Invertebrate Zoology Course Materials 1937

1937

Keys to forms
by
Laboratory Directors
Invertebrate
Course
1937.

Combined list of
Forms taken on
Trips 1937.

Stored with Reprints
under heading Laboratory
Marine Biological
Marine Invertebrate Course

Invertebrate Zoology

Laboratory Study of the Protozoa.

The following directions are merely indicative of the plan of the work and variations are acceptable. The organisms mentioned below are marine protozoa with the exception of the intestinal flagellates of the Termites. Directions for the study of some of the protozoa listed below are given in Drew's, Invertebrate Zoology.

1st day. A . M. Free living Protozoa.

(1) Examine old colonies of Obelia, Tubellaria, Sertularia, or Pennaria (Coelenterates), and Filamentous Algae, taken from wharf pilings, for representatives of the class Suctoria, i.e., Ephelota, Podophrya, and Acineta. Vorticella, Zoothamnium, and Cothurnia (Ciliata) are among the stalked forms which will also be found.

1st day. P.M.

(2) Examine cultures of protozoa from marine habitats and also slides and syracuse dishes which have been standing in old hydroid material or in running sea water for a week or more. The following are some of the forms which may be found: Urostyla, Foraminifera, Dinophysis (Dinoflagellate), Uronychia, Discocephalis, Holosticha, Tintinnopsis, Anisonema, Pelomyxa, Lacrymaria, Euplotes, Gastrostyla, Pleuronema, Strombidium, Trachelocerca (2 species), Philaster, Folliculina, Heliozoa, Dysteria, Aspidisca, Diophrys, Lembus, Allagronia, Protocurcia, Raphidiophrys, Nassula, etc.

(3) Preserved Noctiluca.

Identify and make recognizable sketches of (or describe) as many different Protozoa as time permits, include both stalked and free-swimming forms. Include data on the source of the culture, behavior of the animals, and classify according to Drew, revised edition, 1936. At least six individuals should be carefully studied.

(4) Cultures from brackish water sources are available to those who may care to examine them.

2nd. day. A. M. and P. M. Symbiotic, Commensal, and Parasitic Protozoa.

Association of certain marine Protozoa with marine hosts of this vicinity. The following are available for study:

(1) Commensals.

Example	Host	Location
Folliculina sp.	Limulus Bdelloura	Gill books Egg cases of Bdelloura
Lichnophora sp.	Crepidula Annelid worms Molgula	Egg cases Surface of body On eggs
Ancistruma mytili	Mytilus edulis	Mantle cavity
Ancistruma isseli	Modiolus modiolus	Mantle cavity
Conchophthirius mytili	Mytilus edulis	On muscles & foot
Boveria sp.	Teredo navalis	Gills
Chilodonella hyalina	Orchestia agilis	Carapace
Allosphaerium palustris	Orchestia palustris	Carapace

(2) Parasites.

Ceratomyxa sp.	Puffer (fish)	Gall bladder
Anoplophrya orchestii	Orchestia agilis	Lacunae (blood vascular spaces)
Trichodina sp. (2 types)	Thyone briareus	Digestive tract
Schizocystis sipunculi	Phascolosoma gouldi	Intestine
Haplozoan (Dinoflagellate)	Clymenella	Intestine
A Sporozoan & a ciliate	Hydroides	?
Orchitophyra stellarum	Asterias	Gonad

(3) Symbionts.

Trichonympha sp.	Termites	Intestine
Dinonympha sp.	"	"
Pyrsonympha sp.	"	"
Spirotrichonympha sp.	"	"

Study carefully and draw (or describe) at least six of the above forms, only one from any particular host. Examine as many others as time permits. Include with each drawing the following data: Clissification, host, behavior, and location in host.

All drawings and reports are due tomorrow morning at 9 A.M.

DIRECTIONS FOR SECURING LABORATORY PROTOZOA

Termites

Grasp the head of the termite in one forceps and the tip of the abdomen with the other. Pull the latter gently. By this means the intestine can be pulled out of the body. Tease it gently and add a drop or two of .5% saline solution. The intestinal Flagellates are abundant. The genus Trichonympha is largest, compact and has a spiral structure of the pellicle. Dinonympha is next largest and is flask shaped with the pointed end the anterior. Pyrsonympha is smallest and moves in a corkscrew manner. Spirotrichonympha is compact and has a spiral structure of the pellicle.

Orchestia agilis

Crush the animal on a slide and add .5% saline solution or sea water. Anaplophrya orchestii is small but abundant in the infected host. Examine a leg. In an infected host, the lacunae will be packed with the parasites.

Crepidula fornicata

Separate the individual animals and if present the egg masses will appear as yellowish or dark greyish masses on top of the shell to which the female was attached. Remove to a slide, cover, and examine with low power. Other ciliates are often present.

Modiolus modiolus

Cut the muscle by inserting a scalpel between the valves. Pry apart but do not separate. Wash the surface of the mantle cavity and foot into a syracuse dish by means of a pipette. The ciliate remains quiescent and can be easily studied, or can be transferred to a slide.

Mytilus edulis

Open in the manner described above for Madiolus. Two ciliates will be found if the host is infested. The smaller and more numerous ciliate is Ancestruma. It looks like the form found in Modiolus. Conchophthirius is much larger and less abundant. It sticks to the bottom of the dish or to the surface film.

Suctoria, Folliculina, Heliozoa, etc.

These will be found attached to bolamentous algae or to Hydroid colonies such as Tubullaria, Sertularia, Pennaria, Obelia, etc. taken from wharf pilings. Examine pieces in a syracuse dish or on a slide with low power. Another method is to stick glass slides down into the mass of hydroids in the culture dish a week or more before desired. Among the material attached to the slides will be found (perhaps) Suctoria, Vorticella, Cathurnia, Folliculina, Radiolaria, Zoothamnium, Heliozoa and many free-swimming forms. Another method is to suspend glass slides in the Eel Pond. Folliculina may also be found on the egg cases of Bdelloura on the gill books of the Horse-shoe crab - Limulus.

Teredo navilis

Tease the gill lamellae found on the end of the animal near the valves. Mount fluid on a slide. If Boveria are not found, repeat on another animal.

Phascolosoma gouldi

Remove the intestine, open it and wash the contents into a syracuse dish. Transfer the parasites to a glass slide.

Clymenella Torquata

Similar directions as for Phascolosoma. It may be easier to slit the animal longitudinally and wash into a syracuse dish, or to chop up pieces of it.

Thyone briareus

Place the animal in a weak ammonia solution (2%) and, when it softens slightly, return it to sea water. The animal will immediately eviscerate the alimentary tract. Cut off portions, open, and wash contents on a slide.

Hydroides

This annelid inhabits a hard tube attached to old shells, rocks, etc. Remove the tube with a scalpel, break gently so as not to injure the worm and remove it from the tube by gently drawing it through the pieces. Gametes are shed immediately during the breeding season. The parasites may be found among the germ cells or slit the animal longitudinally and wash out the contents. Identify the parasites, if present.

Free-living Protozoa. Marine and Brackish water Forms.

Lillie's Ditch is a good source for brackish water forms. Secure some of the muck from the bottom and let it stand in a culture dish for several days.

Marine Protozoa will be found in cultures taken from the bottom of the Eel Pond, from wharf scrapings in the buckets of old Hydroid material, and on the slides and syracuse dishes which have been immersed in the hydroid material or in running sea water for a week or more.

Puffer

Open abdomen and pull out the liver. Grasp the gall bladder at the neck with a pair of forceps and pull it away. Open it on a slide and scrape inner surface with a scalpel.

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PORIFERA August 2, 1937

Make a habit sketch of Leucosolenia.

Study Leucosolenia to learn something of character of the body wall. Add a few drops of carmine suspension. Can you observe any water currents?

Make a study of dissociated cells of Microciona and of the cell aggregates which appear soon after the dissociated cells have settled onto slides. In so far as possible determine the method by which the cell aggregates are formed. Look at your material a few times during the evening.

Study living specimens of Sycon. Follow directions in Drew (p.37-40). Only living material need be studied. It is very necessary that you cut the sections as thin as possible. If possible examine choanocytes. At any rate, you should be able to find embryonic stages. Look for an Amphiblastula. Draw such stages, etc. as you may find and consider interesting.

* * *

References

For the above work you may find it advantageous to refer to

Wilson H. V. and J. T. Penney (1930). The regeneration of sponges (Microciona) from dissociated cells. Jour. Exp. Zool. 56, page 73.

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(1925b) Regeneration after dissociation (an experimental study of sponges) II. Histogenesis of Microciona prolifera, Verr. Jour. Exp. Zool. 42, page 223.

All records of your work on the Porifera are due not later than ~~Friday~~, August 3, 1937.

Tuesday

Directions for the Work on the Coelenterata.

CLASS: HYDROZOA.

I. Examples of the GYMNOBLASTEA. (Anthomedusae).

This group is characterized by the absence of hydrothecae and gonothecae in the hydroid generation. The gonads are developed upon the manubrium of the medusae.

A. EUDENDRIUM.

1. Obtain a portion of a colony and examine. Observe such structures as hydrorhiza, hydrocaulus, perisarc, coenosarc, hydranth and gonosome. Make a colony sketch and label the various structures.

2. Focus upon a nutritive zooid. Observe the various parts. Draw and label.

3. The gonosome. (a). Observe a male colony. The gonophores form verticils just beneath the tentacles of a hydranth. Each verticil is composed of a number of gonophores. Each gonophore is composed of two or more chambers (sporosacs) in linear series, and is consequently classified as a multiple sporosac. The distal sac is the primary sporosac, the next proximal the secondary sporosac, etc. Draw a verticil under low power and a gonophore under higher power noting the spadix, gastrovascular cavity, sac contents, ectoderm, entoderm, etc. (b). Study a female colony. The female gonophores are readily distinguished from those of the male. They consist of clusters of peculiarly modified (?) medusae attached to the hydranth or to the stem. They are orange in color. Draw a cluster of gonophores under low power, and a single gonophore under higher power. Observe the distally bifurcated spadix partially encircling the egg.

B. PENNARIA.

1. Obtain a portion of a colony. Observe, sketch, and label.

2. Study an individual hydranth. Note the arrangement of the filiform and capitate tentacles. The latter have an oval shaped nematosphere at their distal ends. Observe the relation of the gonophores to the hydranth body. Draw and label a hydranth.

3. Remove a hydranth (if possible, remove a tentacle or two of the capitate variety and the same number of the filiform tentacles, and examine the tentacles only) and place on glass slide in a little sea water. Study the arrangement of the nematocysts on the tentacles. Are the tentacles hollow or solid? Add a drop of methyl green to your preparation, cover with a cover slip and press gently. Examine under low and high powers. Draw discharged and undischarged nematocysts, especially those of the nematosphere.

4. Obtain male and female colonies. Observe the gonophores. These are borne on the hydranth just distal to the filiform tentacles, and consist of medusae with rudimentary tentacles. The female gonophores when mature contain several opaque or pinkish eggs. The gonophores of the male are whitish in

appearance. Tease apart male and female gonophores and examine the germ cells. Draw and label male and female gonophores, noting rudimentary tentacle bulbs, velum, manubrium, radial canals, etc.

5. The eggs are shed into the water where they are fertilized. If you are interested, set aside small portions of the male and female colonies in a finger bowl. Examine from time to time during the next 24 hrs. for free swimming medusae and embryos in various stages of development.

C. TUBULARIA.

Study as outlined in your text.

D. HYDRACTINIA AND PODOCORYNE.

Examine specimens of Hydractinia colonies. Follow the directions in your text (Drew). Draw a portion of a colony showing nutritive, reproductive, and spiral zooids. Observe that there are two varieties of the latter, one of which is long and slender and does not coil as completely or respond to stimuli as readily as the other type of spiral zooid. Show the sporosacs attached to the reproductive zooids.

Secure a specimen of Podocoryne and compare with Hydractinia. Draw any differences you may observe. Compare especially the gonophores (sporosac) of Hydractinia with the free swimming gonophore or Medusa of Podocoryne.

E. CLAVA.

Examples of Clava are in the laboratory. Secure a specimen and study. Sketch. Label.

F. BOUGAINVILLEA.

In addition to the instructions given in your laboratory text, note the manner of growth in the Bougainvillea colony. Refer your drawings and notes pertaining to this matter to section III below.

II. Examples of the CALYPTOBLASTEA. (Leptomedusae).

This group is characterized by the presence of hydrothecae and gonothecae. The gonads are developed along the radial canals of the medusae.

A. OBELIA.

1. Secure a specimen of Obelia in the living or preserved condition. Observe the features pointed out in your text. Draw a colony, labelling all structures including annulations, nodes, and internodes.

2. Study a gonozooid (blastostyle) under low and high powers and observe as much of the structure of the gonophores (medusae) as possible. Tease open a gonangium of a mature gonozooid and endeavor to liberate the medusae. If they are mature they will probably show swimming movements. Draw a gonozooid showing its attachment to the colony. Draw a free medusa in the living or preserved condition.

B. CAMPANULARIA

The trophosomes of the two genera, Campanularia and Obelia, are very similar. It is difficult to distinguish these two genera by means of the trophosomes alone. The gonozooids and gonophores serve to separate the two genera most readily. (see 2 below)

Of the two species of Campanularia most commonly found in the vicinity of Woods Hole in the summer, C. calceolifera and C. flexuosa, C. calceolifera has a notch on one side of the distal end of the gonangium, while that of C. flexuosa is somewhat similar to that of Obelia with the exception that the distal end of the gonangium is not constricted to form a "shoulder and collar" as is common in Obelia.

1. Secure specimens of these species and draw portions of the colonies, noting the above features with regard to the gonosomes.

2. Unlike the ultimately free and fully developed medusae which are always developed on the blastostyles of the various species of Obelia, the medusae developed on the blastostyles of the Campanularia are undeveloped, remaining in a more or less degenerate (?) condition similar to the sporosacs of Clava, Hydractinia, etc. From these sporosacs free swimming ciliated embryos called planulae are liberated. Try to liberate planulae by means of needles. If you succeed, draw a planula and any of the earlier stages you may secure.

C. SERTULARIA.

Obtain a specimen of Sertularia. Observe the general relation of the sessile hydrothecae to the stems. Sketch a portion of a stem showing, if possible, the expanded hydranths.

D. THUIARIA.

Obtain a sample of this genus. Study the hydrotheca and gonosomes. Draw a portion, being particular to show the gonosome with the acrocyst.

E. SCHIZOTRICHA.

Select a specimen and note the colony as a whole. Observe the sessile, adnate hydrothecae arranged on the upper sides of the hydrocladia. Study the internodes of the main stem and observe that the hydrocladia arise from the shorter internodes. Study a hydrocladium carefully and note internodes and hydranths. Note the nematophores--minute structures associated with the dydrothecae and along the main stem. They contain the sarcostyles. Lastly, observe the beautifully curved gonangia. Make drawings (low and high powers) to show the above features. Label.

Observe the manner of growth in Schizotricha and refer to section III below.

2. Obtain stages of the development of Aurelia. Draw the stages outlined on pages 39, 40, and 41.

II. An example of the STAUROMEDUSAE.

Obtain a specimen of HALICLYSTUS. Observe that the apex of the aboral side is attenuated into a peduncle or stalk; the margin of the umbrella is elongated into eight triangular marginal lobes; the tufts of tentacles on the marginal lobes; between the marginal lobes are situated the marginal anchors; within the subumbrella cavity may be seen the short manubrium and the mouth. To what stage in Aurelia might this Stauromedusan be compared?

CLASS: ACTINOZOA.

I. An example of the ACTINIARIA.

1. Obtain a specimen of the brown sea anemone, MERTRIDIUM, and work out its general morphology from the directions in your text. Make careful drawings of the various structures that you observe.

2. Study the reactions of a living Metridium as detailed on p. 42 of the text. Write up your observations and description of the experiment.

3. Make a study of the acontia under high power. Stain the nematocysts as directed above with methyl green. Draw the types you observe.

II. An example of the MADREPORARIA.

There are two corals found in the vicinity of the laboratory--the "star coral", Astrangia danae, and the "fleshy coral", Alcyoneum carneum. The latter is rarely seen in shallow water and is consequently rarely taken on field trips. The star coral is abundant in this region. It is the only stony coral which extends to any great extent into the temperate zone. Most of the stony corals are confined to the tropical and sub-tropical regions.

A coral polyp is a sea anemone which deposits lime salts at its base. These salts form a stony skeleton or other substance which is commonly called "coral" into which the living animal contracts. This skeleton is a product of the ectoderm. The calcareous exoskeleton in the stony corals usually takes the form of a cup called a corallite. The collective corallites of a colony together with other hard connecting substances which may be present, such as the coenenchyma, constitutes what is called the corallum.

Secure a specimen of the stony skeleton of the star coral. Note the following parts:

a. The theca. This is the outside wall of the cup.

b. The septa. Each septum forms a radiating partition

which proceeds inward toward the center of the cup. It may join with another septum before uniting with a central portion known as

c. The columolla.

Observe these features under the dissecting microscope and draw.

The septa are produced by invaginated folds of the three body layers which push into the various enteric alcoves. Each inpushing fold invades the enteric space between a mesenteric couple. (For a diagrammatic representation of this phenomenon see Parker and Haswell, Fig. 156.). The ectoderm of this invaginated portion secretes the calcareous material of the septum. This deposit is consequently always on the outside of the animal body. The theca is produced by the union of the lateral extremities of the calcareous septa.

Select a living specimen of Astrangia and study an individual zooid by means of a dissecting microscope. It consists of a column, oral disc, tentacles, and a mouth. Observe that the tentacles tend to be capitate, i.e., there is a rounded nematosphere at the end of each tentacle which is in reality a battery of nematocysts. Study the distribution of the nematocysts along the tentacles. The internal anatomy, with the exception of the modification produced by the invaginated septal folds, is essentially the same as that of the common anemone. Sketch.

Directions for the Work on Ctenophora

Your observations on the Ctenophora will be confined mainly to the living "Rainbow Jelly", Mnemiopsis Leidyi. It is generally found in the vicinity of Woods Hole during the summer months, sometimes in large numbers. Preserved specimens of Pleurobrachia pileus are in the laboratory, and if you desire, you may study this form. M. leidyi is a representative of the ctenophoran order Lobata while P. pileus belongs to the Cydippida. Directions for the study of the latter form are in your laboratory text.

Secure a specimen of Mnemiopsis leidyi in a finger bowl or in a stender dish and study the following general features:

A. General Features:

1. Shape. Observe that it is compressed laterally and that an oral pole and aboral pole is present.

2. Symmetry. What is meant by biradial symmetry?

3. Ctenophoral plates or combs. Observe number, extent, and general structure. In what direction is the beat propagated along the plates? What relation does this fact have on the direction of movement of the animal as a whole?

4. Oral pole. Observe the two oral lobes and four auricles. The latter are fringed by cilia more or less fused to form a mem-

brane. The mouth is slit-like, and at right angles to its long axis it has two mobile structures, the oral lappets. Aborally to each oral lappet, and situated in the region between the auricles you will observe.

5. Tentacular pocket and tentacular basal-bulb. Within the pocket you may observe a tuft of small tentacles and extending lateral in curved arcs are two ridges, the tentacular ridges, to which tentacles are attached. Each ridge continues to the base of an auricle. The basal-bulb is elongated and extends orally from the tentacular pocket area. In the young Mnemiopsis, the tentacular bulb is situated much nearer the aboral sense-organ and possesses an enlarged, well-developed tentacle. As the animal matures, the tentacular bulb migrates orally and becomes situated near the oral lappet. The enlarged tentacle is lost during this process.

6. The aboral pole and sense organ. The aboral pole is situated opposite the oral pole. It contains the apical sense-organ. You will study this structure in detail later.

7. The gastrovascular system. This system is complex. The mouth opens into the stomodaeum or stomach, a slit-like chamber leading aborally toward the apical sense-organ. It is lined by cells of ectodermal origin. Just below the sense-organ, the stomach opens into the infundibulum or funnel, the beginning of the entodermal portion of the gastrovascular system. The infundibulum is compressed laterally and at right angles to the stomodaeum. Extending aborally toward the sense-organ from the funnel is a tubular structure, the funnel-tube. It enlarges below the sense-organ. This enlargement can be studied to best advantage in lateral and aboral views. The infundibulum gives origin to eight canals, viz., four interradial, two paragastric and two tentacular canals. Each interradial bifurcates into two adradial canals which lead to the ciliary combs. The adradial canals leading to the bases of the auricles are known as the subtentacular meridional canals whereas the canals lying beneath the combs extending over the oral lobes are designated as the sub-ventral meridional canals. Each paragastric canal extends orally along the flattened surface of the stomodaeum to the oral lappet where it terminates blindly. Just before its termination the paragastric canal gives origin to two laterally extending vessels. Each of the latter vessels curves aborally and ultimately anastomoses with the subtentacular meridional canal at the base of the auricle. After making this anastomosis it continues distally over the inner aspect of the oral lobe where it eventually unites with a similar vessel from the other side of the animal. The branches of the paragastric canals, therefore, anastomose with the subtentacular canals and also form a continuous vessel surrounding the oral area of the animal. Each tentacular canal courses distally to the tentacular pocket and bulb, and bifurcates in the substance of the tentacular bulb. The two sub-ventral meridional canals of each oral lobe course distally over the outer surface of the lobe where they pass inward toward the mouth and soon unite on the inner aspect of the lobe.

8. The apical sense-organ. The apical sense-organ lies at the bottom of a deep depression at the aboral end of the animal. It does not lie within the animal and is a specialization of the ectoderm. The sense-organ consists of a specialized area, the

pole plate, and a small mass of concretions, the lithocysts, lying in a small depression of the elongated pole plate. These concretions are supported and covered by cilia. The covering cilia are fused and form a covering for the statocyst concretions. The apical sense organ is best observed from lateral and aboral views.

B. Special Features.

A more detailed and comprehensive view of the various structures noted above and others may be obtained by cutting the animal into smaller pieces and studying these pieces more particularly. If your specimen is a small one, make one transverse cut thru the animal about mid-way between the sense-organ and the mouth. Such a cut bisects the animal into an oral and an aboral portion. If your specimen is larger, make two cuts, one near the sense organ and one near the mouth. After making these cuts select the proper piece and continue your study, reviewing the various features already observed and in addition observe:

9. The mouth and its surrounding structures.

10. The cut surfaces thru the stomodaeum about halfway between the sense-organ and the mouth. Study the shape of the stomodaeum and observe the grooves along the lateral walls. Note, also, the position of the tentacular and paragastric canals.

11. The ctenophoral combs, structure of and relation to the gastrovascular canal system.

12. Excretory pores. Study the expansions of the funnel tube below the sense-organ. Conclusions?

Make drawings showing the above features.

GLOSSARY

ABORAL-- The side of the body opposite the oral or mouth side.

ACONTIUM-- Thread-like organ containing nettle cells in sea anemones.

ACRASPEDOTE MEDUSA-- A medusa without velum or diaphragm. Typical of the Scyphozoa.

ACROCYST-- An extra-capsular brood chamber or marsupial sac attached to the distal end of the gonosome in certain calyptoblastic hydroids.

ACTINOPHARYNX-- A term used for the throat in sea anemones. It is synonymous with stomodaeum.

ACTINOSTOME-- The external mouth of the actinopharynx.

ACTINULEA OR ACTINULA-- A specialized larval form having aboral and oral tentacles. It is developed in the medusa of tubularian hydroids. It ultimately gives rise to a new colony.

ADNATE-- Growing with one side adherent to a stem.

ALCOVE-- One of the compartments of the enteric cavity in sea anemones produced by the mesenterics.

ANNULATIONS-- The ring-like formations on the stem of certain hydroids.

BLASTOSTYLE-- The reproductive polyp or zooid (probably a degenerate hydranth or person) in certain hydroids. The gonophores (sporosacs and medusae) are developed on the blastostyle. In some forms, e.g. Tubularia, a coenosarcal outgrowth of the hydranths called the "false-blastostyle" gives origin to the medusoid bodies.

CAPITATE TENTACLE-- One that is enlarged or globose at its distal end.

CALYPTOBLASTIC-- A condition in which a protective extension of the perisarc forms around the nutritive and gonozooids.

CINCLIDES-- Minute openings in the body wall of anemones thru which the acontia are thrust out.

CNIDOBLAST-- Stinging cell in Cnidaria containing the nematocyst or thread capsule, a minute stinging organ.

CNIDA-- Synonymous with nematocyst.

CNIDOCIL-- The sensory cilium or process projecting from a cnidoblast cell. Its stimulation causes the ejection of the thread-like stinging structure from the nematocyst.

COENOSARC-- The common flesh-like substance joining the various zooids of a colony.

COENENCHYMA-- A term applied to the soft common body mass of tissue in alcyonarian colonies. It is also applied to the hard skeletal parts joining the corallites of a colony of stony corals.

COLONY-- The various zooids connected by a common coenosarc.

COPPINIA-- A mass formed of a close aggregation of gonangia among which are scattered protective hydrothecae. See family Lafoeidae.

CORALLITE-- The "cup-coral" or exoskeleton of a solitary coral polyp in the stony corals.

CORALLUM-- The skeleton of an entire coral colony in the stony corals. It comprises a number of corallites together with any exoskeletal material which joins the various individual coral cups together such as the coenonchyma.

CORBULA-- A highly modified branch or hydrocladium which forms a protective envelope for the gonangia in certain plumularian hydroids.

CORMIDIUM-- An assemblage of structures (or persons?) of a Siphonophoran colony consisting of 1.) a disc-shaped hydrophyllium, a protective structure covering the rest of the cormidium; 2) a gastro-zooid; 3) a dactylozooid; and 4) a gonozooid.

CRASPEDOTE MEDUSA-- A medusa possessing a velum; a veiled medusa. typical of the Hydrozoa.

DIAPHRAGM-- A basal shelf in the hydrotheca which forms a support for the hydranth.

ENTEROSTOME-- The inner aperature of the actinopharynx or stomodaeum which opens into the coelenteron, i. e., the gastrovascular space.

EPHYRA-- A young stage in the development of a scyphomedusan; the stage following the scyphystoma.

EXUMBRELLA-- The aboral side of a medusa.

FASCICLED-- Used in the description of a hydroid stem (hydrocaulus) when two or more stems are apposed together more or less intimately. The stems may be in a condition of loose contact or there may be actual communications between the stems. This condition is not to be confused with that where young hydroid stems grow over older stems or where parasitic hydroids grow on the stems of other hydroids.

GASTROVASCULAR CAVITY--The general digestive-circulatory cavity of the Coelenterata. The more central portions function as a digestive system while the more peripheral parts act as a circulatory system.

GASTROZOOID-- A feeding zooid of hydractinian and siphonophoran colonies.

GONANGIUM-- The protective chitinous covering of the blastostyle in calyptoblastic forms.

GONOTHECA-- Same as Gonangium.

GONOSOME-- A collective term applied to the generative zooids of a colony; a term which may be used to include both the gonangium and its contents, i. e., blastostyle, medusae, sporosacs, etc., and collectively to the medusae when produced as they are, for example, in Bougainvillea as evagination from various parts of the hydrocaulus.

GONOZOOID-- A reporductive zooid. See blastostyle.

GONOPHORE-- The specialized form which produces the sex cells. It refers to the medusa whether highly developed or vestigial as exemplified in the sporosac, and the intermediate stages between the sporosac and free-swimming medusa.

GYMNOBLASTIC-- A condition in which the hydrotheca and gonotheca are not formed around the hydranths and gonozooids, respectively.

HYDRANTH-- The nutritive zooid of a colony consisting of digestive sac, proboscis (hyperstome), mouth and tentacles.

HYDROCAULUS-- The stem of a hydroid colony.

HYDROCLADIUM-- The polyp bearing branchlets in the Plumularidae.

HYDROPHORE-- Saucer shaped hydrotheca in Halocidae.

HYDROPHYLLIUM-- See Cormidium.

HYDRORHIZA-- The root-like attachments of a hydroid colony.

HYPOSTOME-- The projection of the hydranth body which bears the mouth.

HYDROTHECA-- The chitinous covering for a hydranth in calyptoblastic hydroids.

INTERNODE-- That portion of a stem or branch between two joints.

LITHOCYST-- A marginal sense organ in campanularian medusae.

MANUBRIUM-- The hollow outgrowth supporting the mouth of a medusa.

MESENTERY-- A mesentery is a membraneous lamella or sheet having mesogloea for its middle layer and covered on either face by entoderm.

a). Perfect mesentery-- one that joins the actinopharynx.
b). Imperfect mesentery-- one that does not join the throat or actinopharynx.
c). Primary mesentery-- same as perfect mesentery.
d). Accessory mesentery-- same as imperfect mesentery.

MESENTERY PAIR-- Any two mesenteries which are of the same size and immediately adjacent to each other, with the retractor muscle of one partner occurring on the face nearest to the other partner. This means that the retractor muscles will tend to be contiguous. The arrangement of musculature in the directive pairs is the opposite of this. See below. Also see Parker and Haswell, fig. 156.

MESENTERIES-- DIRECTIVE PAIR-- These are the mesenteries attached to the siphonoglyphs. The retractor muscles occur on the face of the mesentery pair which is turned away from its partner.

MESENTERIC FILAMENT-- Thickenings of the free edge of the mesentery consisting of gland cells and nettle cells.

NEMATOCYST-- The stinging organ contained within the cnidiblast.

NEMATOPHORE-- The chitinous receptacle into which the defensive zooid (sarcostyle) retracts. See Plumularidae

NAMATOSPHERE-- The globose enlargement at the ends of certain tentacles and consisting of batteries of stinging cells.

NODE-- A joint in a branch or stem.

OPERCULUM-- A chitinous protective structure found on the hydrotheca of certain hydroids which closes the hydrothecal aperature when the hydranth is retracted within.

OTOCYST-- Same as lithocyst.

PEDICEL-- The stalk supporting a hydranth or gonozooid.

PERISARC-- The cuticular chitinous covering extending along the outside of the coenosarc.

PHYLACTOGONIUM-- An appendage of a hydrocladium which protects the gonangia of certain plumularian hydroids.

PLANULA-- The oval, ciliated, free swimming embryo developed directly from the egg and which later becomes attached at one end and forms the beginning of a hydroid colony.

POLYPITE-- Same as hydranth.

PROBOSCIS-- The hollow elevation which supports the mouth. An enlarged hypostome found in certain species of hydroids.

ROOT-STOCK-- A creeping stem from which the hydrocauli originate. It may be filitorm or have cross comunications with other root stalks.

SENSE-BULB-- Swelling, usually at base of a marginal tentacle of a medusa. Probably sensory in function.

SESSILE HYDRANTH-- Not having a pedicel.

SIMPLE STEM OR BRANCH-- One not fascicled.

SPIRAL ZOOID-- Defensive person found in Hydractinian colony.

SPIROCYST-- One of the types of nematocysts in sea anemones. The ejected thread does not penetrate but adheres.

SPOROSAC-- A sac that contains the generative cells-- an undeveloped (possibly degenerate) medusa.

STOLON-- Same as root-stalk.

TROPHOSOME-- Collective term for all nutritive zooids and accessory parts such as hydrocaulus, hydrorhiza, etc., that go to make up a colony.

VELUM-- Delicate membrane or "veil" stretched around margin of the bell opening in hydroid medusa.

ZOOIDS-- One of the individuals, more or less independent, that go to make up a colony. Zooids may be nutritive, generative, defensive, or sensory.

A KEY TO THE MORE COMMON HYDROIDS IN THE VICINITY OF WOODS HOLE

Carefully observe the specimen and note the presence or absence of the hydrotheca.

1. Hydranths unprotected by hydrothecae.
   Sub-order Gymnoblastea. A.
2. Hydranths protected by hydrothecae.
   Sub-order Calyptoblastea. B.

A. Key to the Families of the Sub-order GYMNOBLASTEA.
If the specimen is a gymnoblastic hydroid, observe particularly the type and arrangement of the tentacles, the shape of the hypostome, and the type of gonophore, i.e., whether it is a sporosac or a medusa.

a. Hydranths with scattered filiform tentacles; gonophore a sporosac. Family Clavidae. I.

aa. Hydranths with one whorl of filiform tentacles at base of hypostome.

b. Hypostome (proboscis) conical.

c. Colony not branched; zooids arise singly from common basal coenosarc. Found, generally, on shells inhabited by hermit crabs.
Family Hydractinidae. II
Family Podocorynidae. III

cc. Colony regularly branched; tree-like; gonophore, a free-swimming medusa (planoblast) formed on various parts of the hydrocaulus and not restricted to the hydranth body. Found on wharf-piling, etc. Family Bougainvillidae. IV.

bb. Hypostome trumpet-shaped; gonophore a sporosac.
Family Eudendridae. V.

aaa. Hydranths with proximal and distal set of filiform tentacles; gonophore a partially developed medusa.
Family Tubularidae. VI.

aaaa. Hydranths with capitate tentacles scattered over hypostome; gonophore a free-swimming planoblast (medusa).
Family Syncorynidae. VII.

aaaaa. Hydranths with single whorl of filiform tentacles around the base of hypostome and capitate tentacles scattered over body of hypostome.
Family Pennaridae. VIII.

B. Key to the Families of the Sub-order CALYPTOBLASTEA.
If the specimen is a calyptoblastic hydroid, observe the presence or absence of pedicels, and the arrangement, position and shape of the hydrothecae.

a. Hydrothecae sessile and adnate.
b. Hydrothecae arranged on both sides of branches.
Family Sertularidae. IX.

bb. Hydrothecae arranged on one side of branches only.
Family Plumularidae. X.

aa. Hydrothecae not sessile, a pedicel being present.
c. Hydrothecae well developed.

d. Hydrothecae bell-shaped (campanulate); hypostome of hydranth trumpet shaped.
Family Campanularidae. XI.
dd. Hydrothecae tubular or turbinate; hypostome not trumpet-shaped.
Family Campanulinidae. XI.

cc. Hydrothecae reduced and rudimentary being saucer or funnel-shaped; hydranth cannot be retracted completely within the hydrotheca.
Family Halecidae. XIII.

I. Family Clavidae. Key to Genera

a. Colony branching; fresh and brackish-water species.
Genus Cordylorphora.
One species found at Woods Hole, namely, C. Lacustris, on water plants, shells, etc., in ponds and brackish water.

b. Colony non-branching; polyps (zooids) rising singly from the stolon. Genus Clava.
One species, C.leptostyla, found in angles of and on branches of Ascophyllum. Zooids small and flesh colored.

II. Family Hydractinidae.

One species generally found in vicinity of Woods Hole, Hydractinia ochinata, on shells of small hermit crabs. May also be present on legs and shell of Limulus, piles, etc.

III. Family Podocorynidae.

The species, Podocoryne carnea, is sometimes found. The polyps are pinkish white in color and are very similar to those of H. ocinata. The main difference between the two species is that in P. carnea free swimming medusae are developed while in H, ochinata sessile sporosacs are produced; also, the defensive spines in Hydractinia are sharp, jagged and rough in appearance, whereas those in Podocoryne are smaller, smooth, and rounded at the tip.

IV. Family Bougainvillidae.
Genus Bougainvillia.

a. Hydranths with inconspicuous hypostome and with 15-20 tentacles; colony small; medusae with yellowish manubrium.

B. superciliaris.

aa. Hydranths with prominent hypostome and with 12-14 tentacles; colony approximately 2-8 inches high medusae with brick-red manubrium.

B. carolinensis.

Found on piles, rock-weed, etc.

V. Family Eudendridae

Genus Eudendrium.

a. Main stem fascicled, i.e. several stems or hydrocauli apposed to each other and compounded more or less intimately into one stem.

b. Branches and pedicles slightly annulated.

c. Hydranths and gonophores bright red; male and female gonophores borne on separate hydranths which are aborted (i.e., tentacles reduced or absent)

E. carneum.

Found on piling, Fucus, etc.

cc. Hydranths and gonophores of male vermillion or pink, those of female orange; female gonophore borne on hydranth which is slightly aborted, the male gonophore borne on hydranth which may show variation in extent of abortion.

E. ramosum.

Found on piles, etc. also dredged.

bb. Branches and pedicles strongly annulated. E. dispar. Dredged - sand and gravel bottoms.

aa. Main stem simple, i.e., not fascicled; colony small, 1 inch.

d. Gonophores borne on hydranths that are not aborted; hydranths and female gonophores white, male gonophores yellow. E. album.

dd. Gonophores at base of aborted hydranths; hydranths and male gonophores light green, female gonophores reddish. E. capillare.

NOTE: E. tenue, E. capillare and E. album "should probably be merged under E. capillare" - Hargitt, Am. Nat. vol. 25

E. capillare found on Mytilus, U. S. Fish, Com. Wharf.

VI. Family Tubularidae.

Genus Tubularia.

a. Perisarc of stems extensively annulated, annulations varying from deep to shallow. T. larynx.
Found on sea-weed and wharf-piling.

aa. Perisarc of stems not extensively annulated.

b. Hydranth large, may be inch in diameter, and having a proximal row of 30-40 filiform tentacles; stem may be deeply annulated at intervals. T. couthouyi.
Found generally only by dredging during the summer.

bb. Hydranth smaller, proximal row of tentacles 20-25. T. crocea.
Found on piles, wharfs, etc.

VII. Family Syncorynidae.

a. Colony slightly branched; perisarc well developed to base of hydranth body. Genus Syncoryne.

Our species, S. mirabilis, found in Woods Hole region generally during early spring on shells, sea-weed, etc., in shallow water. The gonophores are borne on the basal portion of the hydranth body as medusae which ultimately detach themselves and become free-swimming.

aa. Colony unbranched; zooids small and rise directly from the stolon; perisarc not well developed.

Genus Corynitis.

The species, C. agassizii, is found in deeper waters generally associated with Schizoporella unicornis (see Bryozoa).

VIII. Family Pennaridae.

Genus Pennaria.

One species, P. tiarella, of which two varieties are found, namely, the wharf-pile variety and the eel-grass variety. The stem in the wharf-pile variety is brown, that of the eel-grass variety blackish brown. The color of the hydranth is pink to red.

IX. Family Sertularidae.

a. Hydrothecae arranged in opposite pairs.
Genus Sertularia.

aa. Hydrothecae not strictly opposite; slightly alternate.

b. Hydrothecae bottle-shaped; margin usually without tooth; operculum of a single adcauline flap.
Genus Abiotinaria.
The species, A. abiotina, thrives in deeper waters of Vineyard Sound.

bb. Hydrothecae not distinctly bottle-shaped; margin may be smooth but often with one or two sharp teeth present; operculum of one abcauline flap or with two flaps. Genus Thuiaria.

The species, T. argentea, obtained on dredging trips in Vineyard Sound. It is a winter and spring species and the empty perisarcs are obtained during the summer months. Grows on shells, stones, etc. Sometimes found near tide line.

X. Family Plumularidae.

One species, Schizotricha tenella, commonly taken. Found on piles and wharves as a white fleecy growth of about 1-2 inches high.

XI. Family Campanularidae.

a. a. Margin of hydrothecea ornamented with teeth.

b. Small, glassy white colony, with little if any branching; margin of hydrothecae with teeth; gonangium corrugated producing Japanese lantern effect; free-swimming medusae produced.
Genus Clytia.

c. Stem unbranched or slightly branched; margin of hydrothecae with 12-16 teeth not deeply cut.
C. johnstoni.
Grows on Fucus, etc.

cc. Stem with irregularly arranged branches; pedicles long and slender annulated proximally and distally; hydrothecae with 10-14 deeply cut teeth; gonangium weakly corrugated.
C. edwardsi.
Grows on wharf piling.

bb. Colony branches profusely; gonangium not corrugated; Sessile medusae produced which are ultimately extruded from the gonangium but remain attached to the blastostyle to form "extra capsular sporosacs" extending from the top of the gonangium.
Genus Gonothyrea.
Our species, G. loveni, found generally in the Woods Hole region. The margin of the hydrotheca is ornamented with 12-14 deeply and pointedly cut teeth.

aa. Margin of hydrotheca without teeth; gonangium not corrugated (in Woods Hole species).

d. Gonangium with distal end produced into a definite collar-like aperature.

Genus Obelia.

c. Colony small, inch high or less; stem of zig-zag appearance with little branching; pedicles alternate and borne on shoulder processes of the internodes.

O. geniculata.

Found on Fucus, Laminaria, etc.

cc. Colony large and bushy; much branching

O. commissuralis.

Found on wharf-piles, etc.

dd. Gonangium without collar-like aperature.

Genus Campanularia.

f. Stem and main branches fascicled; pedicles arranged in vorticils.

C. vorticillata.

ff. Stem and branches not fascicled.

g. Colony small- one inch or less, little branching; distal end of gonangium open and not constricted, free medusae not produced; pedicles strongly annulated.

C. flexuosa.

Found on Ascophyllum, Fucus, etc.

gg. Colony 2-3 inches or more; distal end of gonangium constricted into a beak-like structure; hydranth has a trumpet shaped hypostome with about 20 tentacles.

C. calceolifera.

Found attached to Mytilus on piles, on wharfs, etc.

XII. Family Campanulinidae.

One species sometimes dredged in Buzzards Bay, Lovenella clausa. Found on mollusc shells.

XIII. Family Halocidae.

One species, Halecium halecinum, generally encountered. Grows thruout the Woods Hole region attached to stones, shells and piles in shallower waters.

Other species of Halecium sometimes found.

INVERTEBRATE ZOOLOGY

LABORATORY DIRECTIONS

Class Turbellaria:

BDELLOURA CANDIDA: (observe this worm in its natural environment on the gills of Limulus)

1. The Proboscis Mechanism:
Transfer a young individual Bdelloura from the finger bowl on your desk to a small drop of sea water on a slide. Add several drops of 7% alcohol and watch for pharynx protrusion. This usually occurs in most individuals within a few minutes. The musculature of the pharynx may later be clearly seen by examination under high power under a cover glass.

2. External Ciliation (taxonomic characteristic):
Demonstrate external ciliation by adding a drop of sea-water carmine suspension.

3. Detailed Morphology:
Using a medium sized Bdelloura, quiet by exposure for 1 minute to 7% alcohol. Then mount on a slide and hold in flattened position by a second slide.
Follow directions in Drew, pp. 49-52. Wherever it is conducive to increased clearness, make separate diagrams of the different systems of organs.

OPTINAL;

(a) Make a comparative study of the following Turbellaria in respect to gross morphology and taxonomy by orders:
Bdelloura, Syncoelidium, Eustylochus, Proceredes, Planocera.
(b) Observe active flame cells in one of the above mentioned forms. Flame cells only appear in well-flattened individuals.

Class Trematoda:

1. Adult Digenetic Trematode--Cryptocotyle lingua (Gull fluke)
For convenience of supply, this fluke has been introduced in quantity into the intestine of the domestic cat by feeding a cat with meals of cunner fins containing the metacercariae of the worm. Careful study of a small portion of the cat intestine furnished by the assistant will reveal several of these small, colorless flukes in living condition. Remove these flukes carefully and mount for observation in warm-blooded Ringer's solution.
Watch a few moments for egg discharge and then study the structure of the fluke for the following features: suckers, mouth, pharynx, osophagus, intestinal trunks, genital pore, uterus, ovary, seminal receptacle, vitelline receptacle, testes, vitellaria, excretory tubes, and excretory pore. Excretory tubules and flame cells become clear as the worm becomes maximally flattened.

Stained, mounted specimens will show some morphological details not easily seen in fresh mounts.

2. Egg discharge:

Procure one or more living frog lung flukes (Pneumoneces) from the assistant. Place these in cold, fresh water which will cause a discharge of most of the eggs from the uterus. Notice the effect produced by this method upon the worm as a whole. N. B. No records of this latter observation are required.

3. Larval Forms of a Digenetic Trematode:

A. Redia:

From the assistant, obtain a living specimen of Littorina litorea removed from its shell. If the liver is grayish, tease it gently and examine with a binocular. Rediae and cercariae should be numerous and may be transferred to a slide for study.

Being careful to locate an undamaged redia, notice the following features: oral sucker, intestine (very short), birth pore, and stages in cercaria development ranging from undifferentiated "germ balls" at the extreme posterior end of the redia to matuer cercariae near the birth pore at the anterior end.

Patient observation will show the release of cercariae from the birth pore.

B. Cercariae:

Morphology:

Obtain from the assistant a drop of water containing mature cercariae of Cryptocotyle that have been released in a finger bowl in which infected Littorina were kept overnight. To this material, add one drop of 1:2000 solution of neutral red solution and cover with a coverslip. As the cercariae become quiet, observe and draw to show mouth, sucker, pharynx, "penetration glands", cystogenous glands, germinal mass, excretory vesicle, eye-spots, and tail. Finer details are best seen under oil immersion in a flattened individual.

Encystment of Cercariae:

Place a small living Fundulus in a finger bowl 1/2 full of sea water. Add Cryptocotyle cercariae obtained from the assistant. Locate metacercariae in the fins of Fundulus several hours later. To a watch-glass filled with sea water, add first a piece of cunner fin and several mature cercariae (furnished by the assistant). Observe and describe the activities of the cercariae during encystment.

C. Metacercariae:

Study and draw metacercariae of Cryptocotyle as they appear encysted in a cunner fin.

Optional:- Remove a metacercaria from its cyst, mount and study.

1. Scolex:

Examine living scolices of Rhynchobothrium and Calliobothrium (both from the spiral valve of the smooth dogfish; and, if available, Crossobothrium from the sand shark. Look for bothria, hooks, suckers, proboscides with their sheaths and contractile bulbs, the unsegmented neck region, excretory tubes with adjacent

with adjacent flickering solenocytes, and nerve trunks.

Draw the scolices of Rhynchobothrium and one other of the above mentioned tapeworms.

2. Mature Proglottid (optional):

Compress a milky white mature proglottid between slide and coverglass and study, following Drew, p. 56, as far as possible. This study may be supplemented by examination of prepared slides.

3. Plerocercour (Cysticercoid):

The hexacanth embryo of the tapeworm, Otobothrium, from the Hammerhead shark, enters the body of the butterfish, its intermediate host. The cysticercoids are small white spheres in the dorsal body muscles. Tease a cysticercoid out of its sheath of host connective tissue and carefully tease it apart with fine needles. Cover and study in flattened position.

As the larva unfolds, draw to show the scolex bearing exceptionally fine proboscides like those of Rhynchobothrium.

NOTE: THE INDIVIDUAL DISSECTION OF EACH STUDENT SHOULD BE DEMONSTRATED TO AN INSTRUCTOR FOR CREDIT.

Phylum Nemathelminthes---Class Nematoda:

Follow directions on mimeographed sheets distributed with this outline to work out the detailed morphology of Metoncholaimus pristiurus.

Phylum Platyhelminthes-- Class Nemertea:

Amphiporus:

Follow the directions for Tetrastemma in Drew, pp. 57-58 in studying the morphology of this very similar form. The chief difference in gross morphology between the two forms consists of the larger number of eye-spots in Amphiporus.

Metoncholaimus pristiurus

This form is a free-living Nematode found in the mud in shallow salt water. It belongs to a large marine group, the Oncholaiminae (type genus, Oncholaimus, "tooth in the throat").

Preparation for Examination:

Study several specimens in a syracuse dish with a binocular dissecting microscope to observe the continual coiling and uncoiling characteristic of many Nematodes and to distinguish the blunt anterior from the more pointed posterior end. Note that some large specimens contain several large bead-like structures at about the middle of the body. These are eggs and indicate the animal is an adult female.

Place such a specimen in a drop of fresh water for one to two minutes until quiet and then mount at once in clear sea water. Flatten the animal slightly by removing water from under the cover glass. Under these conditions the worm should be quiet except for slow movements of the digestive tract which will help observations.

The Digestive System:

Note that the posterior end tapers very rapidly and is slightly curved. The anterior end tapers gradually. Along the sides of both ends are numerous sensory setae. At the truncated extremity of the anterior end is seen the mouth opening. Behind it is a short pharynx in which there are three sharply-pointed teeth, the onchia. The thick-walled tube running backward from the pharynx is the oesophagus. At its posterior end is a sphincter valve marking the beginning of the intestine, which is a yellowish-brown tube running throughout nearly the entire length of the body. Careful focussing on the anterior part of the intestine will show that its wall is composed of typical columnal epithelium. The inner ends of most of the epithelial cells are filled with granules which give the color to the intestinal wall. About halfway along the tapering tail (ventrally) is seen the anus and running forward from it at an angle is the rectum.

Tail and Spinneret:

The tail is first conoid and then cylindroid in the posterior fourth where it ends in a somewhat blunt, almost imperceptibly swollen, rounded spinneret showing internally the three slightly swollen ampullae of the three candal glands. The cement-like secretion of these glands is poured out of a minute pore at the extreme tip of the tail to be used in temporarily cementing the worm by the tail to the substratum. A spinneret valve (hemispherical posteriorly and tapering anteriorly) is fastened by a contractile fiber to the ampullae and the contraction of this fiber withdraws the valve to allow outflow of the secretion. The candal glands are ellipsoidal, arranged in tandem fashion from a point about five body diameters anterior to the anus to a point about 10 body diameters anterior to the anus.

The Excretory System:

This system consists of a single "renette" cell which is a fusiform, ventral cell located about four body-widths behind the neck. This cell is connected by the renette duct to a single, ventral excretory pore located about one-fourth the distance from the anterior end of the body to the nerve ring.

The Nervous System:

The chief concentration of the nervous system is the thick, semi-translucent nerve-ring which encircles the oesophagus about midway of its length. Before and behind the nerve-ring are numerous distinctly nucleated ganglion cells. Other ganglion cells may be seen along the ventral nerve and in connection with sensory setae of the tail may be seen in demonstration specimens stained with methylene blue. The longitudinal nerve cords are not well developed in Metoncholaimus.

The Female Reproductive System:

A short distance anterior to the large thick-shelled eggs, which are in the uterus, may be seen a row of cuboidal cells nearly as large as the diameter of the body. The most posterior of these cells, the oocytes, marks the posterior end of the ovary. From this point, anteriorly, the ovary continues forward showing progressively more advanced stages in egg development. The broad reflexed ovary is continuous with the much narrower oviduct which turns posteriorly to connect with the uterus near the posterior end of the ovary. Posteriorly, the uterus connects by a short, transverse vagina to the slightly elevated vulva, the ventrally located external opening of the female system.

The Domanian System:

This system is found only in the female. It consists of the following structures: A short distance anterior to the rectum are two large, clear, cross-striated tubes, the moniliform glands, which open posteriorly by separate pores. Anteriorly these tubes unite near the conspicuous, rosette-like uvette. From the uvette a tube runs to the intestine, and another tube, starting as a wide ampulla, soon narrows rapidly to form a thin tube, which joins the uterus in the vicinity of the vulva. The domanian vessels elaborate a copious, elastic, sticky, non-water-soluble secretion possibly utilized during copulation and also presumably to protect and preserve eggs after deposition.

Make a large drawing of a female Metoncholaimus to show as many of the above features as you have been able to identify.

The Male Metoncholaimus:

In the manner already described mount a male specimen and examine. The Domanian system is absent altho possibly represented by obscure homologous structures. The tail of the male diminishes suddenly in size at the arms and is armed with about ten small

"supplementary organs" ventrally located, which give the tail a serrated appearance giving rise to the specific name, pristiurus (saw-tailed). There are also about thirty short ventral sensory setae Supplementary organs and setae are alike sensory in function. The opening of the male genital system is just anterior to the anus. Extending forward from it are two slender, rod-like spicula, about seven times as long as the anal body diameter. There are two testes, the anterior testes and the posterior, extending in opposite directions along the middle third of the body. The two testes join the long vasdeferens which connects with the ejaculatory duct which in turn opens posteriorly thru the genital pore. In each testis there is a progression of stages in sperm development from the blind end of the testis toward the junction with the vasdeferens. Draw to show the male genital organs and the extreme posterior end of the male worm.

Variations in Polychaete Heads

A. Prostomium - Typically conical but exceptions, for example
   Glycera - elongate and annulate
   Nephthys bucera - approximately square
   1. Palps
      Large - Nereids, Aphroditids (scale-worms), Leodice, Syllis
      Much branched to form long, mobile filaments - Hydroides, Pseudopotamilla, Parasabella.
      Reduced or wanting in many forms.
   2. Tentacles
      Absent - Scoloplos, Aricia, Arabella, Lumbrinereis, and majority of forms outside of the Nereidiformia
      One - Sthenelais, Ninoe
      Two - Nereids
      Three - Lepidonotus, Harmothoe, Autolytus, Syllis
      Four - Nephthys, Glycera, Phyllodoce
      Five - Diopatra, Marphysa, Eulalia, Leodice
      Eight - Trophonia
      Numerous - Amphitrite, Lepraea, Polycirrus and most other Terebellids
   3. Eyes
      Absent - Aricia, Scoloplos, Amphitrite, Lumbrinereis, Pista, Nephthys
      Two - Chaetopterus, Eulalia, Phyllodoce, Marphysa
      Four (2 pairs) - Scale-worms, Syllis, Autolytus, Podarke, Nereis, Spio, Polydora
      Four (in a transverse row) - Arabella
      Numerous - Thelepus, Lepraea
      Numerous on branched palps - Parasabella, Pseudopotamilla
      Two to five - Arenicola

B. Peristomium
   Usually asetigerous but setae in Nephthys, Sabellaria
   Peristomial cirri rare outside of Nereidiformia but found in Spio, Polydora, Chaetopterus
C. "Head" includes several segments - Trophonia, due to forward growth of long, slender setae.

* * * * * * * * * *

Variations in Parapodia

A. Notopodium lacking - Phyllodoce
B. Notopodium reduced and neuropodial setae enlarged and set in a transverse row in body wall - Arenicola, Clymenella, Terebellids
C. Modifications of parapodial cirri
   1. Dorsal Cirrus
      Absent - Nephthys
      Degenerate - Glycera
      As gills
         Arborescent - Diopatra (Anterior part), Arenicola, Terebellids
         Short, simple - Scoloplos, Aricia, Spio, Polydora, Sabellaria
         Long, Slender - Cirratulus
      As elytra - some segments of Aphroditids (scale-worms)
   2. Both foliaceous - Eulalia, Phyllodoce

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A Key to the more common Polychaetes of the Woods Hole Region

Key

Scale worms - Scales on dorsal side of body.....I
Parapodial cirri broad and leaf-like; 4 pairs of peristomial cirri; color of worms, greenish.....II
Peristomial and dorsal cirri long and slender; 3 tentacles; 4 eyes; small worms.....III
Head with 2 small tentacles, 2 large palps, 4 eyes, and 4 pairs of peristomial cirri.....IV
Dorso-ventrally flattened worms with 4 very small tentacles; a deep cleft between notopodium and neuropodium with a small sickle-shaped gill depending from the notopodium.....V
Dorso-ventrally flattened, brownish worms with 5 prostomial tentacles in a row; small parapodia.....VI
Head with reduced or no appendages; parapodia small
A. Segments very long.....X
B. Segments relatively short.....VII
Two long peristomial cirri, usually curving over back like a pair of horns.....VIII
Long, slender filaments, usually on anterior end of worm, branching gills on one to three anterior segments of some.....IX
Numerous, long slender setae extending forward to enclose head; 8 tentacles, usually small.....XI
Worms identifiable by their hard cases.....XII
Peristomium projecting forward in the form of a collar to enclose a large crown of branching palps.....XIII

I

a. 12 pairs of scales.....LEPIDONOTUS
aa. 15 " " " .....HARMOTHOE
aaa. 100 or more pairs of scales
b. Black in color; usually found in Amphitrite tubes.....LEPIDAMETRIA
bb. Grayish color.....STHENELAIS

* * * * * * *

II

a. 4 prostomial tentacles.....PHYLLODOCE
aa. 5 " " , one mid-dorsal.....EULALIA

* * * * * * *

III

a. Tentacles and cirri segmented.....SYLLIS
Aa. Tentacles and cirri unsegmented.....AUTOLYTUS

* * * * * * *

IV.....NEREIS
a. Dorsal division of notopodium leaf-like
b. Jaws black.....NEREIS VIRENS
bb. Jaws light amber in color.....NEREIS LIMBATA
aa. Dorsal division of notopodium conical.....NEREIS PELAGICA

* * * * * * *

V.....NEPHTHYS
a. Setae light-colored.....NEPHTHYS BUCERA
aa. Setae black or very dark.....NEPHTHYS INCISA

* * * * * * *

VI

a. Large, branching gills on anterior segments; gills much reduced posterior to 25th segment.....DIOPATRA
aa. Branching gills begin at about 20th segment.....MARPHYSA

* * * * * * *

VII

a. Parapodia small; no gills; anterior end of prostomium rounded
b. No eyes on prostomium.....LUMBRINEREIS
bb. 4 eyes on prostomium.....ARABELLA
aa. Parapodia of medium size with gills; very pointed anterior end (prostomium).....GLYCERA
b. Each parapodim with one dorsal and one ventral unbranched gill.....GLYCERA DIBRANCHIATA
bb. Each parapodium with only a dorsal, branched, retractile gill.....GLYCERA AMERICANA

aaa. Parapodia and their unbranched gills form several rows down dorsal side of animal
b. Anterior region round in cross-section.....SCOLOPLOS
c. Gills begin on 26th segment.....SCOLOPLOS ROBUSTUS
cc. " " " 16th " .....SCOLOPLOS FRAGILIS
bb. Anterior region flattened dorso-ventrally; gills begin on 6th segment.....ARICIA ORNATA

VIII.

a. 5th segment elongate with row of deeply-set, short, heavy setae; other segments with slender setae on parapodia.....POLYDORA
aa. 5th segment not different from the others
b. Gills on all segments.....SPIO SETOSA
bb. Gills absent from posterior portion.....LAONICE VIRIDIS
(See also IX aa)

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IX.

a. Tentacular filaments (head region only)
b. Blood-red; no branching gills
c. Setae on first 25 segments only; parapodia small.....POLYCIRRUS
cc. Setae on all segments; branching, red parapodia in mid-body region.ENOPLOBRANCHUS
bb. Not slender; branching gills dorsal among filaments, on one or more anterior segments.
c. 3 pairs of branching gills
d. Setae on anterior part of body only.....AMPHITRITE
e. Setae on first 40 segments...AMPHITRITE ORNATA
ee. Setae on first 25 segments...AMPHITRITE BRUNNEA
dd. Setae extend to posterior end..LEBRAEA
cc. 2 pairs of branching gills
d. Setae on 4th-20th segments.....PISTA
dd. Setae on third segment to posterior end of body; the "Hydra-worm".....THELEPUS
ccc. 2 pairs of gills on a single base; look like one gill with four parts.....TEREBELLIDES
aa. 4 to 14 pairs of elongate dorsal cirri, beginning on 2nd segment; body usually brownish anteriorly changing to yellowish posteriorly.....DODECACERIA
aaa. Head bare; long dorsal cirri as respiratory organs on many segments of the body, especially numerous near the anterior end.....CIRRATULUS

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X.

a. Segmentation indistinct; branching gills on middle segments.....ARENICOLA
b. 11 pairs of gills.....ARENICOLA CRISTATA
bb. 13 " " " .....ARENICOLA MARINA
aa. Segmentation distinct; no branching gills; bamboo-appearance
b. Anus dorsal to a flattened, smooth, caudal plate; worms dark brown; live in mud-tubes....MALDANE
bb. Anus enclosed in collar with 20-25 cirri; 22 segments, 18 setigerous; live in sand tubes.....CLYMENELLA

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XI.....TROPHONIA

XII

a. Heavy, calcareous tubes, somewhat irregular.....HYDROIDES
aa. Tubes small, coiled, flat spirals; calcareous.....SPIRORBIS
aaa. Tubes long, rather slender cones of sand.....CISTENIDES

* * * * * * * * * *

XIII

a. Peristomium asetigerous
b. Collar notched dorsally; anterior region of 8 setigerous segments; worms small, encrusting sand-tubes.....PARASABELLA
bb. Collar without dorsal notch; live in small, parchment tubes among shells; dredged with Hydroides, etc.....PSEUDOPOTAMILLA

NOTE: Hydroides, when removed from its tube, may be confused with these. Hydroides, however, possesses stalked operculum.

aa. Peristomium setigerous; posterior portion of worm degenerate, usually folding back against anterior part. Usually dredged in Bryozoan nodules.....SABELLARIA

LABORATORY STUDY OF MULLUSCA

1937

The notebook should include well labelled drawings illustrating the chief anatomical features of representative forms as well as records of experiments and other observations.

1st. Day.

A. M. I. External characteristics, habits, etc., of the Amphineura, illustrated by Chaetopleura. Drew, pp. 142-143.

P. M. II. Anatomy of a Gastropod, Busycon.
Study hemisected shells and dissect freshly injected specimens. Do not draw the shell. Follow Drew pp. 143-152. Postpone paragraph 5, p. 150, until the second day.

III. Anatomy of a Nudibranch.

Examine any Nudibranchs that are available. Note the following:

Head. Number of tentacles. Are they retractile? Do they possess sheaths? Eyes. Mouth.

Body. Is there a distinct mantle present? Is the integument soft or are hard spicules present? What is the position and nature of the respiratory organs? Special organs may be entirely absent, respiration occurring through the integument (i.e. Elysia), or special organs may be present in the form of either adaptive gills surrounding a median dorsal anus (i.e. Doris) or rows of cerata which often contain extensions of the liver and also nematocysts derived from ingested hydroids. What color is the animal? Locate the anus and genital apertures if possible.

Foot. Note its width in proportion to its length. When crawling freely small animals frequently attach themselves to the under surface of the surface film. In such cases the activities of the foot may be readily observed.

Internal Organs. The extent to which the internal structures may be observed varies with different individuals. Usually the dorsal heart, the liver, and the large ovary may be observed, and possibly other details.

Eggs in various stages of development may often be found in the dishes with the animals.

Classify the animal.

2nd Day.

A.M. I. Egg laying, sperm shedding, and the formation of trochophore and veliger larvae of Cumingia. Drew, p. 141.

II. Activity of the radula and special dissection of the odontophoral apparatus. Follow Drew, p. 150, paragraph 5.

III. The foot of Polynices

Place in an aquarium of sea water and observe the gradual swelling of the foot. How much of the shell does it finally cover? Can you suggest how the sand collars are formed in which the eggs are laid? Stimulate the snail and explain how such an enormous foot can be withdrawn into the shell. Does water exude from the foot during its contraction?

Frequently veliger larvae may be obtained from the sand collars. If possible secure one and study. Later a comparison of the veliger of Cumingia may be made.

IV. If time permits the following experiments on the gastropod foot may be performed:-

A. The foot of Busycon.

Observe the foot as the animals are attached to the sides of the aquarium. How does it adhere to the glass? Note the character of the surface of the foot. Is it slimy? Examine thin sections of different regions of the foot cut with a razor from animals used in III. Are cilia present? Is the pedal gland present in both sexes? What is its function?

B. Activitiy of the foot of Alectrion.

Allow Alectrion to become attached to a glass plate. Observe with a lens the creeping surface of the foot. Do you distinguish rhythmic waves passing over the foot from end to end? Are cilia present?

By means of wax fasten Alectrion to the bottom of a Syracuse dish so that the creeping surface of the foot will be uppermost. Pour sea water into the dish until the surface film is level with the ventral surface of the foot. Observe the foot with a binocular microscope, noting ciliary activity, direction of movement of carmine particles, etc.

P.M. Anatomy of a lamellibranch illustrated by one of the following:- 1) Venus (Drew, p. 124); 2) Mya (Drew, p. 137): 3) Modiolus (Drew, p. 134); 4) Pecten (Drew, p. 136).

3rd. Day.

A.M. I. Finish dissection of lamellibranch.

P.M. II. Comparative study of the gills of Lamellibranchs.

Study the following types of gills:-
a) Protobranchia - Yoldia, Solemya or Nucula. (Drew, p. 134)
b) Filibranchia - Modiolus or Mytilus (Drew, p. 135)
c) Pseudolamellibranchia - Pecten, Ostrea. (Drew, p. 136)
d) Eulamellibranchia - Venus, Mya (Drew, p. 127)
e) Septibranchia - no representative here.

In each case particular reference should be made to (1) gross anatomy - number of gills on each side of the body, form of gill sheet, etc.; (2) gill filaments, shape, reflected or non-reflected, ostia, distribution of cilia, presence or absence of inter-filamentar, junctions and of inter-lamellar junctions. Study the gill filaments from mounts of portions of the living gill and also from stained sections.

III. As many of the following studies may be made as time permits:

A. Function of the siphons.

By using carmine particles suspended in sea water determine the direction of the currents of water thru the siphons of Yoldia (Drew p. 134, b) Mya (Drew p. 139) Cumingia, or some other available form.

B. Ciliary Mechanism of the Gills

Place powdered carmine particles on the gills of Mytilus, Mya or some other form. Do the particles move anteriorly or posteriorly? What conclusion do you draw as to the method of feeding? Do the labial palps take part in the feeding process?

C. Anatomy and Function of the foot of Pelecypods

1. Byssogenous foot. Mytilus or Modiolus

a. Follow Drew p. 124 sections 2 and 4.
b. Cut off the foot during expansion and mount in sea water on a slide. Note ciliary activity, muscular movements, and unicellular mucous glands containing yellow spherules.

2. Burrowing foot

a. Primitive type - Yoldia (Drew p. 133). Note especially its planter surface; compare with the foot of Chaetopleura and the gastropods.

b. More specialized type - Venus, Ensis, Cumingia, etc. For Ensis see Drew, p. 140, sec., 2 and 3. Also observe the burrowing act if possible in Cumingia, Venus, and others by placing on a sandy bottom in sea water.

c. Degenerate Foot - Mya, Ostrea.
Examine the foot of Mya or Ostrea and compare with the foot of Venus, Ensis, Cumingia, etc. Also compare with a byssogenous foot. Is a byssogenous foot degenerate?

4th Day.

A.M. Anatomy of a Cephalopod.

P.M. I. Study of small, living specimen. (Drew. pp. 140-141) Demonstration of feeding in adult squid.

II. Dissection of freshly injected squid. The specimens for study include both males and females as far as possible. Two males and two females should be dissected at each table and their anatomy compared. (Drew, pp. 140-151).

Note that after study of the "ventral" view of the opened female the nidamental glands must be removed. In both sexes the digestive and circulatory systems must be worked out concurrently: After observing the anterior vena cava this should be tied off, cut, and reflected to gain access to the liver and oesophagus; similarly after study of the kidneys these organs must be carefully removed to expose the stomach and systemic heart.

ARTHROPODA

1937

Tuesday, August 24:

A study of Homarus, Callinectes or Pagurus. Refer to Drew. (Injected specimens will be available in the afternoon for the detail of the circulatory system)

Wednesday, August 25:

A comparative study of some common Malacostraca. Use special direction sheet.

A study of autotomy in Uca. See special direction sheet for suggestions.

Thursday, August 26.

A study of the Nauplius larva (Artemia). Use special direction sheet.

A comparison of the mysis stage of the lobster with the adult Heteromysis.

The zoëa larva of the crab. (Polyonyx macrocheles).

The activities of Balanus.

The anatomy of Lepas. Refer to Drew.

Saturday, August 28:

A Study of Limulus.

Feeding reactions, method of locomotion, external anatomy. (Use small specimens and larval stages. Refer to Drew.)

Internal Anatomy. Freshly-killed animals will be provided. Follow directions in Drew.

Monday, morning, August 30, 9:00 o'clock.

Laboratory records in the form of labelled drawings, tabulations and brief notes are due.

A COMPARATIVE STUDY OF SOME COMMON MALACOSTRACA

(DIVISION EUMALACOSTRACA)

Several common forms are provided. Make a comparative study of the external features and record their characteristics in tabular form. Some of the features which are frequently of diagnostic value are suggested for special attention.

Tribe	Order	Suborder	Genus
Peracarida	Amphipoda	Caprellidea	CAPRELLA
		Gammaridea	TALORCHESTIA
	Isopoda	Idotheoidea	IDOTHEA
Eucarida	Decapoda	Natantia	PALAEMONETES
		Repantia	LIBINIA

Characteristics

Body form: compressed laterally, or flattened, or cylindrical; elongate, or shortened?
Body regions: head, thorax and abdomen, or cephalothorax, abdomen; well-developed, or rudimentary?
Carapace: present? if so, extent and form?
Segments of thorax: free or fused with head; number fused?
Segments of abdomen: free or fused; number fused?
Telson: shape and size?
Appendages of
  Head: particularly the antennae--number, length and form?
  Thorax: number and kind; biramous or uniramous; chelate, subchelate, non-chelate?
  Abdomen: number and kind?
Gills: location and number?
Eyes: stalked or sessile?

AUTOTOMY IN UCA.

Crush the claw without pulling on the leg and note the result.

Is there any relation between the region of the leg injured and the speed or frequency of autotomy?

Is there any relation between the type of stimulus used and frequency of autotomy?

Do any animals exhibit autotilly after the cutting or crushing of the appendage?

Examine the end of the stump which remains after autotomy.

Stimulate the ventral ganglia in freshly killed specimens to see if autotomy can be induced.

(Dissect or hemisect for the nervous system)

Stimulate the nerves of the appendage by inserting a fine pin at the joints.

Perform artificial autotomy. Use either preserved or freshly-killed material. Hemisect the animal and remove the entire leg intact through the coxa. Locate a large muscle inserted by a tendon on the basis dorsally. This is the autotomizer muscle. Pull ventrad on this tendon and observe the mechanics of the process of autotomy.

How do you think the force exerted by your pulling on this tendon compares with the force exerted by the living crustacean muscle?

Pull on the leg of a dead crab and see if the breaking-joint is the weakest point structurally.

If all the parts distal to the ischium are removed by a cut, can autotomy still be induced?

Ref: Wood and Wood: Mechanism of Autotomy in Decapod Crustaceans. Jour. Exp. Zool., 62, 1932.

THE NAUPLIUS LARVA OF THE BRINE SHRIMP, ARTEMIA.

I. Place a Nauplius larva in a drop of water on a cover-slip and study its characteristic swimming (and feeding) movements.

II. Add a few lens paper fibers to the drop and cover with a second cover-slip. Both the ventral and the dorsal surfaces of the larva can now be studied under high magnification.

Your attention is called to the following features:

1. The oval, unsegmented body.

2. A single, median eye.

3. A large, rectangular upper lip (labrum).

4. Three pairs of appendages.

   a. The anterior pair are uniramous. Each is a relatively short, unjointed appendage bearing 3 setae on the free extremity. They serve the larva as tactile and swimming structures and will form the first pair of antennae in the adult.

   b. The second pair are biramous. Each is composed of a thumb-like endopodite, a larger subconical exopodite and a gnathobase in the form of a recurved, conical structure at the base of the protopodite. These are powerful organs for swimming and food gathering in the larva. They will form the second pair of antennae in the adult.

   c. The third pair are biramous in most Nauplii. In Artemia there is a short protopodite bearing a terminal, finger-shaped endopodite. These are principally used for swimming in the larva but will metamorphose into the mandibles of the adult.

5. A digestive tract consisting of mouth, oesophagus, stomach, intestine and anus.

6. Muscles which move the appendages. They originate in a mid-dorsal region.

LIFE HISTORIES OF REPRESENTATIVE CRUSTACEA

In the tabular outline below the stage at which hatching occurs is indicated by the use of a capital letter or letters. In case the organism hatches at some point not coinciding with a definite listed stage, the letter H is used to indicate hatching point. Symbols for the several stages follow:

c---cypris	mn---metanauplius	n---nauplius
H---hatching point	my---mysis "	pz--protozoea
mg--megalopa	mz---metazoea	z---zoea

(ENTOMOSTRACA)									
Phyllopoda	n		MN	gradually to					adult
Cladocera (summer eggs)									adult
" (winter eggs)	n		MN						adult
Copepoda									
Eucopepoda (free)	N		mn						adult
" parasitic (a)	n	H	mn	parasite					adult
" " (b)	n	H		parasite					adult
Branchiura (Argulus)	n	H							adult
Ostracoda	N			c					adult
Cirripedia									
Thoracica (Lepas)	N			c					adult
" (Balanus)	n		MN	c					adult
Rhizocephala (Sacculina)	N		mn	c					adult
(MALACOSTRACA)									
Amphipoda	n							H	adult
Isopoda	N	in brood pouch until							adult
Schizopoda	N	in brood pouch until							adult
Stomatopoda	n				Z'				adult
Decapoda									
Macrura									
Peneidea	N		mn		pz	z	my		adult
Sergestidea (many)	n				PZ	z	my		adult
Lucifer	n		MN		pz	z	my		adult
Eucyphidea	n					Z	my		adult
Astacidea									
Homarus americana	n						MY		adult
Cambarus	n							H	adult
Anomura	n					Z	mz	mg	adult
Brachyura	n					Z	mz	mg	adult

STAGES IN DEVELOPMENT ON CRUSTACEA

Nauplius

Body: Unsegmented
Eye: Simple, median, x-shaped.
Appendages: Three pairs, first pair pre-oral. Later become antennules, antennae, and mandibles.
Occurrence: Free swimming stage in large number of Entomostraca. In Malacostraca usually passed within egg.

Metanauplius

Body: Beginning segmentation in postmandibular region.
Eye: Similar to that of Nauplius (simple, median, x-shaped).
Appendages: As in Nauplius (three pairs)
Occurrence: First larval form in Apus, winter eggs of Leptodora, Lucifer, Hippolyte.

Cypris

Body: Mantle folds present; resembles Ostracod. Folds become calcified in adult (Barnacles), or entire thoracic and abdominal regions slough off when animal assumes parasitic mode of life (Sacculina).
Eyes: 1 simple and 2 compound.
Appendages: antennules become organs of adhesion, antennae disappear. 6 pairs swimming feet present.

Protozoëa

Body: Distinctly separated into cephalothoracic and abdominal regions. Former covered by carapace; latter imperfectly segmented and lacks appendages.
Eyes: Paired, compound, sessile.
Appendages: As in Nauplius plus 2 pairs maxillae and 1-3 pairs anterior thoracic appendages.
Occurrence: In many Malacostraca, as free swimming forms.

Zoëa

Body: Abdomen distinctly segmented.
Eyes: Paired, compound, stalked.
Appendages: As in Protozoëa.
Occurrence:

Metazoëa

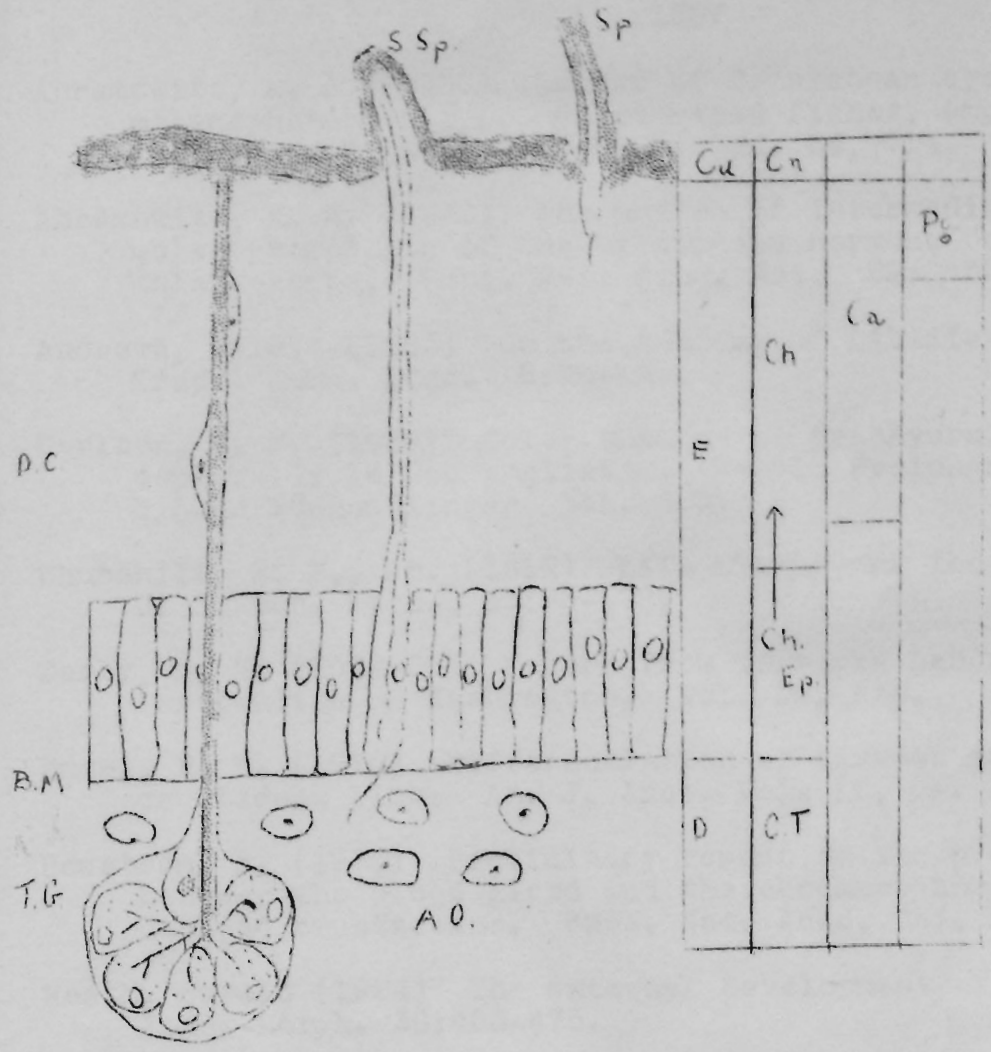
Body: Abdomen distinctly segmented.
Eyes: Paired, compound, stalked.
Appendages: Full number cephalic and thoracic appendages. (5 plus 8). Latter uniramous. Abd. append, developing.
Occurrence: First larval stage in nearly all Brachyura.

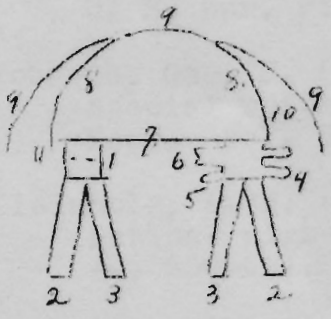
Megalopa

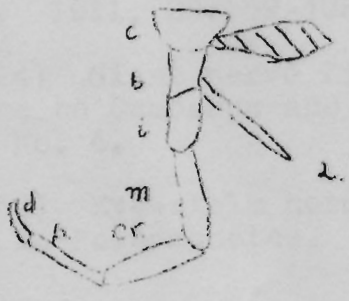
Body: Large broad cephalothorax; small abdomen.
Eyes: Paired, compound, large.
Appendages: As in Metazoea.
Occurrence: As 2nd. Stage in nearly all Brachyura.

Mysis

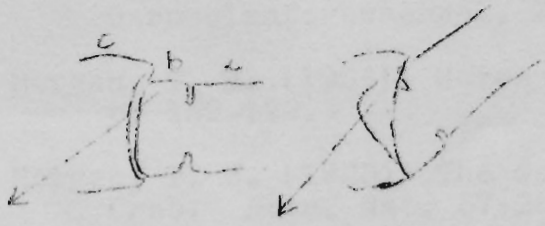
Body: Cephalothorax, abdomen. Latter distinctly segmented.
Eyes: Paired, compound, stalked.
Appendages: Full number thoracic appendages; biramous. Abdominal appendages developing.
Occurrence: In many Decapoda. 1st larval stage in Homarus and in Palinurus. Adult stage in Michtheimysis and in Euphausia.



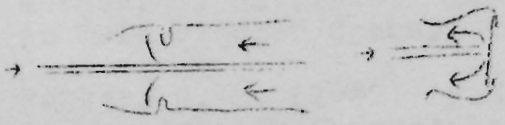




1. protopodite
2. exopodite
3. endopodite
4. exite
5. endite
6. gnathobase
7. sternite
8. tergite
9. carapace
10. gill chamber
11. pleuron



ic. coxa
b. basis
i. ischium
m. merus
cr. carpus
p. propodus
d. dactylus



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See Pratt and Drew for additional references on anatomy and classification.

KEY TO THE BRYOZOA OF THE WOODS HOLE REGION MOST LIKELY TO BE MET.
(After Osborn).

GLOSSARY

ADNATE- Attached to substratum at the back and partly free.
AVIVULARIA- Zooecia modified to look like birds' heads, with movable jaws. Function unknown.
CALCIFIED- Infiltrated with lime salts, giving frosted white appearance.
ENCRUSTING- Forming a crust of zooecia with the backs of all attached to a more or less broad surface.
LOPHOPHORE- Ring around the mouth to which tentacles are attached.
OOECIUM- Zooecium modified as a brood pouch.
OOECIOSTOME- Tube leading from the ooecium to the aperture.
OPERCULUM- Lip overhanging the mouth or orifice.
PEDUNCLE- Stalk of a Zooecium.
STOLON- Connection between the zooecia of a colony or zooarium, drawn out into a strand like a root stalk or trailing vine.
VIBRACULA- Long more or less flexible zooecia modified to resemble spines or hairs. Function unknown.
ZOOECIUM- THE INDIVIDUAL CASE ENCLOSING THE LIVING INDIVIDUAL OR ZOOID.
ZOOARIUM- THE AGGREGATE OF ZOOECIA ENCLOSING A WHOLE COLONY OF ZOOIDS.

Key. (This does not cover forms not frequently found)

(1) Anus inside lophophore; lophophore not retractile. Entoprocta.A.
(2) Anus outside lophophore; lophophore retractile. Entoprocta.D.

A((A_1- Individuals solitary, not colonial. Lophophore oblique. Loxosomidae.B.
A((A_2- Colonial; lophophore transverse; Stolonate----Pedicellinidae.C.

B((B_1- 18-30 tentacles; foot small; 2 mm. long.--Loxosoma davenporti.
B((B_2- About 8 tentacles; foot small; 1/2 mm. long.--Loxosoma minuta.

C((C_1- Peduncle not enlarged at base near stolon; Pedicellina cernua.
C((C_2- Peduncle enlarged near base; stalk not perforated. Barentsia major.
C((C_3- Peduncle enlarged near base; stalk perforated or areolate. B. discreta.

D((D_1- No opercula nor ooecia; Orifice circular; zooecia tubular and calcified; round mouthed forms.-------CYCLOSTOMATA.--E.
D((D_2- Operculum present; zooecia usually calcified; and with ooecia and appendicularia; lipped mouthed forms.-CHILOSTOMATA.-F.
D((D_3- Operculum of a ring of setae; never calcified; no avidularia, vibracula, nor ooecia; soft chitinous walls; zooaria stolonate, encrusting plant-like, or in fleshy lobes; Comb-mouths. Ctenostomata--K

E((E_1- Joints horny; oocecium pear-shaped; long tubular radical processes Crisia eburnea, or others.
(E_2- Zooarium lobate or branched; adnate or from an incursting base; tubular, in single series or contiguous.(Tubulipora or) rarely (Stomatopora.) found.

F((F_1- Stolonate, with expansion on Stolon where tubular zooecia (with lateral membranous area and terminal orifice) come off. Aetea Anguina.
(F_2- Not incrusting nor calcified; zooecia loosely united; appendages pedunculate and jointed;-------Bugula----------G.
(F_3- Incrusting; calcified; front wall of zooecia depressed, membranous and partly bridged by calcafeous shelf; zooecial borders raised.----------Membranipora----H.
(F_4- No median pore, but often a small rounded avicularium so placed; lower margin of primary orifice with a definite notch; or cells erected, with aperture guarded by a projection with avic. on the side----------Myriozoidae.----I.
(F_5- Lower margin of principal orifice straight (occasionally rounded), without notch, though overgrowth of secondary margin may simulate a notch; lateral margins of orifice may bear tooth; Avicularia may be present related to the orifice; zooecia incrusting, not erect.---------Escharidae.-----J.

G((G_1- Orifice occupies nearly whole front of zooecium; no spine below orifice; stalk of colony with uncinate hooks; zooecia biseriate and in spirals-------Bugula gracilis var. uncinata
(G_2- One strong spine at outer edge or orifice; ovicell at angle with axis of biseriate, spirally arranged zooecia; beak of avicularium not toothed.-------Bugula turrita.
(G_3- 4 spines above; ovicell in line with axis; beak toothed. Bugula cucullifera.
(G_4- No marginal spines except at top; ooecia small and hemispherical; avicularia alike and small; Zooecia 4-6 in number across each branch of the fan-shaped flattened zooarium. Bugula flabellata.

Other Bugulas differ from the above ones in minor points but are rare.

Membranipora

(H_1- Front wall, inside raised margin, all membranous; no ooecia, avic. not spines; or only slender erect spinules; Membranipora laeroixii.
(H_2- Area of front wall, below raised margin, perforated with large pores; spines strong and well developed. Membranipora pilosa.
(H_3- Similar to M. pilosa, but not perforated; weaker spines; median ventral spine stout (others usually absent). Membranipora monostachys

H((H_4- Spines few (2); ooecium present with small suberect avicularium at forward end.----------Membranipora unicornis.
(H_5- Spines (13 or more) bent downward over the aperture and flat in cross-section; directed strongly forward.
Membranipora craticula.
(H_6- Spines present only as stout tubercles; calcified lamina well-developed half closing the area; strong teeth projecting toward center.----------Membranipora tenuis

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I((I_1- Adnate zooecia more or less distinct; wall somewhat cylindrical, thin and hyaline; no avicularia; zooecia not prolonged at base; usually forming a crust, but often erected in older colonies.----------Hippothoa hyalina.
(I_2- Calcified; encrusting or foliaceous; continuous crust; avicularia absent; ovicell with special pore; primary orifice usually obscrued;----------Schizoporella sinuosa.
(I_3- Similar to the above; but avicularium pointed, on one or both sides of lower border of aperture; mandible pointing forward and outward; Ovicell without special pore.
Schizoporella unicornis.
(I_4- Like the above, but avicularia rounded or spatulate, not pointed; small oval one on a mound on one or both sides of orifice; ovicell with depressed area with radiating furrows.----------Schizoporella biaperta.
(I_5- Like the above, but small rounded avicularium centrally just below the notch; depressed area of ovidell with pores, regularly placed, in place of furrows.--
Schizoporella auriculata.

J((J_1- Primary orifice without posterior tooth or shelf; no sub-oral avic., spine or mound; secondary orifice, when raised, never a sinus at the posterior margin; orifice large, elongate, widened near its posterior end; ocecia and avicularia absent.----------Lepralia pallasiana.
(J_2- Like the above, but orifice smaller, inner anterior oral margin finely toothed; lateral tooth large and double; Avicularia abundant and of two sizes; Ooecium broader than long; a transverse membranous area above the orifice.
Lepralia serrata.
(J_3- Like the above, but zooecial and ooecial pores small and numerous; the former rounded and often broader than long; projecting marginal denticles give the posterior rounded border the appearance of a broad sinus or notch.
Lepralia pertusa.
(J_4- Like the above, but zooecial pores few and large; zooecial opening quardrangular and usually widest posteriorly.
Lepralia americana.
(J_5- Posterior margin of orifice has overhanging pointed bump, or mucro, without avicularium; no avicularia; ovicells present; zooecia small and slightly convex; flat with age.----------Mucronella peachii.

(J_6- Avicularia absent or large and not on a rostrum; posterior border of primary orifice with prominent tooth-like or shelf-like projection; orifice rounded posteriorly, with small usually pointed tooth or none; avicularium just behind orifice.----------Smittia porifera.

(J_7- Like the above, but orifice straighter in posterior margin; tooth broader; without avicularium just behind orifice; with or without large pointed avicularium in addition to smaller ones----------Smittia trispinosa.

(K_1- In brown gelatinous crust armed with horny spines; not stolonate; orifice 2-lipped, with one lip movable and acting as operculum; on Fucus and Ascophyllum.----
Flustrella hispida.

(K_2- In yellowish gelatinous crust without spines; no lips; orifice closed by invagination of tentacle sheath; zooarium not impregnated with earthy matter; without papillae; On crabs, mytilus, and big scallops.--Alcyonidium mytili.
Other Alcyonidia have spines and earthy matter, but are not common.

(K_3- Stolonate; not gelatinous; zooecia with flattened area more membranous than the rest of the wall, covering most of the ventral side; Zooecia clustered in pairs at nodes of the stolon; 4 strong spines at the top of zooecium.
Hippuraia armata.

K(K_4- Like the above, but without spines on Pinnotheres.
Hippuraria elongata.

(K_5- Stolonate; not gelatinous; no flattened ventral area; creeping or rising in plant-like tufts; not impregnated; Zooecia narrow at base next stolon; expanded tentacles form circle; gizzard present; zooecia clustered in double spiral rows on erect branching stem--Amathia dichotoma.

(k_6- Like the above, but zooarium creeping with erect shoots; zooecia irregularly disposed and occasionally clustered; basal part of zooecia without projections;
Bowerbankia gracilis.

(K_7- Like the above except for the presence of pointed or divided process near the base of zooecium on outer side.
Bowerbankia gracilis var. caudata.

Key to freshwater Bryozoa is not included here.
Most common ones are underlined.

Laboratory directions for study of Bryozoa

Study the forms submitted, for the following features;-(Not all to be found)

1) Habit of the Zooarium or colony case.
2) A Typical zooecium, as to orifice shape, spines, pores, character of cover, etc.
3) Presence, position, and type of Avicularia, and Vibracula, Ovicells or Ooecia.
4) Polypide organs;- tentacles, lophophore, diaphragm, oesophagus, stomach, intestine, funiculus, retractor muscles, cilia, brown body, intertentacular organ.
5) Regenerating zooids.
6) Look for developing embryos in ovicells.

Morning study:-

I. Study and compare as outlined in Drew, Bugula flabellata and B. turrita. Note the method of retraction of tentacles and time the rhythm for various individuals. Note evidences of gemmation or a sexual multiplication. Note differences in number of rows of zooecia, and spines, and position of avicularia, in the two species. Note the mode of activity of avicularia. Note the Swimming Larvae--Cyphonautes--of Bugula flabellata in finger bowl, or B. turrita, if available.

II. Compare also with Flustrella sp. Note the different habit and mode of attachment.

Afternoon study;-

I. Study the Zooaria and Zooecia of Membranipora sp., Lapralia sp., Schizoporella sp., and Crisia sp., Note ovicells where found.

II. On the slides provided study and search for Barentsia sp., an Entoproct. Bowerbankia may also be present, and young colonies of other forms studied above.

III. If time permits look at the permanent slides for Loxosoma sp., the only solitary type of Bryozoan. Statoblasts of Cristatella sp., are also shown.

N. B. Students wishing credit will complete the study of two forms, for organs, as outlined above and topographical and comparative study of the zooecia of any 4 others.

Characteristics of the two classes of Bryozoa compared and contrasted.

A.--Entoprocta or Phylum-Calyssozoa or Comptozoa.

I. Individual consists of a calyx or head with viscera enclosed + a contractile stalk. Tentacles not retractile into the coelom.

II. Lophophore circular with one row of tentacles. Both mouth and anus inside the vestibule.

III. Tentacles may roll inward and be covered by an epistome or flap growing from the base.

IV. No coelomic cavity, as viscera fill whole head, or jelly fills it. Tentacles not pulled into it.

V. U-shaped digestive tube = oesophagus + stomach + ciliated intestine.

VI. Paired gonads open to the vestibule. Unisexual or hermaphroditic. Loxosoma sp. have gonads function first as ovaries then as testes. Fertilization is external.

VII. Paired kidney tubes with flame cells, open into the rectum or into vestibule.

VIII. Nervous system = ganglion between the mouth and anus + radiating nerves.

IX. No blood vessels nor blood fluid.

X. Periodically lose calyx and its contents, and new calyx develops from regenerating bud on the stalk. Powers of regeneration are very great.

XI. No special sense organs yet found.

XII. Found in both fresh and salt water.
3 families with 20 species.

(1) Loxosomidae;-Solitary with young buds attached. Lophophore oblique. Marine.
(2) Pedicellinidae;-Colonial. Marine. Stalked forms from a stolonlike stem.
(3) Urnatellidae;-Colonial. Freshwater on sides of stones.

Characteristics of Two Classes of Bryozoa
Compared and Contrasted.
B--Ectoprocta.

I. Zooecium stalked or sessile. Tentacles retractile, Stalk not retractile.

II. Lophophore circular or C-shaped. Anus outside the vestibule.

III. No epistome, but some have an operculum or comb-like membraneous cover.

IV. Coelom present. Viscera and tentacles may be drawn in by retractor muscle. Coeloms may intercommunicate in colonial forms.

V. U-shaped digestive tube with caecum off the stomach. Funiculus holds gut to bottom of zooecium.

VI. Hermaphrodite. Testes usually on the funiculus. Ovaries either there or on side wall peritoneum. May fertilize in coelom or in ovary of fresh water species. Develop to larvae in Ooecia or in coelom.

VII. No kidneys yet demonstrated. Some hold intertentacular organ is one. Some say sperm and ova get out through it. Gut is probably excretory. "Brown bodies" may be a means of excretion.

VIII. Nervous system as in entoprocts, where demonstrated. Some have none yet found.

IX. No blood vessels; but blood fluid fills coelom.

X. Periodically produce brown bodies which are either extruded or retained. From the rest of the body wall a bud develops as if from a settling larva. New caecum is related to brown body, digests it, passes it out the anus. May be excretory device. Regenerating powers are great. Statoblasts or internal buds in freshwater forms settle and pass winter and regenerate in spring.

XI. No special sense organs yet found.

XII. Both fresh and salt water forms. 2 orders:- or 3, according to Borg.

(1) Gymolaemata; Marine forms with O-shaped lophophore.
(2) Phylactolaemata; Fresh-water forms. C-shaped lophophore.
(3) Stenolaemata.- Cyclostomata, Crisia and such forms. Marine. Round mouthed forms.

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KEY TO THE ECHINODERMS OF WOODS HOLE.

I. Radii more or less elongated to form a 5-rayed star. Body and arms not distinctly marked off from each other, . . STARFISH

(1) Small red star with feet in two rows; pedicellariae wanting; body bright red, purple lavender, or yellow, above, yellowish below; disc small, arms long and cylindrical, ... HENRICIA SANGUINOLENTA.

(2) Arms 5, blunt, stout and cylindrical; 4 rows of feet per ray; spines few and coarse; madreporite bright orange; color very variable, greenish black, most commonly; 30 fathoms to shore, . . ASTERIAS FORBESI.

II. Rays much elongated into slender cylindrical arms, sharply set off from central disc; 2 rows of ambulacral appendages lack suckers; no anus; madreporite on oral surface in an inter-radius; 2 slits at base of each arm into genital bursae; no cilia on external surface; no pedicellariae; spines usually from sides of arms, . . BRITTLE OR SERPENT STARS.

(1) Oral papillae present; arms with distinct and regular superficial plates; lateral spines on arms small and close to the surface; disc granulated; arm plates regular and distinct; lateral plates bear spines which lie close to surface; 4 bursal slits in each inter-radius; brachial spines short and smooth; disc pentagonal; green or brownish; spines short, no scales, . . OPHIODERMA BREVISPINA.

(2) Oral papillae present; plates regular and distinct; lateral arm plates with short solid spines which stand out from the surface of the arm, rather stout and conspicuous; disc covered with scales bearing granules or small spines; arms longer than in preceding; color very variable; both scales and spines Daisy Brittle Star, . . . OPHIOPHOLIS ACULEATA.

(3) Disc small; without spines but covered by scales; arms slender; 6 oral papillae in each corner of the mouth, outer two very wide; 2 scales to each tentacle; color gray or yellowish; radial shields whitish; arms 2-4 cm. long; scales but no spines . . . . . AMPHIPOLIS SQUAMATA.

III. Test rigid; with movable spines. Subglobular, . .SEA URCHINS.

(1) Circular outline and peristomial gills; spines solid and rather large; ambulacral areas narrow; aboral ambulacral feet without suckers; subglobular; inter-rays naked at aboral end; color reddish brown to purple; common here. Purple urchin, ... ARBACIA PUNCTULATA.

KEY TO THE ECHINODERMS OF WOODS HOLE.

(2) Circular outline; test rigid; spines solid; periproct with many plates; more than 3 pairs of pores in ambulacral plates (4-11); spines slender and fluted; tubercles not all of same size; crowded; color green; found north of here, Green Urchin, ... STRONGYLOCENTROTUS DROEBACHIENSIS.

IV. Test rigid; flattened to a disc; anus marginal; spines short and fine, Sand Dollars, ... ECHINARACHNIUS PARMA.

V. Test reduced to hooks or wanting. Body soft and muscular, SEA CUCUMBERS.

(1) Ambulacral feet present; 10 branches oral tentacles; feet scattered thickly over the body; color dull brown to black purple; large and opaque . . . THYONE BRIAREUS.

(2) No ambulacral feet; 10-13 pinnate tentacles; one polian vesicle; calcareous bodies in the form of anchors with serrate arms and perforated plates; partly transparent, ...LEPTOSYNAPTA SP.

(a) Tentacles 12, with 5--7 pairs of side branches; 10--30 cm. long; 5-10 broad; color whitish; common in sand,. . . . LEPTOSYNAPTA INHAERENS.

(b) As above, but 2--3 pairs side branches on tentacles; 10 cm. or less long; color rosy red; usually under stones, . . .LEPTOSYNAPTA ROSEOLA.

ECHINODERMATA
Directions for Laboratory Work

Directions in Drew's Manual will be very useful in supplementing the following directions. N. B. Work here outlined is for 3 days. Use material to best advantage.

1st day. A.M. Asterias forbesi.

I. External structures. Identify the following:-oral and aboral surfaces, mouth, anus, madreporic plate, ambulacral grooves, tube feet, terminal eye-spot, dermal branchiae, spines, pedicellariae.

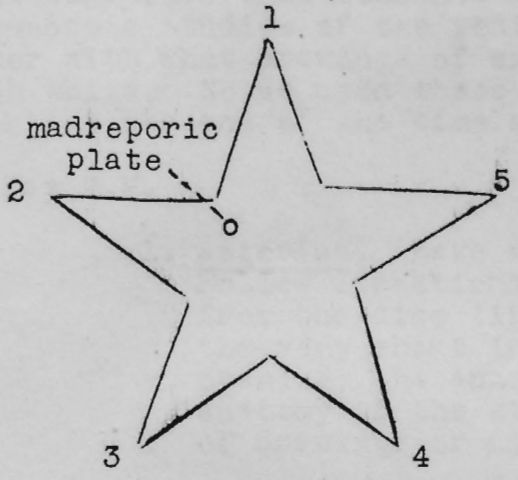
II. Behavior of the Animal.

A. Method of locomotion

1). Do the tube feet act as levers for swing or as ropes for pulling the body forward? Study the starfish as it proceeds over sand. Watch the movement of the tube feet as a starfish travels in a large crystallizing dish filled with sea water. Especially note the movements in climbing a vertical plane (side of dish).

2) Does each tube foot act independently or is there a unified impulse? Is there an intermediate method of action?

3) Does any particular ray seem to go forward and determine this? Make three trials in the following manner. Pick up the starfish by the disc with the thumb and first finger or with all four fingers so that the tactile stimuli will be equally distributed along the five radii. Using the scheme of notation shown in the marginal sketch, record the arm or arms which are anterior during progress forward. Each table may give a report of the results which may be incorporated into the class report which will be placed on the blackboard.



4). Make whatever comparative observations upon the movement of Arbacia and Ophioderma (called Ophiura in Drew) you see fit, when these forms become available in the Laboratory.

B. Righting reactions.

Do starfish use a particular arm in turning over after being placed on the aboral surface? By this is meant the arm or arms which first become attached to the sub-stratum. Make two trials and record results as in A. Make comparisons with other types of Echinodermata by watching the righting of Ophioderma and Echinarachnius. Place the latter in sand and make observations during the days used in study of Echinoderms.

C. Method of respiration.

1). Tie a string around one arm of a starfish and suspend it for a few moments. Put a slide under the tip of an arm and gather on a slide a drop of coelomic fluid which will drip from it. Examine it with a high power for details of cellular structures.

Echinodermata. Laboratory directions continued.

2). In the laboratory are starfish which were injected with carmine solution 12 hours previously. Carmine suspensions were injected directly into the coelomic cavity. On these experimental animals repeat the examination described above. What is the function of the amoebocytes? What is the function of the dormal branchiae?

1st day P.M.

D. Method of surface protection.

1). Draw a camel's hair brush lightly over the surface of a starfish. Does it catch on this surface?

2). Remove a pedicellaria from the circlet at the base of a spine and examine under the microscope. Do the same with a pedicellaria from the region between the spines.

It is suggested that students make the experimental studies and microscopic studies of the pedicellariae and coelomic fluid together with what drawings of external anatomy may seem fit and worth while. Notes upon these studies should be included in the report at the end of the time allotted.

1st Day P.M.

1. Asterias. Make a dissection of the "injected starfish". Follow directions in Drew. In removing the body wall from the disc lift it very carefully in order to see the very short intestine which leads to the aboral opening, the anus. Whatever records of the internal anatomy of the starfish you care to make in the form of drawings or diagrams are in order.

2. Students who do not wish to repeat a dissection of a formalin specimen of Asterias may dissect a living specimen, make a study of the cross-section of the arm of a young star from a slide preparation, or make a comparative study of the brittle star, Ophioderma brevispina.

2nd Day, A.M. & P.M.

1. Arbacia and Strongylocentrotus. Make whatever studies of behavior and external structures of the living Arbacia seem important to you. Study the dry test. The dissection of living or preserved Strongylocentrotus may be made on material furnished. A dried Aristotle's Lantern will also be available. Record may include a general analysis of the internal anatomy of Arbacia with brief notes on physiology of parts with special reference to Aristotle's Lantern. In the study of this complicated structure, both the dried and the fresh or formalin-preserved lantern in position in the body should be used.

3rd Day, A.M., & P.M.

Watch some of the activities of living Thyone. Record.
Repeat for Leptosynapta.
Study the external characteristics.

Dissect Thyone and study its internal anatomy with special reference to homologies with other Echinoderms.
Note vestigial character of the skeleton.
Study Blood cells- Amoebocytes on Mesentery.
Homoeytes in W. V. S. - open the animal along right side instead of ventral body wall.

Make what further studies of behavior you are interested in, upon animals of the groups other than Asterias and report them.

PROTOCHORDATA

Notes:

Leave Botryllus colonies in finger bowls for a few hours or over night. Plenty of tadpoles will be found on the bottom of the container. Developing colonies of Botryllus may be found on glass slides that have been suspended in the Eel pond for several weeks.

Squeeze the fresh Amoroucium colonies in fresh sea water. Tadpoles will be found on the bottom of the container and also swimming at the surface. Pick out the swimming ones and transfer with a little sea water to the bottom of a syracuse dish. Some will set on the glass and undergo metamorphosis. Change the water daily. Only a few drops are necessary at first or otherwise the larvae will attach to the sides and hence will be invisible. After attachment more water may be added.

Cleavage stages and larvae of Molgula can be secured in the following way: Remove the test and, under a dissecting microscope, the ovary and its duct can be identified by the eggs within. The ovary which is hollow can be opened with a sharp needle and the eggs removed. Self fertilization should be avoided. Remove the animal from the dish containing the eggs. From another animal remove the white testis (this more or less encloses the ovary) and cut it finely in the dish containing the eggs. This should be done in a very small amount of water. After a little while add more sea water and wash to remove extra sperm. Development is rapid and tadpoles are formed in about 24 hours.

As described by Berrill 1932, '36, the eggs of Molgula can be freed of their membranes by placing them in a solution consisting of one part of crustacean stomach juice to fifty or a hundred parts of sea water. The membranes are digested off in a few hours with no harm to the egg, and, on removal to fresh sea water, can be fertilized. Fertilized eggs cannot be treated in this manner. Unfertilized eggs remain viable for about 18 hours after removal from the animal. After this treatment and fertilization the blastomeres of the developing embryo can be separated by slight shaking or by decanting from one vessel to another.

Perophora viridis: The normal budding method and formation of a colony can be studied by removing a short length from a freshly collected colony and tying it on a glass slide. Suspend this in a battery jar of sea water which should be changed two or three times daily. Temperature can be kept fairly constant by immersing the battery jar in running sea water. Within 48 hours the formation of new stolons will begin. These new stolons may be removed to finger bowls for further growth and study.

Oözooids, or tadpoles, can be removed from the cloacal chamber for study of their structure and changes during metamorphosis.

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A key to the Protochordates of the Woods Hole Region

Enteropneusta (Hemichordata)

Worm-like; slender elongated body divided into light yellow conical proboscis, orange red collar with white ring posteriorly, orange red trunk shading to greenish yellow posteriorly. Burrows marked by castings on fairly clean sand flats. Characteristic odor resembling iodine. Liver sacs absent.

Dolichoglossus Kowalevskyi.

Tunicata (Urochordata)

Simple and compound, sac-like cylindrical body (in most) inclosed in a test of cellulose. Siphons, large branchial chamber, endostyle. Mostly attached. Tadpole larva. Sea squirts.

I. Minute, trunk and long tail, transparent, animal can move about within the voluminous tunic, tail twisted 90 degrees, no peribranchial cavity. Pelagic, at some distance from continents. Tail about twice as long as trunk.

Appendicularia longicanda.

II. Ascidians or sea squirts. Sac-shaped, sessile, compound, colony flat and incrusting, digestive tract behind branchial sac. Chalky white or yellowish. On stones, shells, etc. Thin test contains calcareous spicules stellate with rays acute or broken.

Didemnum candidum.

Spicules spherical with rounded knobs.

Didemnum albidum

Massive colonies often of large size. Three divisions of zooid and post-abdomen contains gonads and heart. Colonies very large, often in form of thick vertical plates. Common gelatinous tunic. Zooids arranged in stellate clusters, branchial sac and intestine orange.

Amaroucium stellatum

Colonies thick, fleshy, often lobed, smooth surface. Orange or red zooids show through tunic. On piles, rocks.

Amaroucium constellatum

Colonies large, numerous small narrow lobes, larger at upper end, densely incrusted with sand, closely packed together. On sandy bottoms.

Amaroucium pellucidum

Colonial ascidian, transparent tunic, compact body, zooids separate but connected by stolons, digestive tract beside branchial sac, few rows of stigmata, zooids small. Green. On piles, rocks, seaweed.

Perophora viridis

Semi-transparent tunic, elongate body which tapers toward anterior end, attached by larger posterior end, yellowish, small orange or red spots (ocelli) around margins of orifice. On stones, piles, buoys, water tank of M. B. Laboratory. Very contractile. Simple. Buds often present.

Ciona intestinalis

Sessile colonies, compound, thin and incrusting or thick and fleshy, zooids in round or elongate systems about the common cloacal opening, peripheral oral openings. Transparent test, gelatinous, penetrated by branching vessels ending in bulbs. Zooids brown purplish black or combinations of these. Bright colors around openings. On seaweed, piles, etc.

Botryllus schlosseri

Tunic hard rough and wrinkled, brownish or yellowish. Irregularly ovate, adhering by one end or by ventral surface, small granular turbecules on and about papillae of the openings. Often in groups. Simple. On piles, stones, etc. Very common.

Styela partita

Simple. Similar to Styela but only one gonad on right side. Pink or bright red, smooth, depressed dome-shaped with expanded margin. On stones, shells.

Dendrodoa carnea

Simple. Globose body, tough tunic with rough surface fibrous or incrusted, tubes arise near together and are divergent and retractile. 6 branchial folds, stigmata curved. On piles, stones, seaweed. Very common.

Molgula manhattensis

Simple. Body rounded, apertures flush with surface, densely and evenly coated with coarse sand adhering tightly. Apertures inconspicuous when closed. In sand.

Molgula arenata

Simple. Body globose, compressed, covered with mud or dirt, siphons not contiguous and long and diverging. Gonads inverted U-shaped. On sand and gravel in deeper water.

Molgula complanata

Simple. Branchial sac without folds but with numerous conocal internally extending projections around which wind the long spiral stigmata. One gonad on left side. Body globose, unattached, tunic with fibrous hairs to which clings the sand or mud in which the animal lives. Looks like a ball of mud or sand. Tubes small and close together.

Bostrichobranchus pilularis.

III. The salps. Pelagic, transparent, alternation of generations, cylindrical, large oral opening at one end. Swim by causing current of water. Conspicuous muscle bands. Respiratory partition in body cavity.

Several species are given by Pratt, A Manual of the Common Invertebrate Animals, as occuring in the Atlantic Ocean off the coast of New England. Since these pelagic animals are not encountered on the field trips, the diagnostic characters are not given here.

Leptocardia (Cephalochordata)

Do not occur this far north.

INVERTEBRATE ZOOLOGY

Laboratory Study of the Protochordata

The nature of the records and the number and kind of drawings of structure are left to the discretion of the student. Certain ones are suggested in Drew's Invertebrate Zoology, which may be followed or amplified or others substituted for them.

Note - All records are due at twelve o'clock, noon, of the second day. These will be returned early that afternoon. The records of the second afternoon need not be turned in.

1st day. A. M.

(a) Study the external structure of a living Dolichoglossus (Hemichorda), following the directions in Drew, page 233. Devote about one-half hour to this work. In some of the animals the posterior region of the trunk may have been broken off.

(b) The remainder of the morning period should be spent in the study of the simple ascidian, Molgula (Urochorda). Directions for study are given in Drew, page 234.

If time permits, endeavor to record the number of pulsations of the heart between reversals. Compare the results with those of other members of the class. Change the temperature and note the effect upon the rate of pulsation. Where does the pulsation begin? Study the network of finer blood vessels and the circulation of the blood. If possible get some blood on a slide and examine the cells. Feed carmine to show the action of the endostyle and the passage of particles to the oesophagus.

Note - If the structure of Molgula has been studied elsewhere, the time may be spent in examining the functional activities of the animal as indicated above and in Drew. Or a study may be made of Ciona. This transparent, simple ascidian is highly contractile and hence is not suitable for dissection. However, because of its transparancy, it possesses certain advantages over Molgula. Styela may also be substituted for Molgula.

1st day. P. M.

(a) Secure 5 or more living tadpoles of Amaroucium, place in a few drops of sea water in a syracuse dish, cover, and save for the next day. This should be done early in the afternoon.

(b) Study Perophora viridis (Urochorda), following the directions given in Drew, page 238. In this colonial ascidian the greenish, transparent zooids (which resemble small Molgulas) are connected by a stolon. Details of heart action, relation of heart pulsation in members of a colony, and circulation in pharynx and stolon may be followed. Also pay special attention to the phenomenon of budding. Compare the structure of a zooid with that of Molgula (or ciona).

Demonstrations - Didemnum, Styela, stained small Amphioxus, Appendicularia, Salpa, Florida tunicate, Boltenia.

2nd day. A. M.

Study isolated individuals of Amaroucium (Urochorda). These may be secured by cutting the common gelatinous tunic vertical to the surface or by squeezing a small piece in a dish of sea water. Follow the directions given in Drew, page 240. Include with this a study of the living, tailed larva (tadpole) and also of several stages of metamorphosis. Stained larvae will be on demonstration. The larvae placed in the syracuse dish the day before should show early changes during metamorphosis. Later stages will be distributed.

2nd day. P. M.

Study young and old colonies of Botyrllus. The colonies of this transparent, composite, incrusting chordate may be found on wharf piles, stones, etc. Glass slides immersed in the Eel pond several weeks previously will contain young colonies which may be more easily studied. Follow the directions given in Drew, page 239.

Examine the dishes containing the Botryllus material for the tailed larvae. If present, compare with those of Amaroucium.

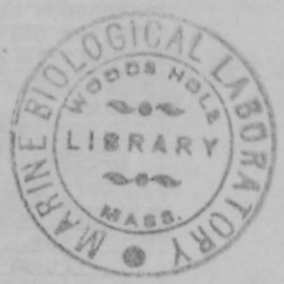
Composite Check List of Invertebrate Animals Found by Invertebrate Class. Summer, 1937.

CHECK LIST OF INVERTEBRATE ANIMALS

Commonly or occasionally found by the
Invertebrate Zoology Classes
at the
MARINE BIOLOGICAL LABORATORY
Woods Hole, Mass.

Forms marked (*) are most commonly found or are conspicuous for other reasons. Where a name used in Pratt's "Manual of the Common Invertebrate Animals" (revised edition) differs from the name used in the check list, the name used in Pratt follows the check-list name, and is enclosed in parentheses.

Woods Hole, Mass.
1936



	Lackey's Bay	Stony Beach	Kettle Cove	Dredging	Pond. Br.	Hadley Harb.	Cuttyhunk	No. Falmouth	Waquoit Bay
PHYLUM PROTOZOA (not listed)									
PHYLUM PORIFERA									
Class Calcarea									
*Leucosolenia botryoides									
*Sycon ciliatum		5	6		6		5		
Class Demospongia									
*Chalina arbuscula									
Cliona celata	3	4	4	6	6	4	4	4	
*Halicondria panicea	4	6	6		6	6	6	4	
*Microciona prolifera	5	6	6	3	6	6	6	4	
Suberites compacta									
Tethya gravida									
PHYLUM COELENTERATA									
Class Hydrozoa									
Abietinaria abietina				1					
*Bougainvillia						1	1		
B. carolinensis									
B. superciliaris									
*Campanularia		1			1	2	3		
C. calceolifera						1			
C. flexuosa									
Clava leptostyla			3						
Clytia						5			
C. edwardsi									
C. johnstoni					3				
(C. bicophora)									
Corynitis agassizi				1					
(Gemmaria gemmosa)									
Ectopleura ochracea									
*Eudendrium				5			1		
E. Album									
E. carneum									
E. ramosum			1						
E. tenue									
Eutima mira									
Gonionemus murbachi									
Halecium halecinum					1				
*Hydractinia echinata	1	3	4	2	6	6	3	6	
Nemopsis bachei									
*Obelia							1		
O. commissuralis									
O. geniculata						1	2		
O. bicuspidata									
*Pennaria tiarella	1		1			1			
Physalia pelagica									
Podocoryne			3		2	2		3	
P. carnea									
P. fulgurans									
*Schizotricha tenella					6	1	1		
*Sertularia pumila	1	5	6	2	3	3	5	5	
Thuiaria argentea				2	1			3	
*Tubularia							1		
T. crocea									
T. larynx									
Class Scyphozoa									
Aurelia aurita									
Cyanea capillata					2				
Dactylometra quinquecirrha									

-2-	Lackey's Bay	Stony Beach	Kettle Cove	Dredging	L. Pond. Br.	Hadley Harb.	Cuttyhunk	Falmouth	Tarpaulin Cove
PHYLUM COELENTERATA (Cont'd)									
Class Anthozoa									
Alcyonium carneum									
*Astrangia danae		4	6	6		6	2		
*Edwardsia									
E.elegans									
E.leidyi									
Eloactis producta									
Halcampa farinacea									
*Metridium dianthus	4	2	2			4	1	2	
*Sagartia									
S.leucolena	3	6	6	1	3	6	2	5	
S.luciae			5		3	3	4	3	
S.modesta						1			
PHYLUM CTENOPHORA									
*Mnemiopsis leidyi					3	3		6	
PHYLUM PLATYHELMINTHES									
Class Turbellaria									
Sub-class Acoela									
*Polychoerus caudatus									
Order Tricladida									
*Bdelloura candida		1			1	4		4	
Procerodes wheatlandi									
Syncoelidium pellucidum									
Order Polycladida									
Eustylochus ellipticus									
Planocera									
P.inquilina									
P.nebulosa									
Stylochus zebra									
PHYLUM NEMERTEA									
Order Paleonemertea									
Cephalothrix spiralis						2			
Order Heteronemertea									
*Cerebratulus lacteus		1	3		3	5	3	6	
*Lineus	1					2	3	2	
L.bicolor							1		
L.ruber							1		
L.socialis							1		
*Micrura leidyi		6	4		4	6	5	3	
Order Haplonemertea									
Amphiporus ochraceus				1	1	1			
*Tetrastema									
T.candidum									
T.vermiculum									
PHYLUM NEMATHELMINTHES (not listed)									
PHYLUM TROCHELMINTHES (not listed)									
PHYLUM ANNELIDA									
Class Chaetopoda									
Sub-class Polychaeta									
Ampharete setosa									
*Amphitrite		1				4	1	1	
A.brunnea					1				
A.ornata	1				3	1		2	
*Arabella opalina	1	2	3		6	5	1	5	
*Arenicola						3	5	1	
A.cristata					1				
A.marina									

PHYLUM ANNELIDA (cont'd)	Lackeys Bay	Stony Beach	Kettle Cove	Dredging	L. Pond Bar	Hadley Harbor	Cuttyhunk	Nor. Falmouth	Tarpaulin Cove
Class Chaetopoda									
Sub-class Polychaeta									
Aricia ornata		2	2		6	4	4	4	
*Autolytus sp.					1				
Chaetopterus pergamentaceus						2		6	
*Cirratulus grandis	4		4		6	6	6	4	
*Cistenides gouldi			4		6	6	2	6	
*Clymenella torquata	5	1	5		6	6	6	6	
*Diopatra cuprea	1	1	3		6	6		5	
Dodecaceria coralii				6					
*Enoplobranchus sanguineus	2	1	2		3	6	4	6	
*Eulalia			1		1	1	1	2	
E.annulata									
E.pistacea				2					
*Glycera			2			3	2	2	
G.americana		1			5	2		1	
G.bibranchiata	3	5	5		5	3	2	3	
Harmothoe imbricata	3	6	6	6	6	6	4		
*Hydroides hexagonus	6	6	5	6	6	6	6	6	
Laonice viridis	4	2	5		1	5	5	5	
*Lepidonotus squamatus	6	6	6	6	5	6	4	2	
*Lepraea rubra	1	6	4	2	2	4	3	2	
Lumbrinereis		1			2	5	1	2	
L.hebes		2	2						
L.tenuis					1	2	3	3	
Maldane urceolata						6	5	4	
Marphysa leidyi					2	1	1	3	
Nephthys		1	1		2	1	1	2	
N.bucera	1	4	5			5	3	3	
N.incisa		2	1		1	4	6	4	
*Nereis						3	2	1	
N.limbata			1		3	2	1	1	
N.pelagica		2	2	2	3	1	3	1	
N.virens	4	3	6	3	6	4	5	4	
Nicolea simplex									
Ninoe nigripes						3			
Notomastus sp.									
Parasabella microphthalmia	1	3	3	1	1				
Phyllodoce catenula		1	2	1	1		1		
Pista palmata					4	4	2	4	
Platynereis megalops									
Podarke obscura					6				
*Polycirrus eximus	1	2	5	4	3	4	2	3	
Polydora sp.									
Pseudopotamilla oculifera				6	1				
Sabellaria vulgaris				3					
*Scoloplos						1	2	2	
S.fragilis	3	5	6		6	6	5	4	
S.robustus	1	4	2		5	3	2	5	
Spio setosa	1		3		1	2	4		
*Spirorbis spirorbis	6	6	6		5	6	6	3	
*Sthenelais			1		4	5	1	2	
S.leidyi		2	1		1			2	
S.picta									
Syllis sp.									
Terebellides sp.			1				1		
Thelepus cincinnatus									
Travisia forbesi		2	2			5	1		
Trophonia affinis						1	3		

	Lackey's Bay	Stony Beach	Kettle Cove	Dredging	L. Pond. Brid.	Hadley Harb.	Cuttyhunk	No. falmouth	Tarp. Cove
PHYLUM ANNELIDA (cont'd)									
Class Chaetopoda									
Sub-class Oligochaeta									
Enchytraeus albidus									
Lumbricillus agilis		1							
Class Gephyrea									
*Phascolosoma gouldi	3		1		6	6	6	6	
PHYLUM ARTHROPODA									
Class Crustacea									
Order Cirripedia									
*Balanus									
B.balanoides	6	6	6	1	6	6	6	6	
B.eburneus	5	1	4	3	6	4	5	6	
*Chthamalus fragilis	5	5	4		5	5	4	5	
Lepas									
L.anatifera									
L.fascicularis									
Order Amphipoda									
Aeginella longicornis		1	2		4	1	2		
Allorchestes littoralis									
Ampelisca macrocephala							3	2	
Amphithoe sp.		1	1		2	1	2	1	
Autonoe sp.									
*Caprella acutifrons		2	3		5	1	1		
Carinogammarus mucronatus			1		1			1	
Chelura tenebrans									
*Corophium cylindricum		2	5	1	5	3	4	2	
*Gammarus sp.	3	5	5	5	6	6	6	4	
Haustorius arenarius	1	2	5			1	5		
*Orchestia platensis	1	1	6		2	3	4	3	
Stenothoe minuta									
*Talorchestia longicornis			6		1	2		3	
Unciola irrorata				6	1	2	1		
Order Isopoda									
Chiridotea caeca			1						
Cyathura carinata			1				2	1	
Edotea triloba			1						
Erichsonella filiformis			3		2	2	3		
*Idothea							1		
I.baltica	3	3	6		2	3	6	1	
I.metallica					2	1	2		
I.phosphorea		1	3				1		
*Jaera marina		4	3		1	5	4		
Jassa marmorata									
Leptochelia sp.							1		
Ligyda oceanica									
Limnoria lignorum							1		
Sphaeroma quadridentatum									
Tanais sp.					1		1		
Order Mysidacea									
Diastylis sp.							1	1	
*Heteromysis formosa				1	2	2			
Michtheimysis stenolepis									
Order Stematopoda									
Chloridella empusa									
Order Decapoda									
Callianassa stimpsoni						5		2	
*Callinectes sapidus							2	6	
*Cancer									
C.borealis							1		
C.irroratus	1	1	2	2	4	1	3		

	Zacke's Bay	Stony Beach	Kettle Cove	Dredging	L. Pond Bridge	Hadley Harbor	Cuttyhunk	N.r. Falmouth
PHYLUM ARTHROPODA (cont'd)								
Class Crustacea								
Order Decapoda								
*Carcinides maenas	5	5	6	1	5	5	5	6
*Crago septemspinosus	3	3	5		5	6	5	5
Emerita talpoida			6		1			
Eurypanopeus depressus								
Heterocrypta granulata								
Homarus americanus								
*Libinia						1		
L.dubia		4		4	3	2	1	5
L.emarginata		3		1	5	3	3	3
*Neopanope texana	4	6	6	6	6	4	4	6
Ovalipes ocellatus	1	2	2			5	1	3
*Pagurus							2	
P.acadianus				2	1			
P.longicarpus	6	6	6	6	6	6	6	6
P.pollicaris		1	1	6	5	6	5	3
P.pubescens				5	1			
*Palaemonetes vulgaris	1	3	5		6	6	4	6
Panopeus herbsti						1		1
Pelia mutica		1	1	5	4	1		1
Pinnixa					4	1	4	2
P.chaetopterana					1	93	1	3
P.cylindrica						1		
P.sayana								
*Pinnotheres maculatus					4	1		
*Uca						2		
U.minax								3
U.pugilator						1		2
U.pugnax						3	1	5
Upogebia affinis						1		1
Virbius zostericola	3	3	2		4	4	1	6
Class Arachnoidea								
Sub-class Xiphosura								
*Limulus polyphemus					2	4	1	3
Class Pycnogonida								
*Anoplodactylus lentus	1 Nymph		4	5	1		1	
*Pallene empusa							1	
*Tanystylum orbiculare					1			
PHYLUM MOLLUSCOIDEA								
Class Bryozoa								
*Aetea anguina								
Alcyonidium sp.								
Amathia vidovici								
Barentsia sp.								
Bicellaria ciliata								
*Bowerbankia gracilis			1	1	3	2	1	
*Bugula		2	3					1
B.flabellata			1		2			
B.turrita		4	3	4	2	1	4	3
B.gracilis var. uncinata								
*Crisia eburnea		2	6	1	4	3	3	
Eucratea chelata								
*Flustrella hispida			1		1	1	1	
Hippothoa sp.								
Hippuraria sp.								
*Lepralia sp.	4	5	6	3	4	4	5	4
(Cryptosula sp.)								
Nymphon					1			

	Zachery's Bay	Stony Beach	Kettle Cove	Dredging	S. Pond Bridge	Hadley Harb.	Cuttyhunk	N. Falmouth
PHYLUM MOLLUSCOIDEA (Cont'd)								
Class Bryozoa								
*Membranipora								
M.lineata								
~~M.pilosa~~ S.P.								
(Electra pilosa)		1	3			3	-	2
M.tenuis								
M.tehuelcha		2	31					
Microporella sp.								
Mucronella immersa								
Porella sp.								
*Schizoporella	5	4	5	4	6	6	6	5
S.biaperta			1					
S.unicornis	3	3	3	3	3	3	2	
*Smittina								
S.porifera								
S.trispinosa								
PHYLUM ECHINODERMATA								
Class Asteroidea								
*Asterias								
A.forbesi	2	5	6	6	6	4	5	4
A.vulgaris			4		1		4	1
*Henricia sanguinolenta			6				1	
Class Ophiuroidea								
*Amphipholis squamata							1	
*Ophioderma brevispinum				1	1			1
Ophiopholis aculeata								1
Ophiura sp.								
Class Echinoidea								
*Arbacia punctulata		2	6	6		4		
*Echinarachnius parma				3				
Strongylocentrotus drobachiensis								
Class Holothuroidea								
*Leptosynapta			1					
L.inhaerens	5	4	5		6	4	4	4
L.rosecla		1	2		4	4	2	1
*Thyone briareus					1	1	2	1
PHYLUM MOLLUSCA								
Class Amphineura								
*Chaetopleura apiculata	1	5	5	6	5	3		3
Class Pelecypoda								
*Anomia simplex	1	6	5	1	6	6	5	5
*Arca		2					1	
A.pexata								
A.ponderosa						2		2
A.transversa	1	4	1	1	4	6	2	3
Astarte castanea								
Barnea truncata								4
Cardium pinnatulum								
Cochlodesma leanum					3			
Corbula contracta		2	2			5	1	
Crassinella mactracea				3				
*Cumingia tellinoides	1	1	2		4	4	4	3
*Ensis directus	2		6		6	5	6	6
Gemma gemma			1		5	4	5	5
Laevicardium mortoni					6	2		6
Lyonsia hyalina					1	1	1	2
Macoma								1
M.baltica			1			1		1
M.tenta						2	1	1
Montacta						1	1	

PHYLUM MOLLUSCA (cont'd)	Lackeys Bay	Stony Beach	Kettle cove	Dredging	L. Pond. Brid.	Hadley Harbor	Cuttyhunk	Nov. Falmouth
Class Pelecypoda								
Mactra								
M. lateralis						1		1
M. solidissima		1	3		3	5		4
*Modiolus								
M. demissus	2	1	4		1	6	2	6
M. modiolus	1	2	2	6	5	4		4
*Mya arenaria	2	2	4		6	6	6	5
*Mytilus edulis	3	6	6	1	6	6	6	6
Nucula sp.				5				
Ostrea virginica		4	5	1	5	6	2	6
Pandora trilineata				1				
*Pecten irradians				6	6	1		6
Petricola pholadiformis		1	3		4	3	4	4
*Solemya velum	2		3		6	3	6	4
Tagelus divisus						4		2
*Tellina tenera	2	5	6		6	6	6	6
*Teredo navalis								
*Venus mercenaria	4	3	5		1	4	2	
Yoldia limatula					6	6	6	6
Class Gastropoda						2		
*Acmaea testudinalis	3	6	6	1	1	3	5	1
Aeolis sp.								
Anachis avara	1	4	4	6	5	4	5	6
*Bittium alternatum		3	2		5	1		4
*Busycon							1	
B. canaliculatum					4		3	6
B. carica	1			1				
Caecum pulchellum						2		2
*Cerithiopsis						1		
C. greeni								
C. subulata		2	1	2	1	2		2
C. terebralis				2				
*Coryphella sp.								
*Crepidula								
C. convexa	6	4	5	3	5	5	4	6
C. fornicata	5	5	6	4	6	6	6	6
C. plana	4	6	6	6	6	6	6	6
Doris sp.								
Elysia sp.								
Epitonium sp.								
Eupleura caudata		1			1			1
Flabellina bostoniensis								
Haminea solitaria		5			6	6		2
*Lacuna vincta	4	4	6	1	5	3	6	1
*Littorina								
L. irrorata								
L. littorea	6	6	6		6	6	6	6
L. palliata	6		6		2	6	6	4
L. rudis	4	3	5		2	6	6	3
*Melampus bidentatus						5		3
Melanella oleacea						2	1	1
*Mitrella lunata	4	6	6	6	6	6	6	6
*Nassa								
N. obsoleta		1	5		5	6	4	6
N. trivittata	2	6	6	4	6	5	6	6
N. vibex								2
Natica clausa								
Tuphosa -			1					

PHYLUM MOLLUSCA (cont'd)	Lackey's Bay	Stony Beach	Kettle Cove	Dredging	L. Pond. Br.	Hadley Harb.	Cuttyhunk	Nor. Falmouth	Tarpaulin Cove	
Class Gastropoda										
*Odostomia sp.		4				4		1		
Phytia myosotis										
*Polinices										
P.duplicata			1		1	4	2	5		
P.heros				2				2		
Rissoa sp.										
Thais lapillus		4	6		1	5	4	1		
Turbonilla sp.				1						
Turritella sp.										
*Urosalpinx cinereus	6	6	6	2	6	6	6	6		
Vermetus radicula										
Class Cephalopoda										
Loligo pealei			1							
PHYLUM CHORDATA										
Sub-phylum Hemichorda (Enteropneusta)										
Dolichoglossus kowalevskyi	1		6		4	6	3	3		
Sub-phylum Urochorda (Tunicata)										
*Amaroucium										
A.constellatum	2	5	4	3	6	6	6	2		
A.pellucidum	2	2	1	1						
A.stellatum				4						
*Botryllus schlosseri					3		6			
*Didemnum candidum lutarium	2	2	6	6	6	5	6			
*Molgula	1	1			1	3	2			
M.arenata			1							
M.manhattensis			1		2	2		1		
M.complanata										
*Perophora viridis		1	4		6	2	5			
*Styela partita	3	6	5	5	6	6	4	4		
Ciona					1		1			

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