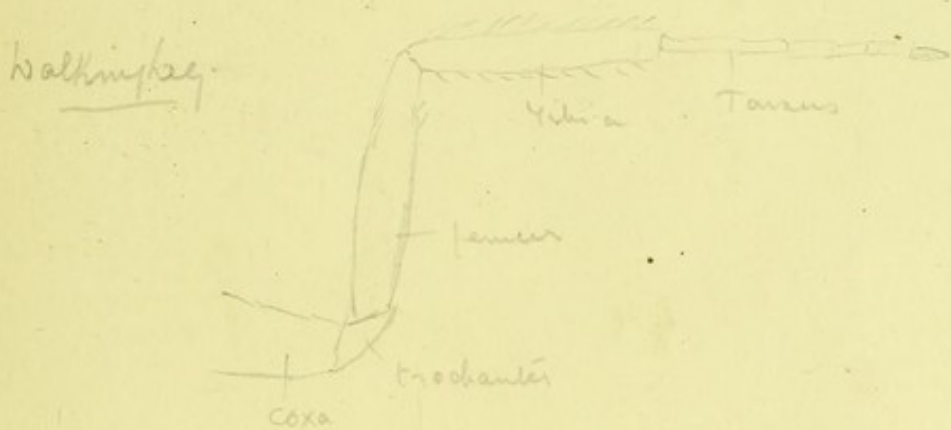




PERIPLANETA

2. Ventral or sternal aspect of abdomen of a male specimen. Sterna of 1st to 9th abdominal somites; right and left styles attached to the 9th sternum; podical plates; tergum of 10th abdominal somite; genital aperture between the sterna of the 9th and tergum of the 10th somites; anus between the podical plates and tergum of the 10th somite.

3. Enlarged view of the posterior part of the sternal aspect of the abdomen of an adult female. Sterna of the 1st to 6th abdominal somites; sternum of the 7th abd. somite (elongate and bifid posteriorly); proper position for the sternal sclerites of somites 8 and 9, represented by a soft expansible membrane, the genital funnel; genital aperture placed beneath the podical plates and leading into genital funnel.



PERIPLANETA

4. The head and neck as seen laterally (enlarged). Antenna; compound eye; fenestra; maxillary palp; labial palp; labrum; cervical sclerites.
5. Head detached and seen from above. Antenna; eyes; fenestræ; epicranial suture; clypeus; labrum; maxillary palp; labial palp.

PERIPLANETA

[For preparations of insect mouth parts, the detached appendage should be boiled with potash to remove attached muscles, dehydrated and mounted in Canada balsam.]

6. The 2nd maxillæ (labium and labial palps). Submentum; mentum; bifid ligula; paraglossæ; labial palp.
7. One of the 1st maxillæ. Cardo; stipes; palp; lacinia; galea.
8. One of the mandibles.

PERIPLANETA

9. Dissection of Heart and Alimentary Canal. Remove the abdominal terga carefully so that the heart lying within the pericardium may be seen *in situ*. Then remove also the thoracic terga and free the alimentary canal from the adherent masses of the fat body and unravel its coils. The larger tracheal branches should be cut with fine scissors. Right salivary gland; right salivary receptacle; œsophagus; crop; proventriculus; pyloric cæca; chylific ventricle; Malpighian tubes, opening into the short small intestine or ileum; large intestine or colon; rectum; cerebral ganglion.

10. Right salivary gland and receptacle removed with ducts, &c. entire. Under low power: acini; tracheal tubes; ducts; nerves. This should be fixed in corrosive sublimate, stained in borax carmine, and mounted in balsam.

11. Portion of fatty body showing tracheæ and fatty tissue. High power.

PERIPLANETA

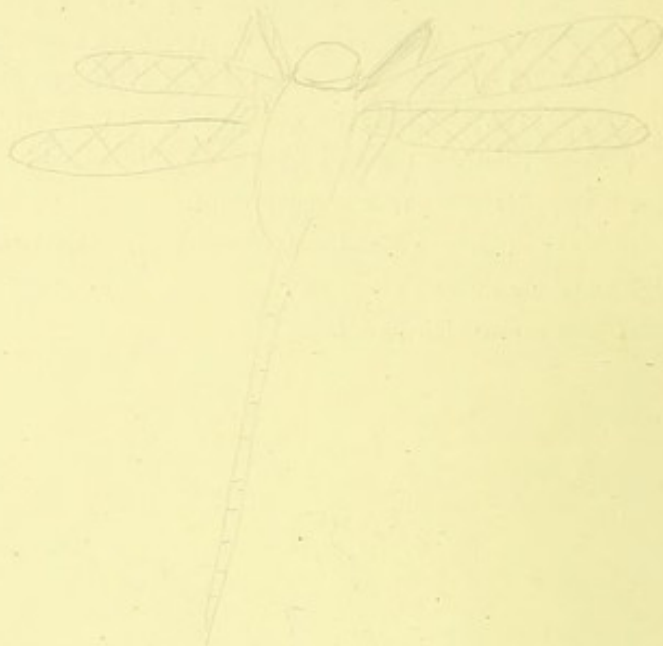
12. The remaining organs of the same cockroach as seen after the removal of the alimentary canal and fatty body. Cerebral ganglion; sub-oesophageal ganglion, closely attached to the cerebral and representing three fused ganglia (those of the mandibular and two maxillary segments); 1st, 2nd, and 3rd thoracic ganglia; 1st abdominal ganglion; 2nd to 5th abdominal ganglia; 6th and last abdominal ganglion. In FEMALES. Colleterial glands; oviduct; spermatheca; ovarian tubes. In immature MALES. Testis as a somewhat transparent lobed body lying on each side in the fat immediately below the 4th and 5th terga; vas deferens as a slender duct passing back to the small mushroom-shaped gland. In adult MALES. Mushroom gland (vesicula seminalis); short duct of same; accessory gland.

13. Ovarian tube under low power of microscope.
14. Contents of the mushroom gland and spermatheca. Spermatozoa.
15. Malpighian tubule under high power.
16. Muscular fibre under high power.

pa (water scorpion)



Dragon fly



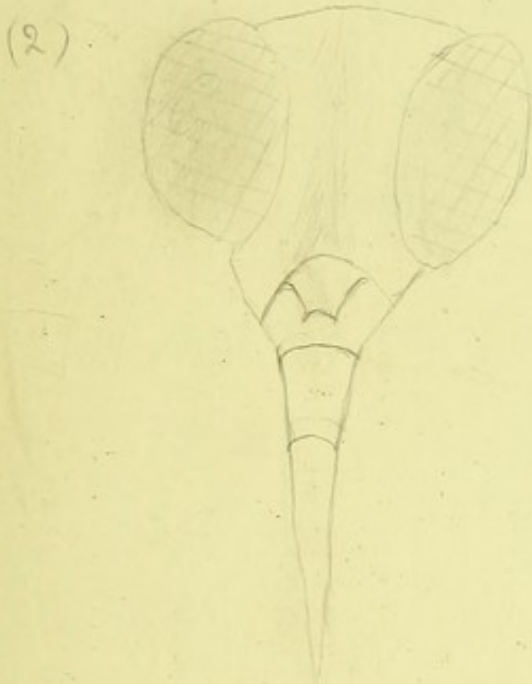
Nymph of dragon fly



1. Head of a female **Culex** [Diptera] from above. (Low power.) Eyes; antennæ; labrum or upper lip; the proboscis constituted by the labium or fused 2nd maxillæ, in a dorsal groove of which are contained (when not extruded) the styliform mandibles and 1st maxillæ and the hypopharynx or lingua; the groove is closed dorsally by the labrum; maxillary palps.

[In the male, the maxillary palps are much longer, and the antennæ bear very long hairs.]

2. Head of a **Notonecta** or Water-boatman [Hemiptera] from above. (Low power.) Eyes; antennæ; labrum; jointed proboscis or labium; the stylet-like mandibles and 1st maxillæ, contained in the proboscis. [There are no maxillary or labial palps.]



sect- Life Histories. Endopterygota

Water Scorpion (order: Rhynchoptera - Bugs)

Nymph & adult -

6 pads on meso & meta thorax of nymph. All stages live in water & changes from nymph to adult are gradual & not very great. They breathe atmospheric air once to surface from time to time to renew air supply through siphon.

Dragon fly (Anisoptera) wing pads, nymph lives in water for 3 years, adult aerial. Nymph catches air in solution in water.

2 types of dragon flies with 2 types of larval respiration

(A) Adult - thick bodied - nymph breathes with rectum, which have great supply of tracheae, water sucked in & out of anus.

(B) Adult thin bodied. Nymph breathes through skin especially through 3 lamellae at end of body.

Dragon fly ^{mouthparts} show same mouthparts.

The labium (mask) is armed with "jaws" at apex (lab. palpi) this shoots forward to seize prey (insects etc in water).

Endopterygota

Butterfly (Lepidoptera)

Caterpillar (= larva) Chrysalis (= pupa)

3 pairs of true legs, pro-legs are true appendages

Head has 6 simple eyes - mandibulate mouthparts. on tip of lab is

Hypopharynx. Pupa. wings have come out of pockets, appendages plastered to sides.

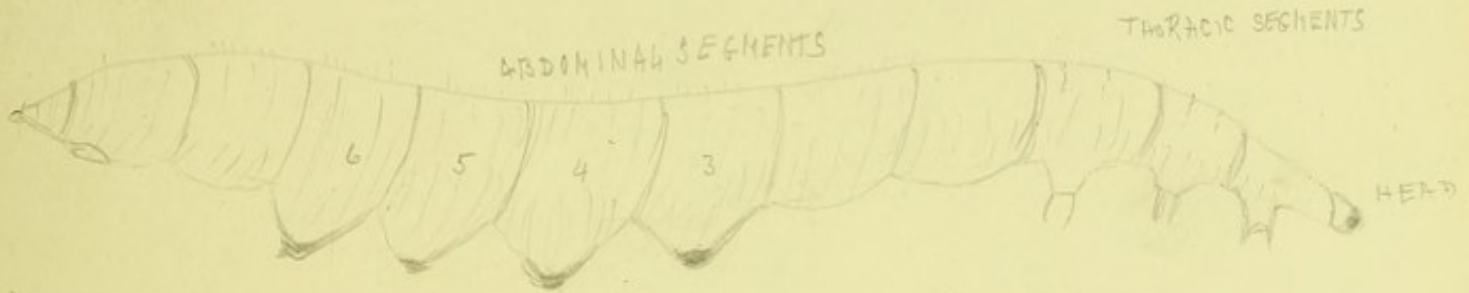
3. Mouth-parts of a **Bee** removed from head and mounted: (1) the labium with the ligula, bearing on each side a shorter process the paraglossa and a long five-jointed labial palp; (2) the 1st maxilla with stipes, lacinia folded back on the stipes and a short palp at end of stipes; (3) the mandible strong and platelike.

4. Mouth-parts of a **Butterfly**. (These can be best seen if the two eyes are removed from the head and the rest boiled in potash and mounted.) Spirally coiled proboscis forced by the union of the two 1st maxillæ; rudimentary maxillary palps; three-jointed palps of the rudimentary labium.

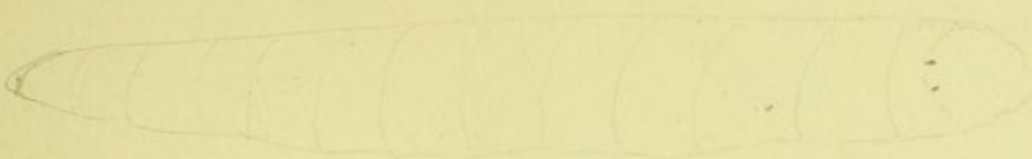
INSECTA

5. Side view of a **Lepidopterous caterpillar**. Head; the three thoracic segments, each with a pair of legs; the ten (9th small) abdominal segments, the 3rd to 6th being each provided with a pair of 'pro-legs'; the eight abdominal stigmata of one side.

6. Side view of a **Lepidopterous pupa**. Head; eyes; antennæ; maxillæ; prothorax; mesothorax; prothoracic leg; mesothoracic leg; mesothoracic wing; metathoracic wing; the ten abdominal segments; the eight abdominal stigmata.



Larva of Blow-fly



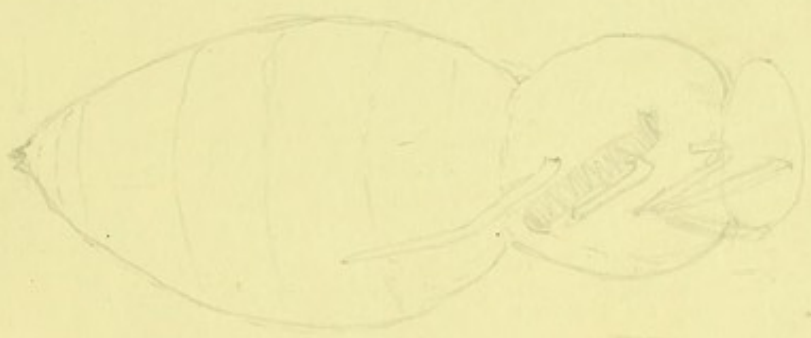
Puparium



Larva of Wasp



Pupa of Wasp



Larva of Gnat

Pupa



Larva of Gnat



astrophilus. Eggs are laid on hairs (hairs) small larvae emerge & probably pierce the skin & are carried by blood stream till they reach final location, free in stomach to which they attach themselves by mouth

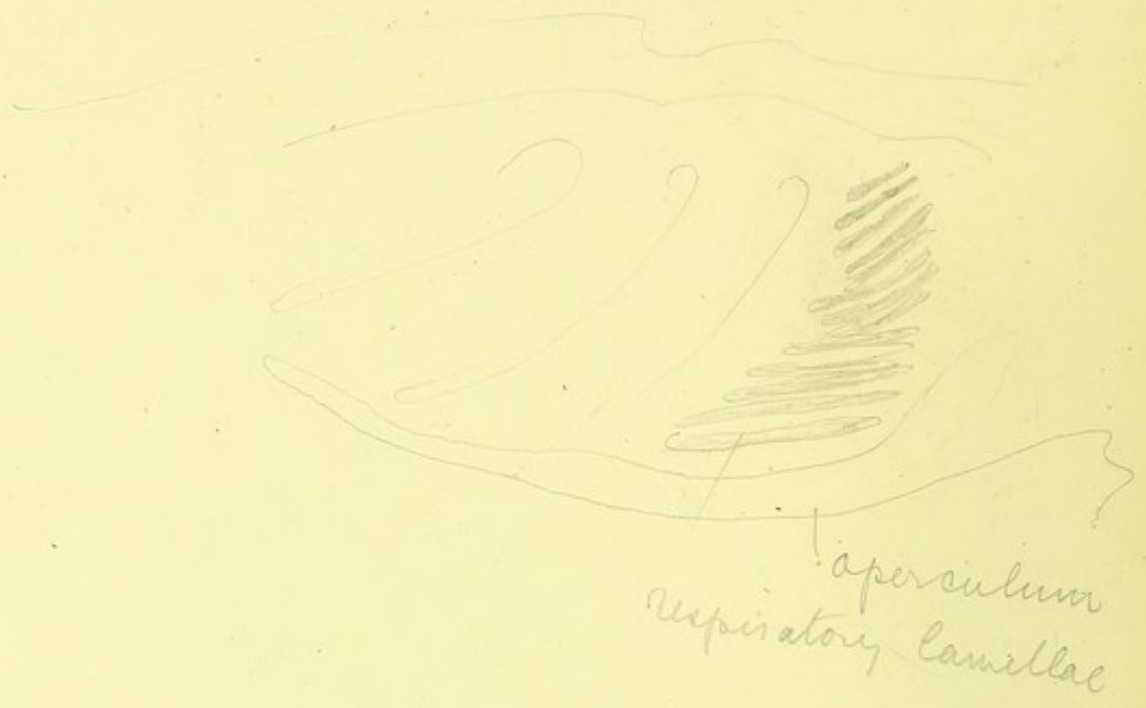


idoptera

with larvae - Hawk moth is often full of parasitic wasp larvae, which can be seen emerging from it. A number of these spin a communal cocoon from which wasps will eventually emerge & go off to oviposit in probably the same species of Hawk moth caterpillars

Hygmecophily, Social insects - Ants, Termites, Bees & Wasps make their home in common dwellings (nests). In ants nest one often finds a great number of other creatures dwelling, some as pests others as scavengers or as definite enemies, which eat ants or their early stages, this is known as 'Hygmecophily'. In one ants nest one may find many species of pests - woodlice, beetles, spring tail, bristle tail, mites, wasps, flies, etc. etc. There is a similar phenomenon in Termites. most pests are blind & white.

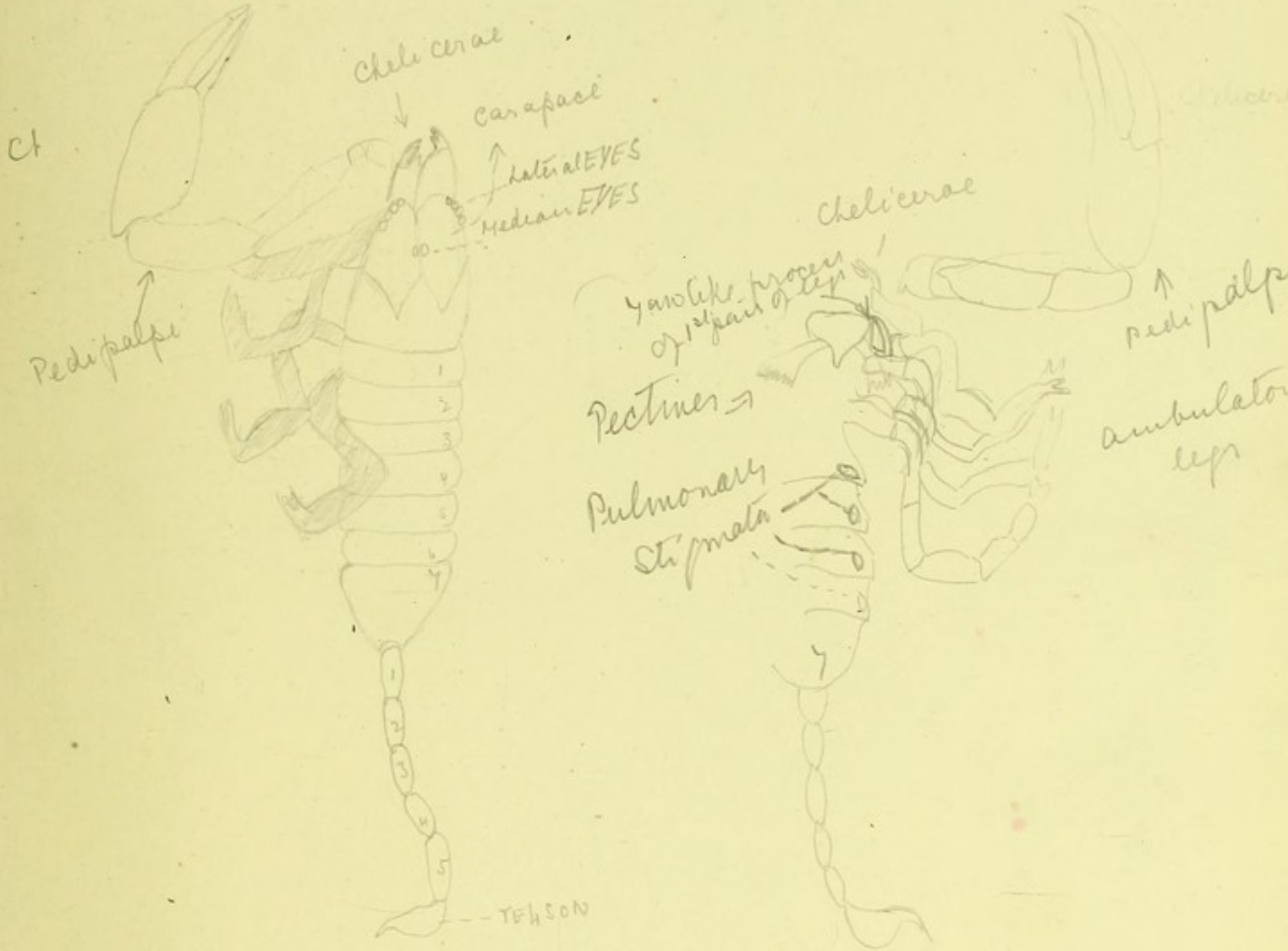
Long section through Amulus showing respiratory lamellae
attached to the post. surface of the abdominal appendages



ARACHNIDA.

1. **Scorpio**, dorsal view. Chelicerae; pedipalpi; carapace; the pair of large median eyes; group of small lateral eyes; terga of first seven abdominal segments; five post-abdominal segments; telson.

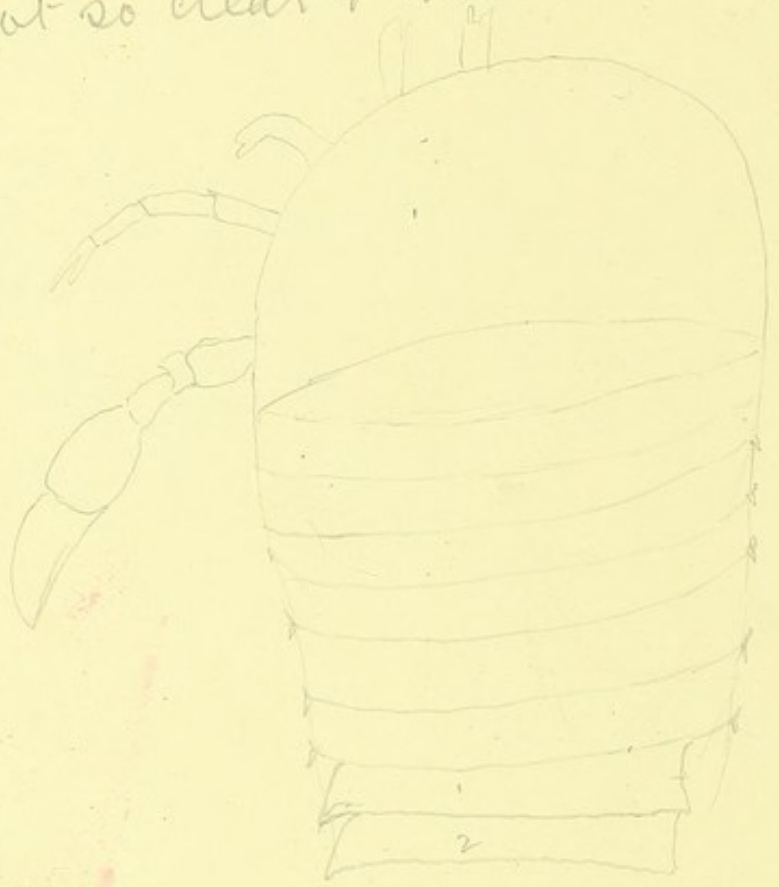
2. **Scorpio**, ventral view. Chelicerae; pedipalpi with stout basal joint; four pairs of ambulatory legs; jaw-like process of basal joints of the legs of the first two pairs; genital operculum (on 1st abdominal); pectines (2nd abdominal); four pairs of pulmonary stigmata; 7th abdominal segment; post-abdomen and telson as in 1.



Eurypterus - is an aquatic form found in fossil only

There are 6 pairs of appendages surrounding the mouth of - which 5 pairs only are seen in the specimen. The 6th pair of limbs is elongated & paddle like.

Eurypterus is an intermediate form between Limulus & Scorpion. The abdomen in Eurypterus being elongated, segmented & divisible into meso & meta soma, but - the division is not so clear & distinct as in Scorpion



Limulus Stapes of Growth.

The so called Grilobite Stape is an accidental resemblance to the fossil Grilobites. Grilobites are Crustacea & possess Antennae. While Limulus does not.

The Grilobite stape is much better compared with the Grilobites.
 estonica



Grilobite Stape



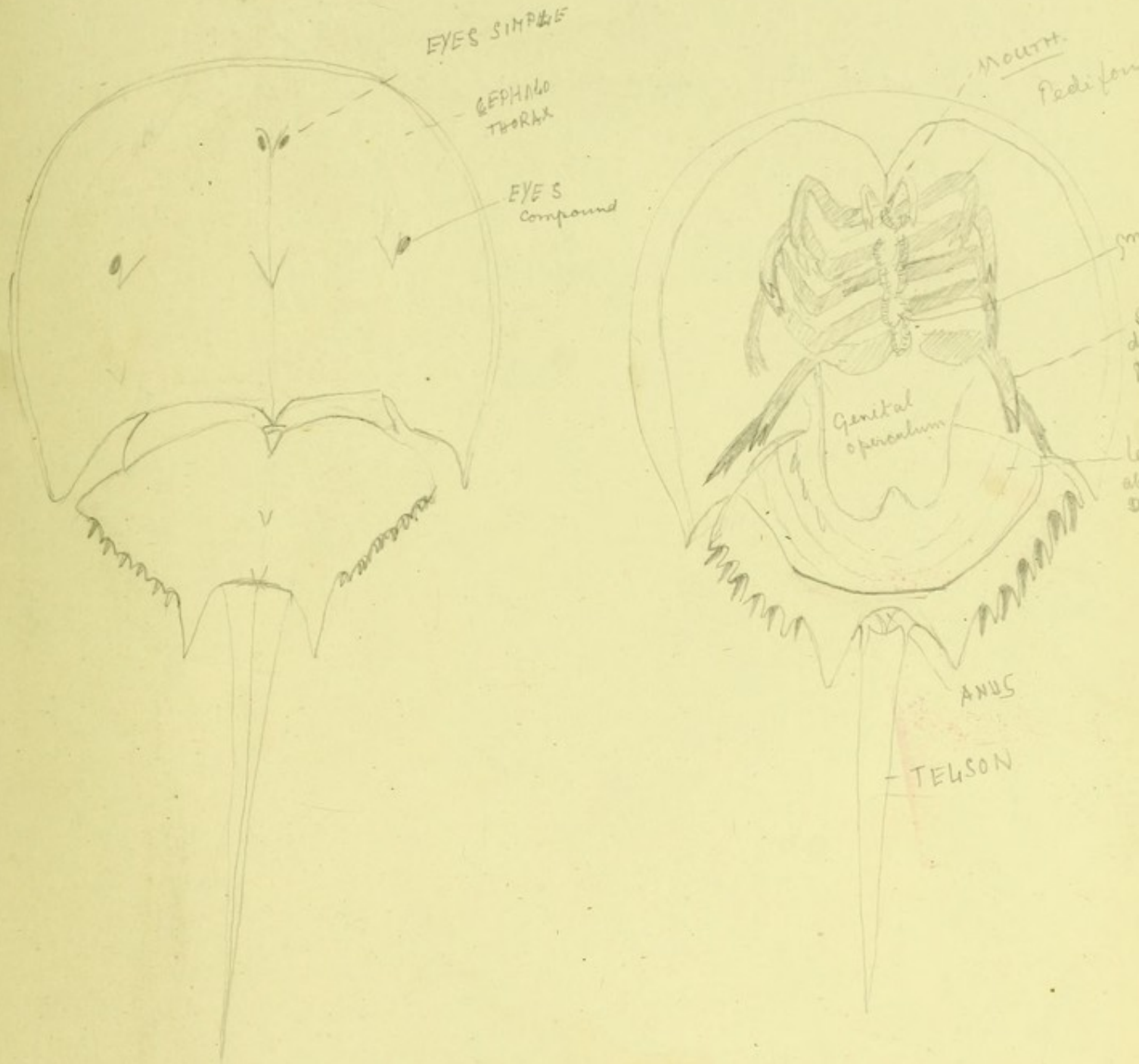
Grilobite

ARACHNIDA

3. **Limulus**, dorsal view. Cephalothorax; abdomen; spines (six on each side) on margins of abdomen; telson; the two compound eyes at the sides of the median region of the cephalothoracic carapace; the two simple eyes at the front end of the same region.

4. **Limulus**, ventral view. Pediform legs on cephalothorax (six pairs), the last five with gnathobase; spatulate digging processes on last leg; genital operculum; lamellar abdominal appendages (five pairs) with gill books; anus; telson; position of mouth.

5. Casts of fossil forms **Eurypterus** and **Prestwichia**.



Mexican Scorpion killer

Acanthoponyx mexicanus

these creatures trace Scorpions with their antennae like legs then attack them with their powerful pedipalps & eat them

Solifugae

Galeodes orientalis: The Solifugae are tracheate arachnids with the last three segments of the cephalo-thorax free & the abdomen well segmented. The chelicerae are well developed pedipalps are leg like processes & possess terminal sense organs. Most nocturnal & produce hissing sound by rubbing the chelicerae together. Only last 3 pairs of legs are used for walking.

ARACHNIDA

6. **Spider**, dorsal view. Chelicerae; pedipalpi; ambulatory legs 1-4; eyes; cephalothorax; unsegmented abdomen.

7. **Mite**, ventral view. Thorax and abdomen broadly fused; chelicerae; pedipalpi; ambulatory legs; reproductive opening and anus.

All spiders form some sort of nest, but in certain forms the jaws are adapted for digging, the spider digs a hole in the ground & lines the cavity with silk. The opening of the cavity may either be closed by a thin sheet of silk which hangs loosely over the opening or a trap door. Trap door spiders are nocturnal in habit.

TUNICATA

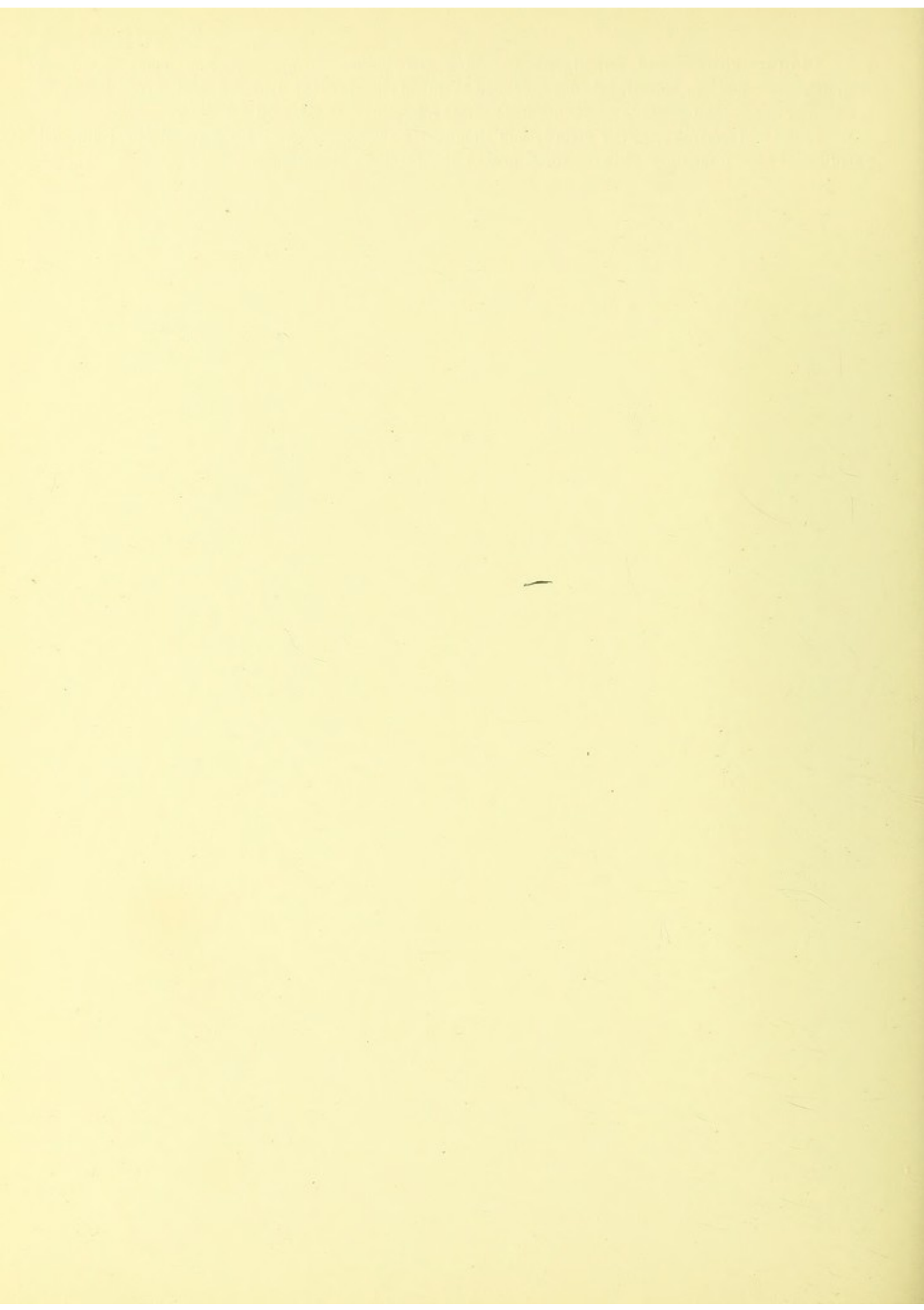
1. **Ciona.** Animal removed from its test and drawn in side view. Mouth; atrial aperture; ganglion; longitudinal muscles of body-wall; red pigment spot marking termination of vas deferens; point of origin of test vessels.

2. Atrial cavity and body cavity opened along the dorsal middle line; body wall separated from the pharynx by cutting the cords passing from one to the other. Pharynx; œsophagus leading into stomach; intestine with typhlosole; rectum; heart in pericardium; oviduct and vas deferens opening into atrial cavity.

TUNICATA

3. **Ciona.** Pharynx and buccal cavity opened and viscera further exposed. Tentacular ring; peripharyngeal groove; dorsal tubercle; subneural gland; endostyle; languets and hyperpharyngeal groove; aperture from pharynx to œsophagus; ovary; testicular follicles on intestine.

4. Portion of pharyngeal wall stained and mounted. Transverse bars; longitudinal bars; internal longitudinal bars from inner side of which project the papillæ; stigmata.

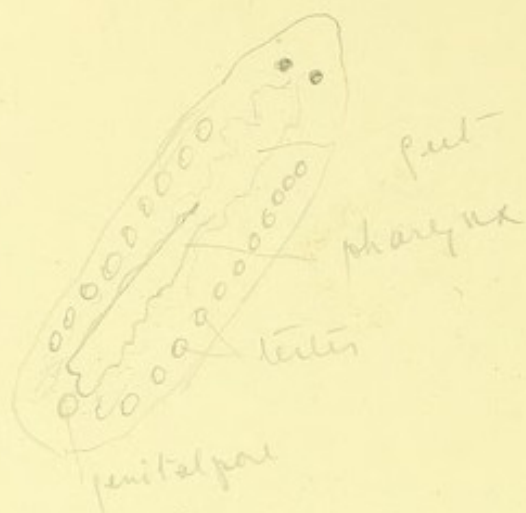


5. An Ascidian tadpole of **Ciona** or some other Tunicate.
6. Transverse section of **Ciona**. Test; body wall with longitudinal muscle bundles; atrial cavity; pharynx with stigmata; endostyle and hyperpharyngeal groove; rectum and generative ducts.

7. Demonstration specimens of other Tunicata.

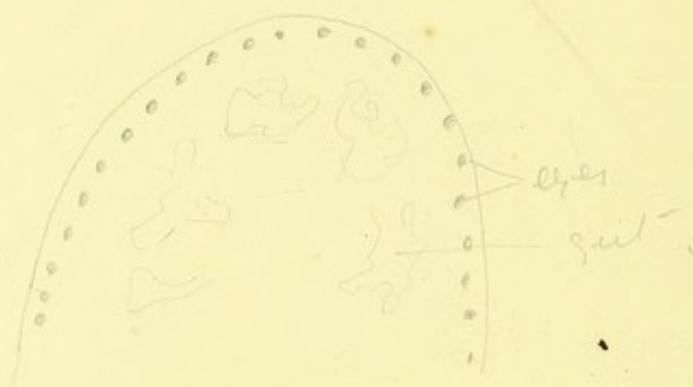
Demonstration specimens of **Balanoglossus**.

Amida segmentata - segmental testes



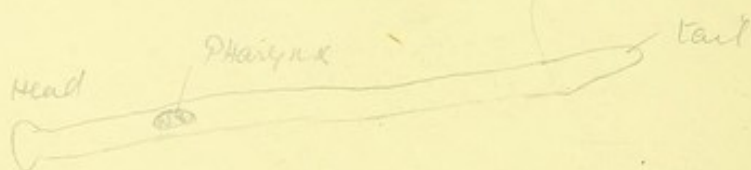
Lycelis nipa

a fresh water form, note ring of eyes & branched pharynx



Palium

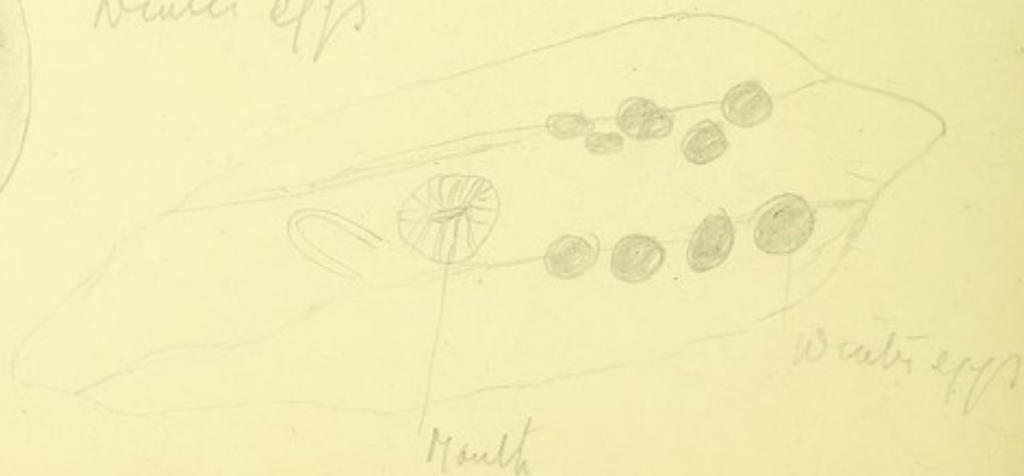
a terrestrial form found in greenhouses



Adocaelida
Desostium

fresh water form in
the summer & winter
forms, the former have
shell & under so develop
in the body of the parent
winter eggs have a thick shell
able to withstand adverse conditions

Winter eggs



PLATYHELMINTHES.

1. **Dendrocœlum.** A fresh-water Triclad; naked eye or simple lens. Eyes; pharynx; terminal portions of generative ducts; enteric cæca.

2. The same compressed with low power to show the organs more in detail. With high power observe cilia and rhabdites.



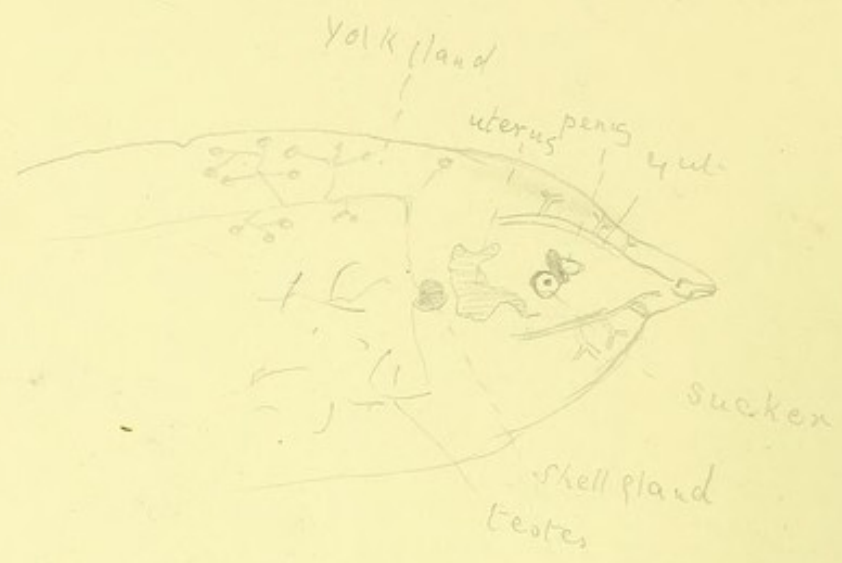
TURBELLARIA

3. Transverse section of a **Planarian**, through pharyngeal region (low power:—the details to be drawn with a high power). Pharynx; pharynx-sheath; epidermis; enteric cæca; longitudinal nerve-cords; testes; yolk-glands.
4. Demonstration specimens of other Turbellaria.

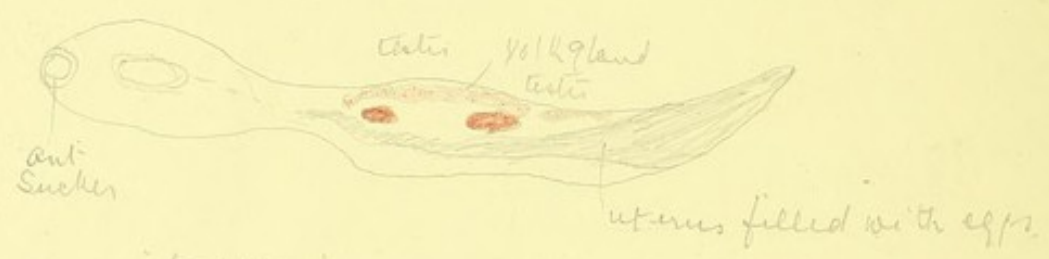
PLATYHELMINTHES

TREMATODA

retary system
rising in network
to terminal aperture



Macrodora longicollis - a common parasite in the lungs of the Grass snake



Polystromum interperimum from bladder of frog

pharynx in front
disk with circles
suckers behind



TREMATODA

1. **Distoma**, the liver fluke. (Simple lens.) Anterior, ventral sucker; genital pore.
2. Another specimen stained and mounted. (Low power.) Testes; ovary; yolk-glands; uterus; shell-gland.

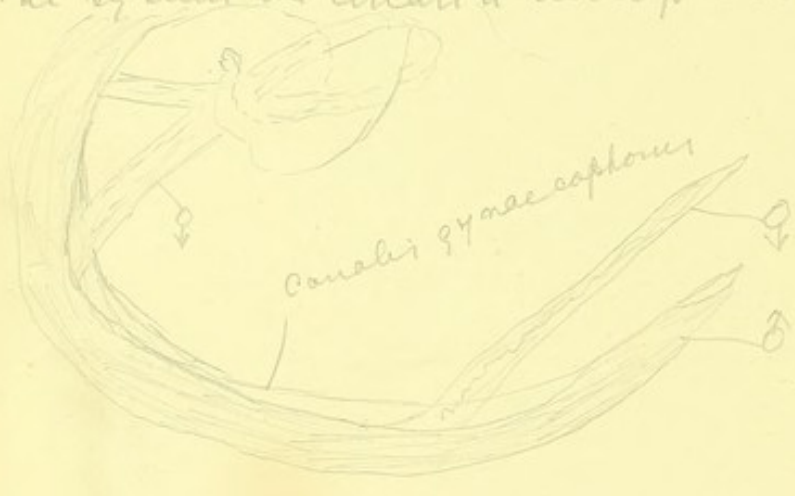


ectobothrium an ectoparasite from the gills of the Whiting.



Claryzia causes "Bilharziasis" very common in Egypt.

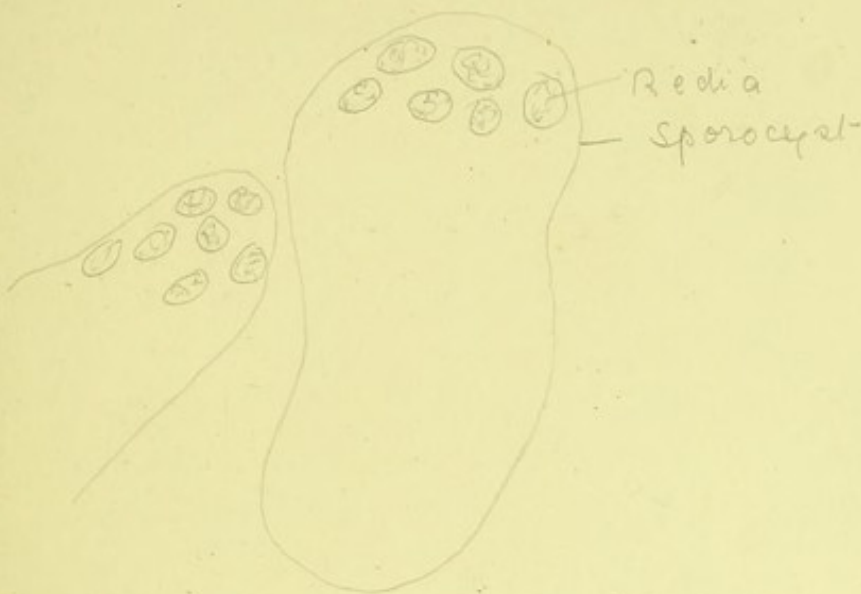
The ♂ is considerably larger than the ♀ & carries the latter in a ventral pouch of its body. The adult is found in the mesenteric veins. The ♀ separates from the ♂ when ripe & lays its eggs in the cavity of the portal vein: by means of a sharp spine the eggs penetrate the wall of the vein & eventually reach either the liver or the rectum. They do not develop unless they enter a snail (freshwater). Planorbis. In the snail they develop into typical Cercaria which swims away into the water by means of their tails. By exposing themselves to fresh water, either by drinking or bathing, the Cercaria are able to penetrate through the skin of man & proceed by the blood stream to the portal vein system via the heart & lungs. In the portal system the Cercaria develop into adult worms.



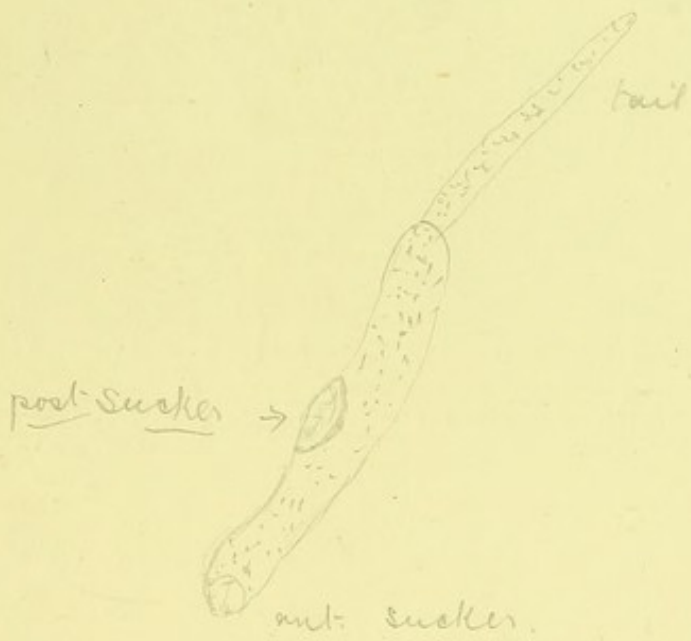
Wall of bladder (human) heavily infested with eggs of Bilharzia

3. **Redia** of **Distoma**. (Low power.) Pharynx; contained Cercariæ.
4. **Cercaria** under high power, with suckers and tail.
5. Demonstration specimens of other Trematoda.

3

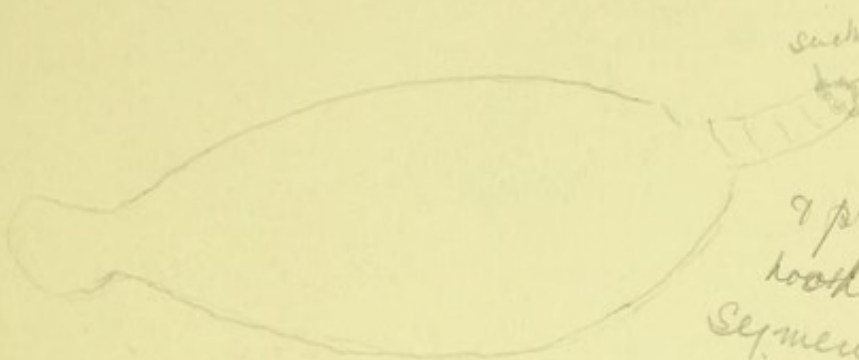


4



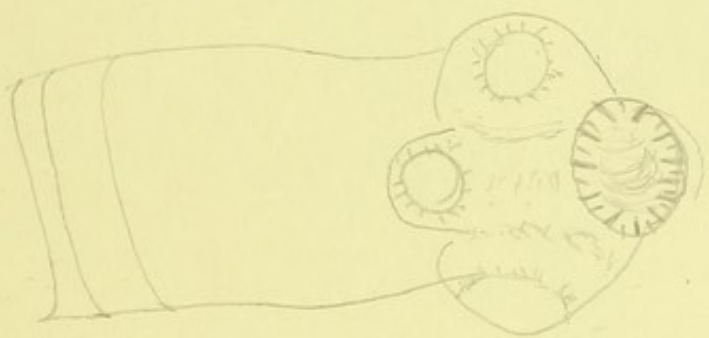
CESTODA

1. **Tænia.** View of head and anterior proglottides as an opaque object. Scolex with suckers and hooks; proglottides with genital apertures; zone of proliferation of new proglottides.
2. Young proglottis stained and mounted as a transparent object. Large and small excretory canals; testes and vas deferens; ovary, uterus and vagina.
3. Older proglottis. Large and much branched uterus with fertilised thick-shelled eggs.



suckers
hooks
Tænia serrata
Cysticercus
observe that head is
provided with a pair
of suckers the first
segments of the body are clearly
visible

Head of Tænia



taenia marginata worm lives in the intestines of the wolf
the dog & attains length of $\frac{1}{2}$ - 3 meters. The cysticercus
larva infects the peritoneum & liver of the pig & man
nauts

taenia echinococcus. The worm lives in the intestines of
the dog, the eggs are transferred to man by licking
the eggs develop into large cysts. The cysts are known
as "hydrated cysts" & usually cause the death of the host
which is usually an ungulate. The adult worm is
small & has only 4 proglottides, it occurs however in
vast numbers in the intestines of dog,

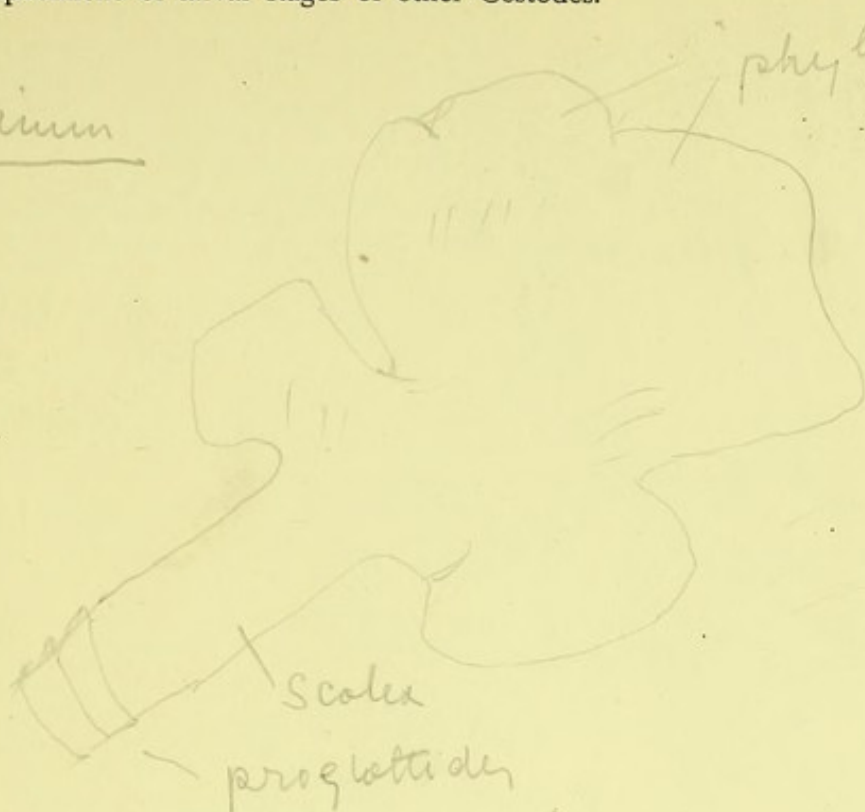
taenia serrata - Adult form in the dog, the cysticercus
is Cysticercus pisiformis & is found in the mesentery
of the rabbit.

taenia coenurus - found in the ileum of the dog; when the
eggs are swallowed by a sheep they migrate into the brain
become Cysticercus, & cause disease - "Staggers". The cysticercus
produces several heads, which in turn give rise to mature worms
in the third day. Cysticercus produces asexually by budding, the
tapeworm produces sexually.

4. **Tænia.** Transverse section through a proglottis. Cuticle; nuclei of ectoderm withdrawn into superficial layers of parenchyma; circular muscle fibres; large and small excretory canals; longitudinal nerve cord; testes with developing spermatozoa; uterus with fertilised eggs; yolk-glands.
5. **Cysticercus** stage of **Tænia.** Scolex with hooks and suckers; young proglottides; bladder.

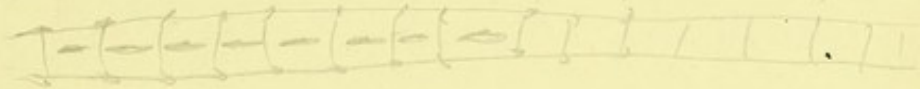
6. Demonstration specimens of larval stages of other Cestodes.

Philocobothrium



Parasitic rays
the phyllidia
are outgrowths
the scolex & con-
part of the excretory
network

Bathriocephalus latus Found in the human intestine, the history is not completely known, but it is probable that infection by eating Pike (the worm is fairly common in the Baltic provinces, where it is a favourite fish)

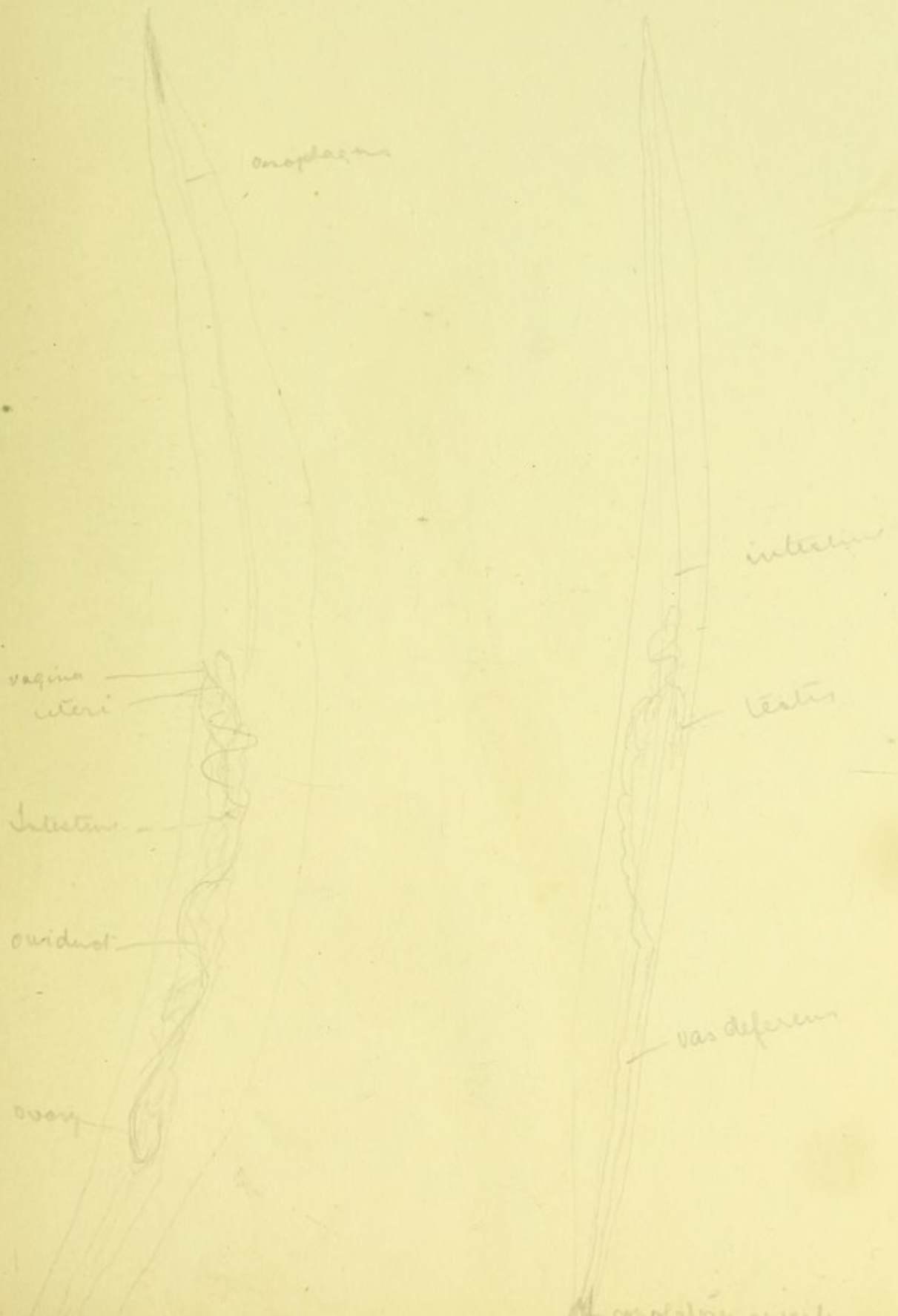


Shistocephalus. Stickleback (*Gasterosteus*) infected by an advanced larva of *Shistocephalus*. Adult worm lives in the intestines of *Tanus*

NEMATODA.

1. **Ascaris.** Female dissected. Oesophagus; intestine; vagina dividing to form the two uteri, which pass backwards to the hind end of the body where they bend round and are continued forwards as the slender oviducts. The oviducts soon become continuous with the convoluted ovaries.

Male dissected. Oesophagus, intestine as above (hind end of intestine pinned on one side); vas deferens passing into testis—a convoluted tube; copulatory spicules in sheaths.



2. Transverse section of **Ascaris**. (Low power.) Cuticle; epidermis; layer of longitudinal muscles; large lateral line of granular matter continuous with the epidermis and containing the excretory canal; less conspicuous dorsal and ventral lines with nerve cords; intestine (or œsophagus); sections of ovary or testis; section of the two uteri; or section of vas deferens.

3. Transverse section of muscular fibre of **Ascaris**. (High power.) Contractile cortical layer; granular inner mass; (nucleus).

4. Other Nematodes, free-living and parasitic, as demonstration specimens.

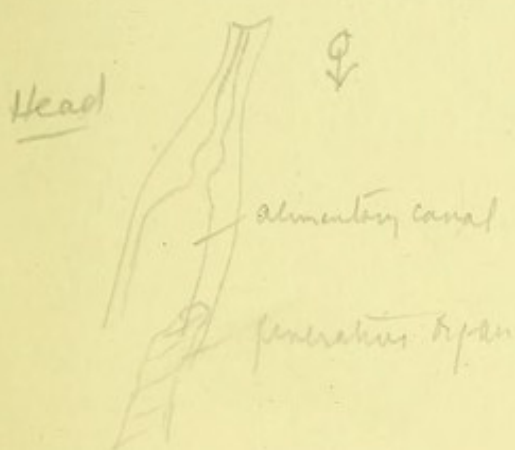
Trichinella bancrofti



Microfilaria in blood



Oxyuris antiqua



Trichina



Degeneration of muscular tissue
round each cyst-

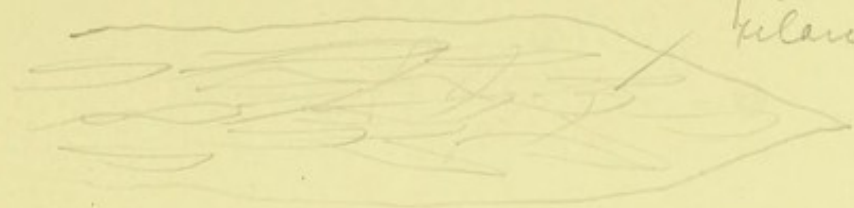


Pathology Oxyuris vermicularis in caecum & rectum in man
enters to enter body in fruit & vegetable



Wilaria immitis (The Cruel Worm)

Heart of dog showing infection of Rt. Ventricle



Wilaria immitis

Arachnida

Arachnida has chelicerae 

internal fertilisation & sometimes viviparous
female kills male after fertilisation

there are 2 or 3 or 4 pairs of spinnerets

Spider - Araneida

Arachnida Arachnida

Mites

