Invertebrate Zoology Course Materials 1941

INVERTEBRATE ZOOLOGY CLASS, 1941

ame Seat No. Team College or University

A Combined List of Forms taken on Field Trips in 1941.

owa

owa

Composite Check List

1941

d

CHECK LIST OF INVERTEBRATE ANIMALS

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

for Women
iv.
rs College

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.

-vania
y

e

Woods Hole, Mass.
1936

rs College

ate Teachers

ieder, Herbert	54	I	Hamilton
ilbur, Chas. G.	55	I	Johns Hopkins
illiams, Robert W.	56	I	Harvard
ilson, Mae E.	48	VI	Southern California

Gross. Louise. — 42 — I — Smith.

	Stony Beach	Lackey's Bay	Lagoon Bridge	Kettle Cove	Cuttyhunk	Hadley Harbor	North Falmouth	Dredging
PHYLUM PROTOZOA (not listed)								
PHYLUM PORIFERA								
Class Calcarea								
*Leucosolenia botryoides	4	2	2	3	5	5	1	1
*Sycon ciliatum	4		1	6	6	6	6	1
Class Demospongia								
*Chalina arbuscula					1		1	
Cliona celata	2	4	2	6	5	6	5	6
*Halicondria panicea	6	6	6	6	5	6	6	1
*Microciona prolifera	6	5	6	6	5	6	6	3
Suberites compacta								
Tethya gravida								
PHYLUM COELENTERATA								
Class Hydrozoa								
Abietinaria abietina								
*Bougainvillia					1			
B. carolinensis								
B. supercilliaris								
*Campanularia				1	1			1
C. calceolifera					2			
C. flexuosa					2			
Clava leptostyla				2				
Clytia					1			
C. edwardsi								
C. johnstoni								
(C. bicophora)								
Corynitis agassizi								
(Gemmaria gemmosa)								
Ectopleura ochracea								
*Eudendrium				1				2
E. Album								
E. carneum								
E. ramosum								
E. tenue								
Eutima mira								
Gonionemus murbachi								
Halecium halecinum								
*Hydractinia echinata	2	1	5	4	4	4	6	3
Nemopsis bachei								
*Obelia							1	
O. commissuralis			3					
O. geniculata	2	1	1	2	3			
O. bicuspidata								
*Pennaria tiarella		1		1	2	1		4
Physalia pelagica								
Podocoryne	2		1	1		1	1	
P. carnea								
P. fulgurans								
*Schizotricha tenella			2		1	2	1	1
*Sertularia pumila	6	5	1	5	5	4	6	3
Thuiaria argentea		1	1					1
*Tubularia			2					
T. crocea								
T. larynx			1					
Class Scyphozoa								
Aurelia aurita								
Cyanea capillata								
Dactylometra quinquecirrha								

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

PHYLUM ANNELIDA (cont'd)	S. Cove Beach	Lardeis Bay	Lagoon Bridge	Kettle Cove	Cuttyhunk Harbor	Hadley Harbor	N. Falmouth	Dredging
Class Chaetopoda								
Sub-class Polychaeta								
Aricia ornata		2	4	2	3	6	5	1
*Autolytus sp.			1					1
Chaetopterus pergamentaceus						1	3	1
*Cirratulus grandis		6	6	3	4	5	5	
*Cistenides gouldi	1		5	2	1	6	6	
*Clymenella torquata	3	6	6	5	6	6	6	
*Diopatra cuprea	2	1	5	3	1	6	6	
Dodecaceria coralii								6
*Enoplobranchus sanguineus	1	6	4	3		5	6	
*Eulalia				1	3	1	1	2
E. annulata								
E. pistacea								
*Glycera			2	3	1			
G. americana	2	1	1		1	1	2	
G. bibranchiata	3	4	3	3	5	6	6	
Harmothoe imbricata	6	6	5	6	6	6	3	6
*Hydroides hexagonus	6	6	5		3	6	6	6
Laonice viridis		5	3	4	2	3	4	
*Lepidonotus squamatus	5	6	6	6	6	6	6	6
*Lepraea rubra	3	2	3	2	1	3	3	1
Lumbrinereis	2		1			1		
L. hebes	1		4		2	3	1	
L. tenuis	2	2	3	1	1	2	4	
Maldane urceolata						6	4	
Marphysa leidyi					1	3	2	1
Nephthys	3	1	1		1			
N. bucera	3	3		4	3	4	2	
N. incisa	2	1		1	3	4	3	1
*Nereis								
N. limbata		1	2	1	4	6	6	1
N. pelagica			3	5	4	2	3	4
N. virens	6	6	6	6	6	6	6	
Nicolea simplex								
Ninoe nigripes								
Notomastus sp.		1		2	3	4	4	
Parasabella microphthalmia				1	2		1	2
Phyllodoce catenula					3			1
Pista palmata			3			4	4	
Platynereis megalops								
Podarke obscura			2				2	
*Polycirrus eximus	3	2	4	3	4	4	5	2
Polydora sp.					1			
Pseudopotamilla occulifera			2					4
Sabellaria vulgaris							1	4
*Scoloplos					1			
S. fragilis	5	3	2	5	3	4	5	
S. robustus		2	5	3	5	5	6	
Spio setosa		2	3	6	5	4	6	
*Spirorbis spirorbis	6	5	6	6	6	4	6	3
*Sthenelais			5			5	5	
S. leidyi						1	1	
S. picta								
Syllis sp.								
Terebellides sp.								
Thelepus cincinnatus		1		1	1			
Travisia forbesi				2	1	4		
Trophonia affinis					1	3		

PHYLUM ANNELIDA (cont'd)	Stony Beach	Lardeis Bay	Lagoon Bridge	Kettle Cove	Cuttyhunk Harbor	Hadley Harbor	N. Falmouth	Dredging
Class Chaetopoda								
Sub-class Oligochaeta								
Enchytraeus albidus								
Lumbricillus agilis								
Class Gephyrea								
*Phascolosoma gouldi		5	6	1	6	6	6	
PHYLUM ARTHROPODA								
Class Crustacea								
Order Cirripedia								
*Balanus								
B. balanoides	6	5	6	6	5	5	6	2
B. eburneus	3		4	2	6	5	5	3
*Chthamalus fragilis	6	4	6	5	5	5	6	
Lepas								
L. anatifera		1						
L. fascicularis								
Order Amphipoda								
Aeginella longicornis	1	4	4	2		1	1	
Allorchestes littoralis					1		3	1
Ampelisca macrocephala	2		2	4	5	3	2	6
Amphithoe sp.			1	1	3			2
Autonoe sp.							1	
*Caprella acutifrons	2	3	6	3	3	4	4	
Carinogammarus mucronatus		1				1		
Chelura tenebrans						1		
*Corophium cylindricum	2	3	4	4	5	4	2	2
*Gammarus sp.	6	5	6	6	6	6	6	3
Haustorius arenarius	2	1		6	4	1	3	
*Orchestia platensis	4	4	4	5	5	4	5	
Stenothoe minuta								
*Talorchestia longicornis	3	1	2	3	1	1	4	1
Unciola irrorata	1					3	3	5
Order Isopoda								
Chiridotea caeca				1				
Cyathura carinata					1		3	
Edotea triloba				2			2	
Erichsonella filiformis				1	1		3	3
*Idothea			1					
I. baltica	3	6	5	6	6	4	6	3
I. metallica				1			1	3
I. phosphorea			1	3	2		1	2
*Jaera marina	3	3	3	3	5	3	5	
Jassa marmorata		2	2	8	8	2	2	1
Leptochelia sp.					1			
Ligyda oceanica								
Limnoria lignorum						1		
Sphaeroma quadridentatum				1			3	
Tanais sp.					3		2	
Order Mysidacea								
Diastylis sp.		1						
*Heteromysis formosa		1	5		1	2	1	2
Michtheimysis stenolepis								
Order Stomatopoda								
Chloridella empusa								
Order Decapoda								
Callianassa stimpsoni		1						
*Callinectes sapidus			4		1		1	1
*Cancer		1						
C. borealis			1	1	2	1	1	2
C. irroratus	1	2	4	4	2	3	4	1

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

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

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

PHYLUM MOLLUSCA (cont'd)	Stony Beach	Lachaya Bay	Lagoon Bridge	Kettle Cove	Cuttyhunk	Hadley Harbor	N. Falmouth	Dredging
Class Gastropoda								
*Odostomia sp.	6	2		4		5	5	
Phytia myosotis								
*Polinices							1	
P.duplicata	2		1	1		1	4	
P.heros			1	1		2		
Rissoa sp.						1	2	1
Thais lapillus	2			6	5	5		
Turbonilla sp.	1				1	1		
Turritella sp.								
*Urosalpinx cinereus	6	6	6	6	6	6	6	2
Vermetus radicula								
Class Cephalopoda								
Loligo pealei								
PHYLUM CHORDATA								
Sub-phylum Hemichorda (Enteropneusta)								
Dolichoglossus kowalevskyi	6		2	6		3	6	
Sub-phylum Urochorda (Tunicata)								
*Amaroucium		1						
A.constellatum	5	2	6	6	6	4	5	1
A.pellucidum	2	1			1	2	1	2
A.stellatum								6
*Botryllus schlosseri			3		6	3	4	
*Didemnum candidum lutarium		4	5	6	6	5	1	5
*Molgula	3		1		3	1		
M.arenata								
M.manhattensis	1		1		1	4	4	
M.complanata								
*Perophora viridis	3	2	6	3	5	6	2	
*Styela partita	6	3	4	5	5	5	5	4

INVERTEBRATE ZOOLOGY CLASS, 1941

Name	Seat No.	Team	College or University
Anderson, Dorcas J.	1	I	Purdue
Andrews, Thos. Jos.	19	VI	Mass. State
Aram, Hartley H.	20	VI	State Univ. Iowa
Batchelor, Wm. Henry	23	VI	Harvard
Berg, Philip W.	21	VI	State Univ. Iowa
Beardsley, Margaret	2	I	Smith
Brainerd, John W.	22	VI	Harvard
Brown, Henrietta B.	3	I	Tufts
Burke, Roger K.	24	VI	Springfield
Byerrum, Richard	25	V	Wabash
Carpenter, Elizabeth	4	I	Mt. Holyoke
Cole, LaMont C.	26	V	Univ. Chicago
Corder, Henry R.	27	V	Williams
Cornish, Helen R.	5	II	Univ. Richmond
Culberson, Arthur W.	28	V	Williams
Dodd, Samuel G.	29	V	Wesleyan
Dole, Dorothy C.	6	II	Vassar
Garman, Elizabeth M.	7	II	N. J. College for Women
Gillette, Roy J.	30	V	Washington Univ.
Gilligan, Catherine	8	II	Boston Teachers College
Goffin, Mary F.	9	III	Seton Hill
Hahn, Rhea J.	10	III	Radcliffe
Harris, Norman D.	32	IV	Harvard
Hauschka, Theodore S.	33	IV	U. of Pennsylvania
Heaps, Marian E.	11	III	Lebanon Valley
Hinde, Howard P.	34	IV	Yale
Humm, Douglas G.	35	IV	Yale
Kielich, E. Randolph	36	IV	Canisius
King, Ellen E.	12	III	Sarah Lawrence
Kohler, Chas. E.	37	III	Rutgers
Lumb, Ethel S.	14	IV	U. Missouri
Mahr, Merle M.	38	III	N. Y. U.
Mead, Albert R.	39	III	Cornell Univ.
Miller, Helena A.	13	IV	Radcliffe
Minor, Howard D., Jr.	40	III	Wabash
Osmun, John V.	41	III	Amherst
~~Paull, Joseph~~	~~42~~	~~II~~	~~Harvard~~
Perkins, David D.	43	II	Rochester
Pond, Sidney M.	44	II	Wesleyan
Powers, William T.	49	II	DePaul
Randall, Walter C.	50	II	Purdue
Roberts, Beryl J.	15	IV	Boston Teachers College
Roberts, Henry S., Jr.	51	I	Duke
Roberts, Wesley F.	52	I	Northwestern
Robinson, Margaret H.	47	V	Wellesley
Ross, Lucille	16	IV	Barnard
Schlichter, Helena L.	17	V	Wilson
Senyard, (Euala) Juanita	18	V	Oberlin
Talmage, Roy V N.	53	I	Richmond
Tuttle, Ruth F.	45	VI	Wheaton
Weber, Ann M.	46	VI	Montclair State Teachers
Wieder, Herbert	54	I	Hamilton
Wilbur, Chas. G.	55	I	Johns Hopkins
Williams, Robert W.	56	I	Harvard
Wilson, Mae E.	48	VI	Southern California

Grass. Louise. — 42 — I — Smith.

INVERTEBRATE ZOOLOGY CLASS, 1941.
FIELD TEAMS

Team I	Team II	Team III
1. Wilber	1. Randall	1. Osmun
2. Williams	2. Powers	2. Mead
3. Wieder	3. Pond	3. Miner
4. Talmage	4. Perkins	4. Mahr
5. Roberts, H. S. Jr.	5. ~~Paull~~ Roberts, W.H.	5. Kohler
6. ~~Roberts, W. H.~~ Brosch.	6. Cornish	6. Hahn.
7. Anderson	7. Dole	7. Goffin
8. Beardsley	8. Garman	8. Heaps
9. Brown	9. Gilligan	9. King
10. Carpenter		

Team IV	Team V.	Team VI.
1. Kielich	1. Dodd	1. Burke
2. Humm	2. Gillette	2. Batchelor
3. Hinde	3. Culberson	3. Berg
4. Hauschka	4. Corder	4. Brainerd
5. Harris	5. Cole	5. Aram
	6. Byerrum	6. Andrews
6. Lumb		
7. Miller	7. Schlichter	7. Tuttle
8. Ross	8. Senyard	8. Weber
9. Roberts, B. J.	9. Robinson	9. Wilson

N.B.- Numbers before the names give the numbers for pieces of equipment for the team given on the schedule of equipment for each field trip on the sheet marked "TEAM ORGANIZATION".

Each member of a team will please to provide him or herself with the proper item of equipment for each trip and report to the team's instructor for the trip scheduled as given on the sheet marked "RELATION OF TEAMS TO INSTRUCTORS" with the proper utensil, in the laboratory and remain with him (and it) until he leaves the laboratory, unless he directs otherwise. Each team member will be responsible also for the proper use and return of his utensil to the store room or the laboratory after the trip is over. This is very important to insure success for the next trip.

Teams meet in the laboratory again after removing wet clothing, at times specified by instructors in charge of teams or at 7.30 if not specified, to review or identify specimens brought in in the ARK and to become familiar with species names. This is your chance to learn the names and characteristics of the forms found and identified.

All specimens brought in by a team must be removed from the ARK as soon as possible (immediately) on return and placed in open dishes of fresh SEA WATER on some desk agreed upon by the team. This must be done before changing clothes. Don't put worms and crustaceans together in the same dish; they will eat each other up. Teams should organize for work in these laboratory sessions by making some persons responsible for certain groups of animals, etc. Instructors are not responsible for this organization. Each team should do it for itself. Elect captains, etc. Instructors are present to help not drive you. Members are to be active learners not passive absorbers.

INVERTEBRATE ZOOLOGY COURSE

Seating Plan

1941

Preparation table and sink.

31.			
32. Harris, N.D.			
33. Hauschka, T.S.	34. Hinde, H.P.	29. Dodd, S.G.	30. Gillette, R.J.
36. Kielich, E.R.	35. Humm, D.G.	28. Culberson, A.W.	27. Corder, H.R.
37. Kohler, C.E.	38. Mahr, M.M.	25. Byerrum, R.	26. Cole, L.G.
40. Miner, H.D. Jr.	39. Mead, A.R.	24. Burke, R.K.	23. Batchelor, W.H
41. Osmun, J.V.	42. Paull, J.	21. Berg, P.W.	22. Brainerd, J.W.
44. Pond, S.M.	43. Perkins, D.D.	20. Aram, H.H.	19. Andrews, T.J.
45. Tuttle, R.F.	46. Weber, A.M.	17. Schlichter, H.L	18. Senyard, E.J.
48. Wilson, M.E.	47. Robinson, M.H.	16. Ross, L.	15. Roberts, B.J.
49. Powers, W.T.	50. Randall, W.C.	13. Miller, H.A.	14. Lumb, E.S.
52. Roberts, W.F.	51. Roberts, H.S. Jr.	12. King, E.E.	11. Heaps, M.E.
53. Talmage, R.VN.	54. Wieder, H.	9. Goffin, M.F.	10. Hahn, R.J.
56. Williams, R.W.	55. Wilber, C.G.	8. Gilligan, C.	7. Garman, E.M.
		5. Cornish, H.R.	6. Dole, D.C.
		4. Carpenter, E.	3. Brown, H.B.
			2. Beardsley, M.
Lecture Desk and Table.			1. Anderson, D.J.

TEAMS AND INSTRUCTORS FOR FIELD TRIPS, 1941.

Instructors	THB.	SC.	AML.	WEM.	NTM.	JSR.	AJW.	ERJ.	PWG.	Total
STONY BEACH Fri. July 25. 2.00-3.10-4.30.	1	2	3	4	5	6	---	---	---	6
LACKEY'S BAY Sat. July 26. 2.00-4.02-4.30	2	3	4	5	6	1	---	---	--	6
LAGOON BRIDGE Sat. Aug. 2. 9.00-1.22-3.30.	3	4	5	6	--	--	2	1	--	6
KETTLE COVE. Wed. Aug. 6. 10.00-2.26-4.00	4	5	--	1	2	--	3	--	6	6
CUTTY HUNK. Fri. Aug. 8 9.00-3.06-3.30	5	1	--	2	--	4	--	6	3	6
HADLEY HARBOR. Thurs. Aug. 21. 10.15-1.06-3.30.	--	--	6	--	3	2	1	4	5	6
NORTH FALMOUTH. Sat. Aug. 23. 9.00-2.28-3.30	--	--	1	--	4	5	6	3	2	6
DREDGING. Wed. Aug. 27.										
Teams 1-3 A.M.	--	Tow	2	Tow	Tow	3	--	--	1	6
" 4-6 P.M.	6	Tow	--	Tow	Tow	--	4	5	--	6

Teams will meet in laboratory with their instructors after supper following field trips to review specimens brought in and to identify small ones not readily identified in the field. The Ark Angel of each team must see that all specimens in bottles are deposited in suitable containers and aerated in new salt water before leaving the Ark to change to normal clothing for supper. The emptied bottles are then returned to the Ark with corks and the Arks returned to the store room near the front door ready for the next trip. After the HADLEY HARBOR trip an exhibit of the specimens brought in will be made in the lobby of the Main Brick Building with suitable labels on waxed cards. This can be started before supper and finished afterward. Volunteer crews to change seawater in the late evening and next morning will be needed

TEAM ORGANIZATION
INVERTEBRATE ZOOLOGY COURSE

STONY BEACH	LACKEY'S BAY	LAGGON BRIDGE	KETTLE COVE
1. Shovel	1. Sieve	1. Shovel	1. Ark
2. Sieve	2. Shovel	2. Ark	2. Ark
3. Shovel	3. Shovel	3. Ark	3. Shovel
4. Ark	4. White pan	4. Shovel	4. Sieve
5. Ark	5. Ark	5. Sieve and Scrapenet	5. Shovel
6. Angel	6. Ark	6. Net and Sea Bucket	6. Net & Sea Bucket
7. Net & Sea bucket	7. Wg.Fb. Pipette	7. Wg.Fb.Pipette, Bucket	7. Angel
8. Wg.Fb. Pipette	8. Angel	8. White pan	8. White pan
9. White pan	9. Net & Sea Bucket	9. Angel	9. Wg.Fb. Pipette
10. Wg.Fb. Pipette	10. Wg.Fb. Pipette	10. White pan	10. Bucket

CUTTY HUNK	HADLEY HARBOR	NORTH FALMOUTH	DREDGING
1. ~~Scrape net,~~ Angel Bucket	1. Net & Sea Bucket	1. Shovel	1. Water bucket
2. Shovel	2. Angel	2. Ark	2. Dredgings bucket
3. Ark	3. Shovel	3. Ark	3. White pan
4. Ark	4. Sieve	4. Sieve	4. Angel
5. Shovel	5. Shovel	5. Shovel	5. White pan
6. Sieve ~~scrapenet~~	6. Ark	6. Net & Sea Bucket	6. Wg.Fb.Pipette
7. Net & Sea Bucket	7. Ark	7. Wg. Fb. Pipette	7. Wg.Fb.Pipette
8. Wg.Fb. Pipette	8. Wg. Fb. Pipette	8. Angel	8. Ark
9. White pan	9. White pan	9. White pan	9. Ark
10. Bucket	10. White pan	10. Wg. Fb. Pipette	10. White pan

INVERTEBRATE ZOOLOGY COURSE, PROGRAM, 1941.

N.B.- Subject to change to suit the weather.

Thur. July 24. 8.00 P.M.-Introductory remarks on conduct of the course, duties of team members, dangers of tides, poison ivy, etc., in Laboratory.

Fri. " 25. A.M. Protozoa (Waterman, Jones, Gilbert)
P.M. STONY BEACH (2.00-3.10-4.30) bring in specimens.

Sat. " 26. A.M. Protozoa (Waterman, Jones)
P.M. LACKEY'S BAY (2.00-4.02-430) No lab. review tonight. Mixer.

Sun. " 27. ----------

Mon. " 28. A.M. Protozoa (Waterman, Jones)
P.M. Porifera (Lucas, Jones)

Tues. " 29. Coelenterata (Crowell, Gilbert)

Wed. " 30. Coelenterata (Crowell, Gilbert)

Thur. " 31. Coelenterata (Crowell, Gilbert)

Fri. Aug. 1. A.M. Coelenterata (Crowell, Gilbert)
P.M. Platyhelminthes (Rankin, Jones)

Sat. " 2. LAGOON BRIDGE (9.00-1.22-3.30) Bring in specimens. Lab. rev. 7.30.

Sun. " 3. ----------

Mon. " 4. Platyhelminthes (Rankin, Jones)

Tues. " 5. Platyhelminthes (Rankin, Jones)

Wed. " 6. Marine Zoology Lecture, Rankin, 8.30.
KETTLE COVE (10.00-2.26-4.00). Lab. review, 7.30 tonight.

Thur. " 7. Annelida (Lucas, Jones)

Fri. " 8, CUTTY HUNK (9.00-3.06-3.30) Review in Lab at 7.30 P.M.

Sat. " 9. Annelida (Lucas, Jones)

Sun. " 10. ----------

Mon. " 11. Annelida (Lucas, Jones)

Tues. " 12. Bryozoa (Bissonnette, Gilbert)

Wed. " 13. Mollusca (Mattox, Gilbert)

Thurs. 14. Mollusca (Mattox, Gilbert)

Fri. " 15. Mollusca (Mattox, Gilbert)

Sat. " 16. Mollusca (Mattox, Gilbert)

Sun. " 17. ----------

Mon. " 18. Echinodermata (Bissonnette, Jones)

Tues. " 19. Echinodermata (Bissonnette, Jones)

Wed. " 20. Echinodermata (Bissonnette, Jones)

Thur. " 21. Marine Ecology Lecture, Lucas, 9.00
HADLEY HARBOR (10.15-1.06-3.30) Exhibit in Main Lobby.

Fri. " 22. Arthropoda (Martin, Gilbert)

Sat. " 23. NORTH FALMOUTH (9.00-2.28-3.30) Review in Lab. at 7.30.

Sun. " 24. ----------

Mon. " 25. Arthropoda (Martin, Gilbert)

Tues. " 26. Arthropoda (Martin, Gilbert)

Wed. " 27. DREDGING (9.00-12.00, Teams 1-3; 2.00-4.30, teams 4-6)
Study of towings in Lab. for teams not dredging (Martin, Mattox, Crowell)

Thur. " 28. Arthropoda, Limulus (Martin, Gilbert)

Fri. " 29. Chordata (Waterman, Jones)

Sat. " 30. Chordata (Waterman, Jones)

Teams will meet in the laboratory after field trips, unless otherwise stated, for review of forms found and for identification of those not classified in the field. An exhibit will be prepared, for inspection by the members of the Marine Biological Laboratory, after the Hadley Harbor trip on Thursday August 21, and placed in the Main Lobby of the Brick Building. Volunteers to change seawater and keep the animals alive will be needed.

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. Attached protozoa.

(1) Examine old colonies of Obelia, Tubularia, Sertularia, or Pennaria (Coelenterates), and Filamentous Algae, taken from wharf pilings and laboratory boats, for representatives of the class Suctoria, i.e., Ephelota, Podophrya and Acineta. Trichophrya salparum may sometimes be found on the external body surface of Molgula manhattensis, and Paracineta limbata on algae, bryozoans, and hydrozoans. Vorticella, Zoothamnium, Folliculina and Cothurnia (Ciliata) are among the attached forms which will also be found. Slides, which have been immersed in Eel Pond for several weeks, are good sources for stalked, attached and certain free-living protozoa.

Free-living protozoa.

(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, Chaenia, Foraminifera, Dinophysis (Dinoflagellate), Uronychia, Discocephalis, Holosticha, Tintinnopsis, Anisonema, Peloryxa, Lacrymaria, Euplotes, Gastrostyla, Pleuronema, Strombidium, Trachelocera (2 species), Philaster, Heliozoa, Dysteria, Aspidisca, Diophrys, Lombus, Allargronia, Protoctucia, Raphidiophrys, Nassula, etc. Note the rapidity with which marine animals and plants have accumulated on clean material suspended in sea water and also their abundance.

(3) Preserved Noctiluca, or slide.

(4) Slides of Foraminifera, Radiolaria, etc.

Identify and make recogonizable 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 briefly according to Pratt, revised edition, 1936. At least eight individuals should be carefully studied.

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

2nd. Day.

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
Boveria teredinidi	Teredo navalis	Attached to gills
Lichnophora macfarlandi	Crepidula	Egg cases
Ancistruma mytili	Mytilus edulis	Mantle cavity
Ancistruma isseli	Modiolus modiolus	Mantle cavity
Conchophthirius mytili	Mytilus edulis	On muscles & foot
Chilodonella hyalina	Orchestia agilis	Exoskeleton
Allosphaerium palustris	Orchestia palustris	Exoskeleton
Folliculina ampulla	Limulus Bdelloura	Gill books Egg cases of Bdelloura

(2) Parasites.

Trichodina sp. (2 types)	Thyone briareus	Digestive tract
Schizocystis sipunculi	Phascolosoma gouldi	Intestine
Ceratomyxa mesospora (spore stage)	Puffer (fish)	Gall bladder
Haplozoan clymenella	Clymenella	Intestine
Monocystis clymenellae	Clymenella	Intestine
A Sporozoan & a ciliate	Hydroides	?
Anoplophrya orchestii	Orchestia agilis	Lacunae (blood vascular spaces)
Protophrya ovicola	Littorina rudis	Brood sac & ovary
Selenidium echinatum	Dodecaceria	Intestine
A gregarine	Balanus eburneus	Intestine
Porospora gigantea (Sporozoa)	Lobster	Intestine
Merogregarina amaroucii (Sporozoa)	Amaroucium	Intestine
Cristispira balbianii (Spirochaete)	Oyster	Crystalline style
Nematopsis ostrearum (Gregarine)	Oyster (secondary host)	Spores in muscle gill mantle
Panopeus herbstii	Mud crab (primary host)	Intestine

(3) Symbionts.

Trichonympha sp.	Termites of this region.	Intestine
Dinenympha 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: Brief classification, host, behavior, and location in host.

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

DIRECTIONS FOR SECURING MARINE PROTOZOA FOR LABORATORY

A. Suctoria, Folliculina, Family - Vorticellidae, Cothurina and other attached protozoa.

These will be found attached to filamentous algae or to Hydroid colonies such as Tubularia, Sertularia, Pannaria, Obelia, etc. taken from wharf pilings. Examine pieces in a syracuse dish or on a slide with low power. Another method is to line a large glass container with syracuse dishes, fill the container with hydroids, stick slides down into the mass of hydroids in the culture dish and place under a salt water tap several weeks before desired. Among the material attached to the slides will be found (perhaps) Suctoria, Vorticella, Cothurnia, Folliculina, Radiolaria, Zoothamnium, Heliozoa and many Free-swimming ciliates. 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 hooks of the horse-shoe crab, Limulus.

A method which gives numerous Folliculina is as follows: Place syracuse dishes bottom up in a crystalizing dish (with or without old hydroids) under the salt water tap about 48 hours to a week or more before desired. The Folliculinae will often be found in great abundance on the under (or cavity) surface of the syracuse dishes. Wipe the bottom surface of syracuse dish clean, turn it over and put in about one-eight inch sea water. Study under the microscope. An individual may be removed to a slide for high power observation.

Suctoria are abundant on filamentous green algae taken from the laboratory boats, live fish car, and the piles of the wharf in front of the laboratory or in the Eel Pond. Examples of the family Vorticellidae and of the genus Cothurnia are also abundant. Algae from the wharfs in the Eel Pond and hydroid material give examples of the Vorticellidae and of Cothurnia. Suctoria are not usually abundant.

B. 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 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 and buckets of old Hydroid material, and on slides and syracuse dishes which have been immersed in hydroid material or in running sea water for a week or more. Also material from bottom of aquaria is sometimes good, as well as slides which have been immersed in the Eel Pond.

Marine Amoebae may be cultured as follows: Place fucus in a jar with sea water. Use large glass jars holding about 20 liters and have a slow stream of sea water flowing into them. This is the settling basin culture method which may give almost a permanent culture. Tidal pools where distoms grow luxuriantly are good places for amoebas (Schaeffer).

C. Parasitic Protozoa.

Teredo navalis

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. They are attached to the Lamellae.

Directions for Securing Marine Protozoa for Laboratory

Phascolosoma gouldi

Remove the intestine, open it and wash the contents into a syracuse dish. Transfer the parasite to a glass slide. It is pointed at both ends, curved and wriggles slowly.

Clymenella Torquata

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

Thyone briareus

Place the animal in a weak ammonia solution (2%) and, when it softens slightly, return to sea water. The animal will immediately eviscerate the alimentary tract. Cut off portions, open and wash contents on a slide. Two types may be found; one in the anterior part of tract and the other in the posterior.

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 worm and remove it from 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 contents. Identify the parasites, if present.

Orchestia agilis

Crush the animal on a slide and add .5% saline solution of 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. Other types on exoskeleton and gills.

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 the egg cases 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 may be transferred to a slide. Use little water.

Mytilus odulis

Open in the manner described above for Modiolus. Two ciliates will be found if the host is infested. The smaller and more numerous ciliate is Ancistruma. 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.

Puffer

Open abdomen and pull out the liver. Grasp the gall bladder at neck with a pair of forceps and pull it away. Open on a slide and scrape inner surface into salt solution with a scalpel. The spore stage may be present.

Balanus eburneus

The gregarine will be found in the intestinal lumen. Remove the digestive tract and tease carefully.

Littorina rudis

The ovary is red in color and will be found near the tip of the shell.

Termites - local.

Grasp the head of 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 .4% 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.

Solutions available, if desired:

0.4% and 0.5% saline solutions.
2% sea water solution of ammonia.
Saturated methyl green in 1% acetic aceto-carmine (super saturated carmine in 45% glacial acetic)
Carmine in sea water.
Neutral Red.
Methylene Blue.

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PORIFERA

The laboratory outline is prepared for a full days work on the Porifera but since your time is shortened by the field trip this afternoon, organize your work so that at the end of the day you will have accomplished those parts of the laboratory study which is most interesting and beneficial to you.

The regeneration experiments on Microciona will be started first in order that the material may be observed at intervals during the morning and again in the evening.

Regereration of Microciona. Each student will need a finger bowl, a Syracuse watch-glass and a slide. The group at each table will need an additional finger bowl to be used in common. Fill the finger bowls about two-thirds full of sea-water. Place the watch-glass on the bottom and the slide on top of the watch glass. Into the common bowl, cells and broken fragments from Microciona will be pressed through fine meshed bolting cloth. Pipette a small quantity of this material into the finger bowls containing the slides. As soon as the cells have had time to settle on the slide, carefully lift it out and examine it. Return it carefully to the finger bowl. Study several times during the day. Have the cells shown a tendancy to aggregate?

The structure of the reunition mass and the cells involved are discussed in papers by Wilson and Galtsoff. Many of the cell types, the syncytium which forms the surface layer and all of the skeleton are retained by the bolting cloth. Wilson considers three types as represented in the free cells, one, the choanocytes which remain specific and produce a new gastral epithelium, two, cells with nucleolate nuclei and possessing granules to a variable degree in their cytosomes and, three, non-nucleolate cells possessing in their cytosomes fine granules of uniform size which gives to the cells a grayish color. He regards the nucleolate type as a primordial cell which produces in the reunition mass, as in the adult, skeletal and reproductive cells. The non-nucleolate cell produces the syncytium which covers the body and lines those canals not occupied by choanocytes. Some indication of cell types can be learned from fresh preparations but fixed and stained material has been found more satisfactory Do not spend too much time trying to identify the different types of cells.

Ascon type. (Leucosolenia). Note relation of individuals to each other and prevalence of buds. Make a habit sketch.

Select an individual which is relatively free from debris. With a razor or sharp scalpel cut it lengthwise and place the halves on a slide so that both inner and outer surfaces may be viewed under the same cover glass. Note the different types of spicules and especially their general arrangement. Note, also, the lack of cementing material (spongin) to hold them together such as will be found in some monaxonid sponges, e.g. Halichondria and Chalina. Focus on the gastral surface and observe the beating of the chonocyte flagella. (The details of the collar cells may be studied better in Sycon). Note the numerous porocytes with their intracellular openings. Draw a porocyte and some adjacent choanocytes.

The spicules in this form and also in Sycon, Chalina, Halichondria and Microciona can be studied best by examining the residue which

remains after sponges have been boiled in potassium hydroxide. Material has been treated in this way for you and is available on the preparation table. Draw acetic acid under the cover glasses of your several preparations. Note the results. Illustrations and names of some typical spicule shapes are found in Pratt's Manual and Human's Invertebrates, p. 298. Compare the descriptions given in the text for species represented in Woods Hole with your observations. Draw each type of spicule found in each of the sponges available. For the non calcaria refer to Vosmae's The Sponge of the Bay of Naples. Write the scientific term under each spicule. See pp. 95-105 in Delage and Herouard. Emphasis has been placed on the form of the spicules because the spicule is frequently the most constant morphological structure available in the classification of some sponges.

Sycon type. (Sycon called Grantia in older texts) Suggestions for study of this sponge are given in Drew (pp. 37-40, 5th edit.) The remarks here are supplementary to the text. The relative sizes of incurrent and radial canals and their relation to each other may be seen clearly in a tangential section of a dried skeleton made as follows: Two cuts are made parallel to the long axis; the plane of the first passes tangentially to the middle of the body wall, the plane of the second, parallel to the first, is made sufficiently near the long axis so as to include part of the inner surface.

Study of living material. Observation on the direction of current flow can be carried out either in Sycon according to directions in Drew or in Halichondria which shows a more vigorous flow of current if good material is available.

It is suggested that, instead of tangential sections mentioned in Drew for living material that you try to make cross-sections sufficiently thin to allow study with a 4 mm. objective and yet, in making the sections, to retain typical relations of the animal's structures. Sections a quarter to a fifth of a millimeter are about right. The choanocytes lining the radial canal will be visible and with proper adjustment of condensor and illumination one may observe flagella, collars, and the prosopyles. Draw a choanocyte if you did not observe one in the fragments of Microciona.

Observe also in this preparation germ cells and developing embryos which may be present. Compare these amphiblastulae with the larvae of Microciona. These latter may be obtained by dissecting pieces of the adult sponge with needles. When freed from the parent the larvae swim out into the surrounding water. Draw whatever embryonic stages, either in Sycon or Microciona that may be available in your material.

Leucon type. 1. (Chalina). Observe the general organization of the colony. Identify the oscula. Only a rough idea can be gained of the anatomy of the sponge from thin cross-sections but such a preparation will reveal the manner in which short monaxonid spicules are effectively held together by spongin. Use magnification of about 400 x. Make a drawing to illustrate this.

2. (Halichondria). Place a piece of a colony in a Syracuse watch glass and look for an osculum. Note the vigorous flow of water from it. A thin membrane which forms the osculum is a syncytium. It covers the surface of the sponge forming its dermal layer. The spicules beneath support it like so many tent poles. Numerous ostia are present in the membrane which lead into the extensive subdermal space below. From this lead the incurrent canals

directing the water toward the flagellated chambers.

Other Sponges. Examine such other sponges as may be available in the laboratory, probably Tethya and Cliona. Cliona is the sulphur sponge -- smell it. It is able to bore into shells, but apparently not by the use of an acid.

All records of your work on the Porifera are due not later than 9:00 a.m.

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Classification of the Phylum Porifera

Class I. Calcarea of Calcispongiæ, the calcareous sponges. Skelton composed of separate calcareous spicules, one-, three-, or four-rayed, not divisible into megascleres and microscleres.

Order 1. Homocoela, the ascon sponges. Structure asconoid.

Order 2. Heterocoela. Structure syconoid leuconoid.

Class II. Hexactinellida or Triaxonida or Hyalospongiae, the glass sponges. Skeleton composed of triaxon (six-rayed* siliceous spicules or some modification of the triaxon form, separate or united into networks; chaonocytes limited to finger-shaped chambers arranged in a simple or folded layer; without surface epithelium.

Order 1. Hexasterophora. With hexasters, without amphidisks.

Order 2. Amphidiscophora. With amphidisks, no hexasters.

Class III. Demospongiae. Skeleton of siliceous spicules or horny fibers or both; siliceous spicules not triaxon, generally differentiated into megascleres and microscleres; flagellated chambers mostly small, round, of the leuconoid type.

Subclass I. Tetractinellida. With tetraxon spicules; no spongin; spicules sometimes wanting.

Order 1. Myxospongida. Without spicules; structure simple

Order 2. Carnosa or Homosclerophora or microsclerophora. Megascleres and microscleres not sharply differentiated; mostly without triaenes; asters may be present.

Order 3. Choristida. With long-shafted triaenes; megascleres and microscleres distinct.

Suborder 1. Astrophora. Microscleres include asters.

Suborder 2. Sigmatophora. Microscleres when present are sigmas.

Subclass II. Monaxonida. Megascleres monaxonial; with or without spongin.

Order 4. Hadromerina or Astromonaxonellida. Megascleres mostly tylostyles; microscleres when present some form of aster; without spongin.

Order 5. Halichondrina. Megascleres mostly or two or more kinds; microscleres wanting or are rhaphas; with little spongin.

Order 6. Poecilosclerina. Megascleres often of two or more sorts, localized in distribution; reticulate, united by more or less spongin; often with echinating spicules; microscleres include sigmas, chelas, and toxas.

Order 7. Haplosclerina. Megascleres of one kind, diactinal without special localization; with or without microscleres; spongin generally present.

Subclass III. Keratosa, the horny sponges. Skeleton composed of spongin fibers, without siliceous spicules.

Taken from "The Invertebrates" by L. H. Hyman

PLATYHELMINTHES AND NEMATHELMINTHES
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KEY TO THE MORE COMMON

POLYCLAD TURBELLARIANS OF THE WOODS HOLE AREA

POLYCLADIDA: Fairly large turbellarians, with thin, leaf-like body; intestine with very numerous branches which ramify throughout the body; eyes usually numerous.

1 (6) Tentacles absent.....2
2 (3) Marginal eyes present.....Coronadena mutabilis.
(marginal eyes around anterior body half; gray to yellowish-brown; 18 X 5mm; among shells and algae)
3 (2) Marginal eyes absent.....4
4 (5) Four conspicuous eye clusters near anterior end.....
.....Notoplana atomata
(Syn.: Leptoplana variabilis)
(28 mm. long; brownish; sluggish; under stones in tide pools, also on pilings and algae)
5 (4) Eyes few, about six on each side, not in conspicuous clusters.....Euplana gracilis
(yellowish to brownish-gray; 8 - 12mm. long; on pilings among algae and shells)
6 (1) Tentacles present.....7
7 (8) Tentacles formed by upfolded anterior margin.....
.....Eurylepta maculosa
(thin undulated margin; 10 - 12mm. long; tentacles brownish on a pale flesh-colored ground; on piles among algae)
8 (7) Tentacles formed just posterior to anterior body margin.....9
9 (12) Marginal eyes present, surrounding or nearly surrounding body edge.....10
10 (11) Color pattern of alternating yellowish or white and brown cross bars of which the most anterior and posterior ones are V-shaped; usually found in hermit crab shells (Pagurus pollicaris); often on wharf piles.....Stylochus zebra
11 (10) Color usually cream or yellow; body with undulated margins; under stones in shallow water and tide pools.....Stylochus ellipticus
(Syn: Eustylochus ellipticus)
12 (9) Marginal eyes absent.....13
13 (16) Oval form; tentacles without eyes scattered through them.....14
14 (15) Living in mantle cavity of Busycon; white in color...
.....Hoploplana inquilina
(Syn; Planocera inquilina)
15 (14) Living on Sargassum weed; flesh-colored.....
.....Hoploplana grubei
16 (13) Elongate forms; tentacles with eyes scattered through them.....17
17 (18) Color green with median dorsal light stripe, 29 X 10mm.; on algae.....Planocera nebulosa
18 (17) Color yellowish, with brownish spots, 6 - 8 mm. long; on algae.....Gnesioceros floridana

Metoncholaimus pristiurus

This form is a free-living Nematode found in the mud in shallow salt water. It belongs to the 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 spincter valve (the cardia) 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 opithelium. 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 the minute pore at the extreme tip of the tail to be used in temporarily cementing the work 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. Each caudal gland is connected with an ampulla by a long, slender caudal gland duct.

The Excretory System:

This system consists of a single "renette" cell which is a fusiform, ventral cell located ventrally 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 renette duct enlarges near the excretory pore to form a minute excretory vesicle.

The Nervous System:

The chief concentration of the nervous system is the thick, semi-translucent nerve-ring which encircles the eosophagus 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 proximal 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 proximal 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 Demanian 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, the efferent uterus, which joins the uterus in the vicinity of the vulva. The demanian 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 demanian 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.

PLATYHELMINTHES - LABORATORY DIRECTIONS

First Laboratory Period - one half day.

Class: Turbellaria.

A. Bdelloura candida; Observe this worm in its natural environment on the ventral surface of the horseshoe crab, Limulus. It lays its eggs in cocoons on the leaves of the gill books, but may be found in large numbers at the basal joints of the walking legs.

1. The pharyngeal-proboscis mechanism: Transfer a worm to a drop of sea water on a slide without a cover-slip. Add several drops to 7% alcohol and watch for pharynx protrusion. This usually occurs within a few minutes. The musculature of the pharynx may be seen clearly later under a cover slip by examination under high power.

2. External ciliation (a taxonomic character): add a drop of sea-water carmine suspension to a slide with Bdelloura and observe the current set up by the epithelial cilia. Cilia may be observed also under high power.

3. Morphology: Place a medium-sized Bdelloura between 2 glass slides with vaselined edges and gradually compress until the worm is quite flat and quiet. Follow directions in Drew: 68-70. If necessary, for clearness, make separate diagrams of the different organ systems. These systems may be included in a single composite diagram. It may take several specimens before the entire morphology can be determined.

B. Optional: For students who have studied Bdelloura previously and for those who prefer to make comparative and embryological studies.

1. Make a comparative study of the several species of Turbellaria in the laboratory as to gross morphology and taxonomy.

2. Study the eggs and developing larvae of Euplana gracilis. This polyclad is found in abundance on ulva in the Eel Pond. Use Kukenthal on the front desk for reference.

Second Laboratory Period - one half day.

Class: Trematoda.

1. Adult Digenetic Trematode - Cryptocotyle lingua (Creplin). (See Stunkard, H. W. 1930. The life history of C. lingua Creplin), with notes on the physiology of the metacercariae. Jour. Morph. and Physiol., 50: 143-191).

Obtain two or three specimens from the assistant and mount on a slide. Vaseline the edges of the cover slip and apply pressure until the worms are fairly well flattened. As the worms flatten, body details may be observed more clearly. Beginning anteriorly, look for the following features: oral sucker, surrounding the mouth; short prepharynx; bulbous pharynx; esophagus, branching into two long intestinal crura that extend laterally to almost the posterior end; acetabulum, or ventral sucker, at about mid-body length, followed by the genital pore; uterus, filled with yellow eggs; dextral lobate ovary; median vitelline or yolk reservoir; dextral ovate

seminal receptacle; two obliquely-situated testes; median excretory bladder, extending as a slender tube to the posterior tip, emptying, posteriorly, and to a large extent anteriorly, are the vitelline or yolk follicles.

2. Optional: Examine slides of different species of Trematodes. Compare and draw a few.

Third Laboratory period - one half day.

Larval Forms of a Digenetic Trematode;

1. Redia. In a finger bowl at your desk are specimens of Littorina littorea infected with C. lingua and removed from their shells. Find an undamaged redia and mount on a slide. Note the pharynx, short intestine, antero-lateral birth pore, and developing cercariae, ranging from undifferentiated germ balls at the posterior end to mature cercariae near the birth pore at the anterior end. Release of cercariae through the birth pore may be observed.

2. Cercaria.

a. Obtain from the assistant a drop of water containing mature cercariae of C. lingua, add a drop of 1:10,000 solution of neutral red, and cover with a cover-slip. As the water evaporates the pressure of the cover slip flattens and quiets the cercariae and the body details become more distinguishable. Note the general resemblance of the body of the cercaria to that of the adult fluke. Find oral sucker, pharynx, intestinal crura, penetration glands with ducts (how many?) leading forward to empty near the anterior tip, cystogenous glands scattered over the whole body surface, germinal mass, excretory bladder, eye spots, and tail. Note the distribution of the fin on the tail, and spines on the body.

b. Optional. Make a comparative study of the various cercariae in the laboratory.

3. Encystment of cercaria:

a. The metacercariae of C. lingua are found in fishes (especially the Cunner). Add C. lingua cercariae to a fingerbowl containing a small Fundulus. Locate metacercariae in fins a few hours later. Add a piece of Fundulus fin to watch glass containing cercariae. Observe and describe the activities of the cercariae during encystment.

b. Optional: Instead of studying encystment of C. lingua cercariae, that of C. parvicaudata may be substituted. Obtain a specimen or two of the turbellarian Euplana gracilis and place with several specimens of Cercaria parvicaudata in a watch glass or depression slide and observe penetration and encystment. If interested, try other turbellaria with this cercaria and compare.

4. Metacercaria.

a. Study a metacercaria of C. lingua as it appears encysted in a Cunner fin. Remove a metacercaria from a cyst and study. Note that except for maturity it resembles the adult worm.

b. Optional: May be substituted for the metacercaria of C. lingua.

1). Remove and study the metacercaria of C. parvicaudata from Euplana gracilis that you infected previously; or

2). Remove and study the metacercaria of Maritrema arenaria from the barnacle, Balanus balanoides. This worm matures in the Ruddy Turnstone (Arenaria interpres), a shore bird. These cysts occur in large numbers throughout the tissues of the barnacle and may be teased out easily with needles under the dissecting scope. Place the cysts on a slide in a drop of water. Slight pressure of the cover-slip usually excysts the worms.

Fourth Laboratory Period - one half day.

Class: Cestoda.

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 flame-cells, and nerve trunks.

2. Mature proglottid - optional: Compress a milky white proglottid between a slide and cover-slip and study, following Drew, p. 74, as far as possible.

3. Plerocercous (Cysticercoid); The hexacanth embryo of the the tapeworm Otobothrium from the Hammerhead shark, enters the body of the butterfish, its intermediate host. The cysticercoids are small white dots in the dorsal body muscles. Tease a cysticercoid out of its sheath of host connective tissue and carefully tease it apart with needles. Cover and study in flattened position. As the larva unfolds, see the fine probascides like those in Rhynchobothrium.

Class: Nemertea. Optional.

1. Amphiporus; Follow the directions for Tetrastemma in Drew, p. 77-78. The chief difference in gross morphology between the two forms consists of the larger number of eye-spots in Amphiporus.

2. Make a comparative study of nemertines in the Laboratory.

Fifth Laboratory Period - one half day.

Phylum Nemathelminthes - Class Nematoda:

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

KEY TO THE MORE COMMON NEMERTEANS OF THE WOODS HOLE AREA

NEMERTEA: Soft, very contractile, often brightly colored, mostly free-swimming; body elongate, tapelike or filiform; proboscis often protruded on stimulation.

1 (20) Eyes present.....2
2 (15) Eyes few in number.....3
3 (10) Four eyes, forming a rectangle.....4
4 (5) Body stout.....Tetrastemma vittatum
(Green or yellowish, with 1 or 2 dorsal stripes; 5cm X 4mm; on muddy bottom at low tide)
5 (4) Body slender.....6
6 (7) Body tapering from middle both ways.....
.....Tetrastemma elegans
(2cm X 1mm; median dorsal yellow and two lateral brown stripes; among weeds and stones)
7 (6) Body wider in front. tapering posteriorly.....8
8 (9) Body pale yellow or reddish, spotted; found on muddy bottom.....Tetrastemma vermiculum
9 (8) Body white, light green, or yellowish; not spotted; among algae.....Tetrastemma candidum
10 (3) Eyes 4 - 14, lateral, never forming a rectangle.....11
11 (12) Body small, somewhat flattened, dark green with mid-dorsal yellowish stripe.....Lineus bicolor
(45mm X 1.5mm; single row of 8-14 eyes on each side; among algae and hydroids in shallow water)
12 (11) Body long and slender, not flattened.....13
13 (14) Body coiled in tight spiral when contracted.....
.....Lineus socialis
(15 cm X 1.5mm; green or brown with a few narrow encircling light rings; single row of 4-6 very small eyes on each side of head; under stones between tides)
14 (13) Body not coiled in tight spiral when contracted.....
.....Lineus ruber
(Green, brown, or reddish; single row of 4-8 eyes on each side of head; 20cm X 6mm; under stones between tides)
15 (2) Eyes numerous, more than 20.....16
16 (17) Body slender, 4cm long, light green; eyes in 2 or 3 parallel rows along each side of body; between tides.
.....Zygonemertes virescens
17 (16) Body relatively sho t and thick; eyes never in parallel rows.....18
18 (19) Eyes converging backwards; yellowish; 7cm X 3mm; under stones between tides.....Amphiporus ochraceus
19 (18) Eyes arranged in 2 frontal clusters on the white marginal area, and in 2 dorsal groups; reddish or brown; head wider, set off from body, white in front with a white spot on each side and an H-shaped figure in the middle; under stones between tides.....Amphiporus angulatus
20 (1) Eyes absent.....21

21 (28) Caudal cirrus present.....22
22 (23) Body very long, 2m or less X 25mm; broad, flat; head lancet-shaped with lateral groove; flesh-colored; in sand.....Cerebratulus lacteus
23 (22) Body long and slender; head without lateral groove...24
24 (25) Head long and pointed, pure white; body whitish; in sand between tides.....Zygeupolia rubens
25 (24) Head short and triangular; body flat.....26
26 (27) Body dark brown or yellow; in sand.....
.....Micrura caeca
27 (26) Body red or purple dorsally with light median line; 15cm X 4mm; in sand between tides.....
.....Micrura leidyi
28 (21) Caudal cirrus absent.....29
29 (30) Body short, flat, thick, with large sucker at posterior end; in branchial cavity of Mya, Venus, etc.....
.....Malacobdella grossa
30 (29) Body slender, cylindrical, no sucker, free-swimming..31
31 (34) Body cylindrical in front, flattened behind.....32
32 (33) Color orange; 25cm X 10mm; at low tide mark.....
.....Parapolia aurantiaca
33 (32) Buff in color; head white, flattened, rounded in front; 12cm X 3mm.....Carinoma tremaphoros
34 (31) Body cylindrical and filiform, not flattened.....35
35 (36) Body very small, 25mm X 0.5mm; head large and distinctly set off; whitish; among annelid tubes at low tide mark
.....Tubulanus pellucidus
36 (35) Body long, slender, tapering to pointed anterior end; 15 cm X 1mm; worm coils body in spiral; flesh-colored; under stones and in sand between tides.....
.....Cephalothrix spiralis

ANNELIDA
1941

First Day

General remarks: The materials available for study today are, Nereis virens, Arenicola, Glycera dibranchiata and Amphitrite ornata. It is suggested that the narcotization of Arenicola be started first and while the animal is relaxing study Nereis or some of the other forms available. Large, clear, accurate, line drawings are considered the best method for recording morphological observations.

1. Nereis virens. Follow directions given in Drew, pp. 91-95 (5th edit.) After studying reactions of living worm, narcotize it in order to examine its external and internal structures. Do this by adding about 10 cc. of 95 percent alcohol to enough sea-water in a finger bowl to cover the worm. After 5 or 10 minutes add an additional amount of alcohol if necessary. Your study and drawings of head and parapodium should lead to a clear understanding of the following terms: annulus, prostomium, peristomium, tentacle, palp, parapodium, notopodium, neuropodium, seta, aciculum, dorsal and ventral peristomial cirri, and dorsal and ventral parapodial cirri. Brief descriptions of these structures may be obtained from Pratt's Manual, pp. 320-325. Cleared and mounted preparations of Nereis parapodia, which show the acicula, may be obtained from the preparation table. Draw dorsal view of head and 1st 2 segments, cross section of worm to show parapodia and dorsal view of dissection.

2. Arenicola. This is the largest marine worm available for study and shows clearly many interesting internal structures. Plan to devote most of the day's available time to this animal. Directions may be found in Drew pp. 102-107. Make a large drawing to show a dorsal view of dissection and any additional drawings of parts you may wish to show in greater detail, e.g. a nephridium. The specimen will not keep over night very well.

3. Glycera dibranchiata will be available for those who have previously studied Nereis or for those who wish to make a comparison with Nereis. Allow the worm to swim freely. Which end usually moves foremost? Observe the protrusion of the proboscis. Identify a nephridiopore anterior to a parapodium. Narcotize the worm with proboscis extended. Open near the dorsal blood vessel. Pin out the body wall. Note absence of septa. Is the mechanism for everting and retracting the proboscis the same in Nereis and Glycera? How might differences in their longitudinal musculature be correlated with differences in their movements? Locate the nephridia. Draw dorsal view of dissected worm.

4. Amphitrite ornata. Note the reactions of the living worm. Narcotize with alcohol as given for Nereis. Laboratory directions may be found in Drew pp. 100-101, and especially complete ones in a paper by Adolph (see bibliography)

Second Day

There will be available numerous annelids in the laboratory for identification and study. Pratt's Manual and the Key of the Common Woods Hole Chaetopoda will be helpful in this work.

Record your identification according to the number given each specimen on the mimeograph sheets prepared for you. Make careful drawings of the heads and first few segments of about 6 species. The study of parapodia will be given special attention tomorrow.

Third Day

1. Continue, if you wish, the study of the various types of polychaetes.

2. Several living specimens of the Archiannelid, Dinophilus gardineri, will be available. Study this specimen in conjunction with the paper by Ruebush (see bibliography).

3. Make a comparative study of parapodia. Prepared slides are available, also segments cleared in oil. If you choose you may cut off with a sharp scalpel segments of worms preserved in alcohol and glycerin. Kindly use care in handling the preserved slides and return to proper places in slide boxes. Draw cross-sections or half cross-sections of 5 or more species of Polychaetes.

4. Trochophore larva of Hydroides. Mount the larva on a slide, using lens paper to entangle it. Study its external and internal structures. Identify: apical plate, apical tuft, prototroch, mouth, digestive tract, anus, and eye spots. The addition of carmine suspension will aid in the study of the digestive tract.

5. Phascolosoma, a Gephyrid worm. This group of worms is represented by relatively few species. Compare it externally and internally with the Polychaete annelids already studied. Follow Drew pp. 119-121. Draw dorsal view of dissected worm.

All records of work on annelids due 7:00 P.M. this evening.

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1941

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), (Eunice), Syllis
   Much branched to form long, mobile filaments - Hydroides, Pseudopotamila, 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 (Eunice)
   Eight - Trophonia
   Numerous - Amphitrite, Lepraea, Polycirrus and most other Terebellids.
3. Eyes
   Absent - Aricia, Scoloplos, Amphitrite, Lumbrinereis, Pista, Nephthys, Tranesia, Dodecaceria
   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. Perisotomium
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

Variations in Worm Tubes.

A. Calcareous tubes--Hydroides, Spirorbis.
B. Membraneous tubes--Dioptra, Pseudopotamilla, Chaetopterous.
C. Sand agglutinated with adhesive material--Clymenella, Cistenides, Sabellaria, Parasabella.
D. Mud agglutinated with adhesive material. Maldane, Pista, Amphitrite.

1941

Name_____

Place in the column at the left the dish number of the worms which you identify. Turn in with your drawings.

Dish Number	
	CLASS POLYCHAETA
	ORDER POLYCHAETA ERRANTIA
	Family -- APHRODITIDAE
.....	.....Lepidonotus squamatus (L)
.....	.....Harmothoë imbricata (L)
.....	.....Lepidametria sp.
.....	.....Sthenelais sp.
	Family -- PHYLLODOCIDAE
.....	.....Phyllodoce catenula Verrill
.....	.....Eulalia sp.
.....	.....Eteone sp.
	Family -- SYLLIDAE
.....	.....Syllis sp.
.....	.....Autolytus sp.
	Family -- HESIONIDOE
.....	.....Podarke obscura Verrill
	Family -- NEREIDAE
.....	.....Nereis virens Sars
.....	.....Nereis limbata Ehlers
.....	.....Heteronereis stage of N. limbata
.....	.....Nereis pelagica Linn.
	Family -- NEPHTHYDIDAE
.....	.....Nephthys incisa Malmgren
.....	.....Nephthys bucera Ehlers

Neme_____

Dish Number	
	Family -- EUNICIDAE
.....	..... Diopatra cuprea (Bosc)
.....	..... Marphysa leidyi Quartr.
.....	..... Lumbrinereis tenuis (Verrill)
.....	..... Lumbrinereis hebes
.....	..... Arabella opalina (Verrill)
	Family -- GLYCERIDAE
.....	..... Glycera dibranchiata Ehlers
.....	..... Glycera americana Leidy
	ORDER POLYCHAETA SEDENTARIA
	Family -- ARICIIDAE
.....	..... Aricia ornata Verrill
.....	..... Scoloplos robustus (Verrill)
.....	..... Scoloplos fragilis (Verrill)
	Family - SPIONIDAE
.....	..... Spio setosa Verrill
.....	..... Laonice viridis Verrill
.....	..... Polydora sp.
	Family -- CHAETOPTERIDAE
.....	..... Chaetopterus pergamentaceus Cuv.
	Family -- CIRRATULIDAE
.....	..... Cirratulus grandis Verrill
.....	..... Dodecaceria coralii

Name _____

Dish Number	
	Family -- TEREBELLIDAE
.....	..... Amphitrite ornata (Leidy)
.....	..... Amphitrite brunnea (Stimpson)
.....	..... Pista palmata (Verrill)
.....	..... Pista cristata
.....	..... Terebellides sp.
.....	..... Lepraea rubra Verrill
.....	..... Thelepus cincinnatus (Fabricius)
.....	..... Polycirrus eximius (Leidy)
.....	..... Polycirrus phosphoreus Verrill
.....	..... Enoplobranchus sanguineus Verrill
	Family -- AMPHARETIDAE
.....	..... Ampharete setosa Verrill
	Family -- AMPHICTENIDAE
.....	..... Cistenides gouldi (Verrill)
	Family -- CAPITELLIDAE
.....	..... Notomastus filiformis
	Family -- OPHELIIDAE
.....	..... Travesia forbesii
.....	..... Ophelia simplex
	Family -- MALDANIDAE
.....	..... Maldane urceolata (Leidy)
.....	..... Clymenella torquata Leidy
	Family -- ARENICOLIDAE
.....	..... Arenicola marina (L.)
.....	..... Arenicola cristata

Name_____

Dish Number	
	Family — CHLORHAEMIDAE
.....	..... Trophonia affinis (Leidy)
	Family — SABELLIDAE
.....	..... Parasabella microphthalma Verrill
.....	..... Pseudopotamilla oculifera (Leidy)
	Family -- SERPULIDAE
.....	..... Hydroides hexagonus Boxc
.....	..... Spirorbis spirorbis (L.)
	Family -- SABELLARIDAE
.....	..... Sabellaria vulgaris Verrill.
	CLASS OLIGOCHAETA
	Family -- ENCHYTRAEIDAE
.....	..... Enchytraeus albidus Henle
.....	..... Lumbricillus agilis

1941

A Key to the Common Chaetopoda of the Woods Hole Region.

POLYCHAETA

Dorsal surface more or less completely covered by overlapping scales (elytra) I

Leaf-like dorsal and ventral cirri which do not cover the dorsal surface, 2 eyes, 2 short caudal cirri. Blood colorless II

Prostomium with 2 palps, 3 tentacles and 2 pairs of eyes. 6 peristomial cirri (arising from 3 fused segments). Dorsal cirri about as long as body is wide. Length up to 4 cm. Color brown III

Peristomial and dorsal cirri long and slender, 3 tentacles (1 median) and 4 eyes. Protrusible pharynx. Small slender worms IV

Head with 2 small tentacles, 2 large palps, 4 eyes and 4 pairs of peristomial cirri V

Dorso-ventrally flattened worms with 4 very small tentacles. Protrusible pharynx. A deep cleft between notopodium and neuropodium with a small sickle-shaped gill depending from the notopodium VI

Dorso-ventrally flattened, brownish worms with 5 prostomial tentacles in a transverse row. Small parapodia VII

Small conical head with no appendages VIII

Small conical head with 4 minute tentacles at tip of prostomium. Segments composed of 2 annuli. No eyes. Proboscis with 4 hook-shaped teeth. Small retractile gills. Parapodia small IX

Two peristomial cirri, usually long and curving over back like a pair of horns; short in one genus of this group X

A disk-shaped cephalic lobe, on reflexed margin of which arise numerous long filamentous tentacles. Body thicker anteriorly, tapering posteriorly (see also Dodecaceria and cirratulus under VIII) XI

Numerous, long slender setae extending forward to enclose head. 8 tentacles, usually small XII

Peristomium projecting forward in the form of a collar to enclose a large crown of branching palps XIII

OLIGOCHAETE

Clitellum present. No parapodia or cephalic appendages. XIV

Polychaete Key

I

a. 12 pairs of scales . . . . . .LEPIDONOTUS
aa. 15 " " " . . . . . HARMOTHOE
aaa. 40 to 60 pairs of scales. Black in color; usually found in Amphitrite tubes . . . . . LEPIDAMETRIA
aaaa. over 100 scales. Grayish color . . . . . STHENELAIS

* * * * * *

II

a. 2 pairs of peristomial cirri; 4 short prostomial tentacles . . . . . ETEONE
aa. 4 pairs of peristomial cirri.
b. 4 prostomial tentacles . . . . . PHYLLODOCE
bb. 5 (1 median) prostomial tentacles . . . EULALIA

* * * * * *

III . . . . . PODARKE OBSCURA

* * * * * *

IV

a. Tentacles and cirri segmented 1 pair of palps . . . . . .SYLLIS
aa. Tentacles and cirri not segmented. Palps fused and not well developed . . . . AUTOLYTUS

V . . . . . .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

* * * * * *

VI . . . . . NEPHTHYS
a. Setae light-colored. Paddles on noto- and neuropodia . . . . . NEPHTHYS BUCERA
aa. Setae black or very dark. Paddles absent . . . . . NEPHTHYS INCISA

* * * * * *

VII

a. Large, branching gills on anterior segments; gills much reduced posterior to 25th segment . . . . . DIOPATRA
aa. Branching gills begin at about 20th segment. 2 short brood palps first 2 segments without appendages . . . . . MARPHYSA

* * * * * *

VIII.

a. Segments of body long with protruding setigerous setal sacs of contrasting color.
  b. Anus dorsal to a flattened, smooth, caudal plate; mud tubes . . . . . MALDANE
  bb. Anus at posterior tip enclosed in a collar of cirri; sand tubes . . . . . CLYMENELLA
aa. Segments not conspicuously ellongated
  b. Large, branching gills on median segments of body . . . . . ARENICOLA
    c. 11 pairs of gills . . . . . A. cristata
    cc. 13 pairs of gills . . . . . A. marina
  bb. Gills filaform
    c. Gills (dorsal cirri) longer than diameter of body
      d. 4 to 14 pair on anterior segments. Filaments may begin on segment posterior to mouth and 1st pair may be thicker than those following. Worm usually not over 2" long. Common in Bryzoa nodules . . . . . DODECACERIA
      dd. Pair of filaments on nearly every segment, esp. anteriorly . . . . . CIRRATULUS
    cc. Gills (dorsal cirri) short approximately equal to diameter of worm or less.
      d. Has proportions of a worm, not short and fat like a maggot.
        e. Anterior region round in x-section . . . SCOLOPLOS
          f. Gills begin on 26th segment . . . . . .S.ROBUSTUS
          ff. Gills begin on 16th segment . . . . . .S.FRAGILIS
        ee. Anterior region flattened dorso-ventrally. Neuropodal setae on anterior end are dark. Gills begin on 6th segment . . . . . ARICIA ORNATA
      dd. Animal less than 1 1/2" long. Short and fat like a maggot
        e. Anal cirri, 8 small dorsal and 2 large ventral . . . . . .OPHELIA SIMPLEX
        ee. Anal cirri absent . . . . . .TRAVESIA FORVESI
  bbb. Gills absent.
    c. Transverse row of 4 eyes at base of prostomium . . . . . .ARABELLA OPALINA
    cc. No eyes
      d. Anterior 12 segments biannulated. Biannuli not conspicuous, [illegible] ring-shaped smooth. Prostomium pointed. Notopodal and neuropodal setae widely separated. No parapodia . . . . . .NOTOMASTUS FILIFORMIS
      dd. Segments not biannulated. Prostomium rounded. Setae on tip of short conical parapodia . .LUMBRINEREIS
        e. Long thread-like worm . . . . . L. TENUIS
        ee. Proportion of length to width about as in large earth-worm . L.HEBES

IX . . . . . .GLYCERA

a. Each parapodium with one dorsal and one ventral, unbranched gill . . . . . GLYCERA DIBRANCHIATA
aa. Each parapodium with only a dorsal gill which is branched . . . . . GLYCERA AMERICANA.

X

a. Body not divided into distinct regions. Dorsal cirri as gills arched toward the mid-line.
b. 5th segment elongate with row of deeply-set, short, heavy setae; other segments with slender setae on parapodia . . . . . .POLYDORA
bb. 5gh segment not different from the others
c. Gills on all segments . . . . . SPIO SETOSA
cc. Gills absent from posterior portion . . . . .LAONICE VIRIDIS
aa. Body divided into 3 regions. No gills. Color white, throughout most of body. Luminescent . . CHAETOPTERUS.

* * * * * *

XI

a. No branching gills on 3 segments behind tentacular filaments.
b. Setae on first 25 segments only. Parapodia small . . . . . .POLYCIRRUS
c. Color blood red . . . . . POLYCIRRUS eximus
cc. Transparent--white or light orange. Luminescent . . . . . POLYCIRRUS phosphor-eus

bb. Setae on most segments-sometimes absent from last few. Branching red parapodia in mid-body region. . . . . ENOPLOBRANCHUS
aa. Branching gills on one or more anterior segments.
b. 3 pairs of branching gills
c. Setae on anterior part of body only .AMPHITRITE
d. Setae on first 40 segments . . . . AMPHITRITE ORNATA
dd. Setae on first 25 segments . . . . AMPHITRITE BRUNNER
cc. Setae extend to posterior end . . . .LEPRAEA RUBRA.
bb. 2 pairs of branching gills
c. Each gill has a separate origin from the body.
d. Setae on 4-20 segments. Frequently one or more gills broken off but stump usually remains). Eyes absent . . PISTA.
e. Gills have tree-like appearance. Blood green . . . . PISTA PALMATA.
ee. Gills conical with branches in rows aroung central stalk. Blood red . . . . . PISTA CRISTATA.
dd. Setae on 3rd segment to posterior end of body; the "Hydra-worm". Eyes numerous in a transverse row. (Young forms up to 1/4 " long may only have one pair of gills . . . THELEPUS
cc. 2 pairs of gills arise from body by a single stalk. (looks like 1 gill with 4 parts) Eyes numerous. Setae segment 3 to posterior end . . . . . TEREBELLIDES.

XII . . . . . .TROPHONIA

XIII

a. Peristomium asetigerous
  b. Collar broadly notched dorsally. Gill filaments with minute eye spots. Anterior region of 8 setigerous segments, Worms small. Form encrusting sand-tubes PARASABELLA MICROPHTHALMA
  bb. Collar without dorsal notch
    c. Stalked operculum.
      d. Worm as usually taken over 10 mm. long--up to 75 mm. Sinuous calcareous tube . . . . . HYDROIDES
      dd. Worm small, about 3 mm. long. 9 gill filaments. Dextrally coiled tube. . . . . SPIRORBIS.
    cc. No operculum. A narrow slit present on dorsal side of collar. Membraneous tube. Frequently found in Bryzoa models . . . . . PSEUDOPOTAMILLA
aa. Peristomium setigerous. Posterior portion of worm degenerate, usually folded back against anterior part.
  b. Peristomium forms 2 disk-like pillars projecting beyond the prostomium. Numerous tentacles on ventral side of peristomium. Tube of agglutinated sand grains . . . . . SABELLARIA.
  bb. Peristome carries a single disc composed of 2 rows of fused golden bristles. Tube of a single layer of agglutinated sand grains; open at both ends . . . . . CISTENIDES.

XIV.

a. Setae of equal length
  b. Setae straight. Color white . . . . ENCHYTRAEUS
  bb. Setae sigmoid. Color red . . . . . LUMBRICILLUS

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 one form , for organs, as outlined above and topographical and comparative study of the zooecia of any five others.

Characteristics of Phylum, Entoprocta, Calyssozoa or Comptozoa.

Compare with those of Ectoprocta on next sheet.

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 bulbs, open into the rectum or into vestibule.

VIII. Nervous system = ganglion between the mouth and anus + radiating nerves + plexus at base of Colyx and one at base of stem.

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, except sensory pits.

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 Bryozoa (Ectoprocta)

Compare with those of Entoprocta on preceding sheet.

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 membranous 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, in coelum, or externally.

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. Lately a "Colonial herve net" in zooecial walls of membranipora and the Phylactolaemata (fresh water forms) has been 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) Gymnolaemata; 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 BRYOZOA OF THE WOODS HOLE REGION MOST LIKELY TO BE MET.
(After Osborn).

GLOSSARY

ADNATE- Attached to substratum at the back and partly free.
AVICULARIA- 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.
or Calyssozoa. A.
(2) Anus outside lophophore; lophophore retractile. Ectoprocta. D.

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

B((B_1- 18-30 tentacles; foot small; 2 mm. long.--Loxosoma davenporti.
((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_2- Peduncle enlarged near base; stalk not perforated. Barentsia major.
((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_2- Operculum present; zooecia usually calcified; and with ooecia and appendicularia; lipped mouthed forms.-CHILOSTOMATA.-F.
((D_3- Operculum of a ring of setae; never calcified; no avicularia, vibracula, nor ooecia; soft chitinous walls; zooaria stolonate, encrusting, plant-like, or in fleshy lobes; Comb-mouths. Ctenostomata--K

Key to Bryozoa (cont'd)

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

F(F_1- Stolonate, with expansion on stolon where tubular zooecia (with lateral membranous area and terminal orifice) come off. Aetea anguina.
F(F_2- Not incrusting nor calcified; zooecia loosely united; appendages pedunculate and jointed;--Bugula-------G.
F(F_3- Incrusting; calcified; front wall of zooecia depressed, membranous and partly bridged by calcareous shelf; zooecial borders raised----------Membraniporidae or Electrinidae.H
F(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---------Schizoporellinae Hippothoidae. I.
F(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 teeth; Avicularia may be present related to the orifice; zooecia incrusting, not erect. Hippoporinae & Microporellinae.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(G_2- One strong spine at outer edge of orifice; ovicell at angle with axis of biseriate, spirally arranged zooecia; beak of avicularium not toothed.--Bugula turrita.
G(G_3- 4 spines above; ovicell in line with axis; beak toothed. Bugula cucullifera.
G(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.

Membraniporidae or Electrinidae - Pratt uses Electra in place of Membranipora given below.

H(H_1- Front wall, inside raised margin, all membranous; no ooecia, avic. nor spines; or only slender erect spinules; Membranipora lacroixii.
H(H_2- Area of front wall, below raised margin, perforated with large pores; spines strong and well developed. Membranipora pilosa.
H(H_3- Similar to M. pilosa, but not perforated; weaker spines; median ventral spine stout (others usually absent). Membranipora monostachys

Key to Bryozoa (cont'd)

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.
Callopora 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 obscured;----------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 ovicell with pores, regularly placed, in place of furrows.--
Schizoporella auriculata.

(Pratt uses Cryptosula instead of Lepralia.)

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; ooecia and avicularia absent.---------- Lepralia pallasiana. or Cryptosula P.
(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 small and present; zooecia small and slightly convex; flat with age. 6 slender marginal spines--Mucronella peachii.
or immersa.

Key to Bryozoa (cont'd)

J((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;----------Smittina 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----------Smittina trispinosa.

K((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. or Polyoum

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_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, or Vidovici.

(K_6- Like the above, but zocarium 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 gracilus var. caudata.

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

1. External characteristics, habits, etc. of the Amphineura, illustrated by Chaetopleura.

Drew, pp. 142-143.

2. 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 later (see p. 2).

3. Anatomy of a Nudibranch.

Examine any Nudibranchs that are available. Advantage should be taken of the opportunity to study these forms as living Nudibranchs are not always 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 there hard spicules present? What is the position and nature of the respiratory organs? Special organs may be entirely absent, respiration occuring through the integrument (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 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 organs may be observed varies with different individuals and species. Usually the dorsal heart, the liver, digestive tract, the large ovary, the otocyst, and possibly other details may be observed. If small specimens are used this detailed study may be best carried on with the specimen on a slide and slightly depressed with a cover glass. Mount one of the cerata on a slide and observe under high power. Can nematocysts be seen?

Eggs in various stages of development may often be found in the dishes with the animals. If Cumingia are not available a detailed study of these stages is advisable, the veliger are excellent for study.

See demonstrations of types other than the one used for study.

Classify the animal used.

4. Egg laying, sperm shedding, and the formation of trochophore and veliger larvae of Cumingia.

The animals should be washed clean before placing in finger bowls. When fertilizing use about 1 drop of sperm suspension for 40 c.c. of H_2O. Drew, p. 141. After fertilizing the eggs may be

mounted in a hanging drop and observed under high power.

In the absence of Cumingia a study of the eggs and larvae of a Nudibranch or Crepidula may be made. The eggs of these forms are not as suitable for such a study, but the larvae will be satisfactory.

5. Activity of the radula and special dissection of the odontophoral apparatus. Busycon.

Follow Drew, p. 150, paragraph 5.

The number and arrangement of teeth on the radula is used in the classification of many of the gastropods. The animal is first killed by immersing in hot water for a minute or so and is then removed from the shell. The radula sac is removed and boiled gently in 10% KOH for a short time, until the radula sac is dissolved. The radula may then be mounted in a drop of glycerine under the binocular microscope, taking care to mount it straight.

The following specimens, if available, make a good series for contrast:

Ptenoglossa -- Epitonium.
Gymnoglossa -- Melanella.
Taenioglossa -- Littorina.
Rachiglossa -- Urosalpinx.

A fifth division, the Toxoglossa, has no representatives here.

6. 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? Can you determine how much water is taken up by the foot?

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

7. If time permits the following experiments on the gastropod 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 5. Are cilia present? Is the pedal gland present in both sexes? What is its function?

B. Activity of the foot of Nassa.

Allow Nassa to become attached to a glass plate. Observe

with a lens the creeping surface of the foot held 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.

8. Anatomy of a lamellibranch illustrated by one of the following:

1) Venus (Drew, p. 124); 2) Mya (Drew, p. 138): 3)Modiolus Drew, p. 134); 4) Pecten Drew, p. 136)

9. 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.

10. 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 plantar 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?

D. The Pelecypod heart.

Use a fresh animal. Carefully remove one valve of the shell and open the pericardial cavity. Place the animal in a finger bowl containing marine Molluscan Ringer (NaCl 0.4, $CaCl_2$ 0.005M, $MgCl_2$ 0.05M). Observe the beat and time it. Immediately after exposure the heart may remain temporarily at rest. Open several animals until a satisfactory heart is obtained. Remove the animal from the Ringer's solution and place in a second finger bowl (empty) and observe the effect of dropping M/2 KCl on the heart. The rate of the beats changes. Does the heart tend to stop beating in systole or diastole? Now add M/2 $CaCl_2$ and note the effect. Return the animal to Ringer's solution to note recovery.

If kymographs and heart levers are available a record of this experiment may be made.

How does the effect of these salts on the Pelecypod heart compare with their effects on the vertebrate heart? For a discussion of this experiment see Clark: "Comparative physiology of the heart"; Wanzl, Physiol. Zool., vol. 10, 1937, pp. 25-140; Motley, ibid. vol. 7, 1934, pp. 62-84.

Can you note any effect of mechanical or electrical stimulation of the visceral ganglion on the heart rate? See Oka., Sci. Rep. Tohoku Univ., vol. 4, 1932, pp. 133-143.

11. Anatomy of a Cephalopod.

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

B. 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 caya 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.

MOLLUSCA

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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, ambulaoral grooves, tube feet, terminal eye-spot, dermal branchiae, spines, pedicellariae.

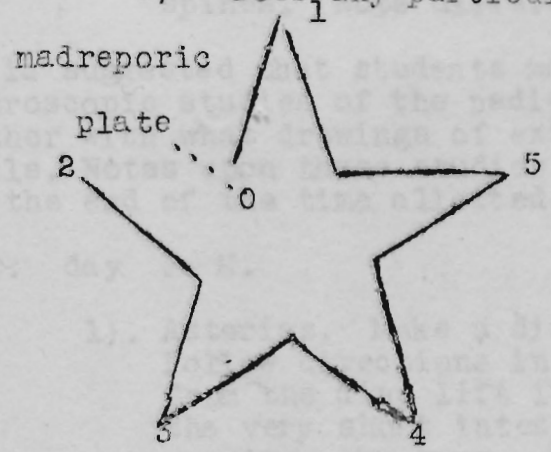
II. Behavior of the animal.

A. Method of locomotion.

1) Do the tube feet act as levers for swing or as rope 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 may be placed on the blackboard if time permits.



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 on 1st and 2nd days or later.

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.

Echinodermata. Laboratory Directions, Cont.

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.

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 dermal 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. Note differences.

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, following outline for Asterias above. A check on ciliary action in the intestine and coeca and in coelomic cavity is of interest.

Echinodermata. Laboratory Directions, Cont

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 Arbacia or preserved Strongylocentrotus may be made on material furnished. A dried Aristotle's Lantern of each species 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. Note differences between lantern of Arbacia and Strongylocentrotus.

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

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

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.
Hemocytes in W. V. S. - open the animal along right side instead of ventral body wall. Are the small pair of tentacles ventral?

Study animals regenerating gut and c. after evisceration 3 weeks before this day. Note size and characters of regenerated parts and which are most advanced in completeness. Order of regeneration?

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

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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.

(3) Arms 5, pointed, bulged near middle, 4 rows tube feet. Madreporite light lemon yellow, color usually purple.. Commoner northward. . A. VULGARIS.

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; small star, 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 . . . . . AMPHIPHOLIS 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; interrays 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 branched 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 or in gravel . . . LEPTOSYNAPTA ROSEOLA.

ARTHROPODA. 1941

Laboratory Schedule

First day:

A branchiopod, Artemia salina. (See special sheet).

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

Demonstration of parasitic Crustacea.

Second day:

A comparative study of some common Malacostraca. (See special sheet (2) for suggestions.)

Experimental problems.
Autotomy in Uca (See special sheet (3).
Color changes in Palaemonetes and Uca.

Third day:

Larval stages: Nauplius larva of Artemia (See special sheet
Mysis stage of Homarus (Compare this with adult Heteromysis).
Zoëa larva of Polyonyx macrocheles.

Cirripedia: Activities of Balarus
Anatomy of Lepas. (Refer to Drew)

Fourth Day: Dredging and study of tow. (The tow will provide material for a comparative study of some common Entomostraca).

Fifth day:

Limulus: Feeding reactions, method of locomotion, external anatomy. (Use a small specimen and larval stages. Refer to Drew. Place a larva under a cover slip and note the distribution of the hepatopancreas.)

Limulus: Internal Anatomy. (Freshly-killed animals will be provided. Follow directions in Drew).

Sixth day, 9:00 O'clock.

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

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--protozoëa
mg--megalopa	mz---metazoëa	z---zoëa

(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 OF CRUSTACEA

Nauplius

Body: Unsegmented
Eyes: 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.

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See Pratt, Drew, Calman (Lankester's Treatise on Zoology), Sars (Crustacea of Norway) Smith (Cambridge Natural History) and Das Tierreich for additional references on anatomy and classification.

The Brine Shrimp, Artemia.

Observe free-swimming shrimps: (1) the movements of the 11 pairs of foliaceous appendages for locomotion, food-gathering and respiration; (2) the orientation of the shrimp (a) when swimming (b) when feeding on the bottom, and (c) when the source of light is beneath the culture dish; (3) the huge 2nd antennae of the male which is developed into a clasping organ (Smith, p. 26); (4) the ovisac, just behind the last pair of swimming appendages on the mature female.

Study a shrimp with the dissecting and compound scope for structural features. (hanging drop preparation will show many features but the slight pressure of a cover glass will be necessary to bring out the finer details).

I. Head: (Packard, p. 560.)
- (1) Compound eyes (on flexible, unsegmented stalks).
- (2) Ocellus (a median or Nauplius eye).
- (3) Antennae (two pairs).
- (4) Labrum (large upper lip).
- (5) Mandibles (one pair).
- (6) Maxillary gland (typical excretory gland in adult Entomostraca and larval Malacostraca).
- (7) Oesophagus (vertical tube from mouth to stomach).
- (8) Stomach (globular expansion of alimentary canal in head)
- (9) Digestive glands (two diverticula of the stomach in the form of branched tubes, packed into the head around the brain).

II. Trunk:
- (1) Foliaceous appendages (11 pairs).
  Prepare a slide of a cross-section of the trunk to see details. Identify the endites (medially directed processes). The proximal one is an important food-gathering mechanism (gnathobase). The exites are an upper and lower gill-sack. (Smith, p. 27; Packard p. 530) (The endopodite and exopodite homologies are obscure).
- (2) Limbs of the 12th trunk segment (genital segment). In female, fused to form the uterus or ovisac. (Smith, p. 20, fig. 2) (Packard, p. 558, fig. 2) In male, forms two penes or cirri. (Packard, p. 558, fig. 3) (Colman, p. 30).
- (3) Limbless segments of trunk (1st is fused with genital segment).
- (4) Telson.
- (5) Gonads (in trunk, posterior to genital segment), ovaries (Smith, p. 20, fig. 2). Testes (Packard, p. 558, fig. 3)
- (6) Heart (dorsal tube in trunk; pair of ostia in each segment except the last; open widely at posterior end, forming a short cephalic aorta anteriorly (Packard, p. 560, fig. 2 and 3). Remainder of blood system lacvaar).
- (7) Intestine (straight tube ventral to heart).
- (8) Rectum (very short, at level of telson).
- (9) Anus (terminal).
- (10) Telson (with an anal plate on each side of the anus).

References:

Borradaille and Potts: Invertebrata (1936) pp. 356-360. Chirocephalus is similar to Artemia.

Colman, W. T. (1909): Lankester's Treatise on Zoology, Crustacea

Packard, A. S. (1883); Phyllopod Crustacea.

Smith, G. F. (1909): Cambridge Natural History Crustacea.

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 tubular 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 a cheliped autotomized more quickly than a walking leg?

If a number of appendages of any given specimen are autotomized, will the last ones be cast as quickly as the first in the series?

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 for 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 ventral 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: 1932. Mechanism of Autotomy in Decapod Crustaceans. Jour. Exp. Zool., 62.

Headley, L: 1937. Autotomy in the Brachyuran, Uca pugnax. Biol. Bull., 73, 155-163.

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. The originate in a mid-dorsal region.

INVERTEBRATE ZOOLOGY

Laboratory Study of the Protochordates.

The nature of the records and the number and kind of drawings are left to the discretion of the student. Certain drawings are suggested in Drew's, Invertebrate Zoology, which may be followed, amplified or others substituted for them. If you have never studied Amphioxus, some material is available although this animal is not found on this coast.

Demonstrations of several ~~uncommon~~ protochordates will be on display, i.e. Salpa, Boltenia, Appendicularians, etc.

Note - All records are due at 4 o'clock on the second day. These will be returned as soon as possible that evening.

FIRST DAY - A.M.

a) Study Perophora viridis (Urochorda), following the direction given in Drew, page 238. In this colonial ascidian the greenish, transparent zooids (which resemble small Molgulae) are connected by stolons.

Gently prick the animal and note the kind and amount of contraction. After strong stimulation does the heart stop beating and the circulation cease? For how long? Is there a difference in the number of abvisceral beats of the heart (toward the branchial basket and stolon) as compared with the advisceral (toward the viscera)? Does the number vary in each series? Does the blood circulate in the stolon? Is there any coordination of the heart beat in several individuals connected by a common stolon? Note the circulation in the test, and the glumped cells (vanadocytes?) along the course of the test vessels.

If the animal is placed in a solution of strychnine, what happens to the heart and to the circulation? Use 1-40,000. After 10 minutes of exposure to this solution, transfer the animal to sea water. Does the heart recover?

Acetylcholine, mecholyl, adrenalin, pilocarpine etc., in appropriate concentration will increase the length of the abvisceral phase. Adrenalin is especially effective and by changing to fresh solution hourly, the heart can be made to beat this way for hours. Use 1-20,000 for adrenalin. What happens when the animal is returned to sea water? Atropine appears to inhibit the pilocarpine effect, while eserine potentiates the action of acetylcholine.

To what extent do temperature changes affect heart activity Study first in fresh sea water. Then place dish into sun for an hour, and again count the number of beats with time. Take temperature readings.

b) By using carmine particles suspended in sea water determine the direction of the currents of water through the siphons.

c) Fertilize some eggs of Molgula by removing the hermaphroditic gonads of several animals and cutting them up in a small amount of sea water. If fertilization occurs, the early development as far as the tadpole stage may be followed during these two days.

Laboratory Study of the Protochordates.

FIRST DAY - P.M.

a) Examine young and mature colonies of Botryllus schlosseri. Directions are given in Drew, page 239. In the mature colonies note the arrangement of the zooids of a colony, their colors and the movement. The colonies of this semi-transparent, composite, incrusting chordate may be found on wharf piles, stones, algae, etc. Glass slides which have been immersed in the Eel Pond for one to two weeks previously will have on them single individuals and early colony formation. These are more easily studied for structure and activity of the internal organs because of the absence or small amount of the pigment. Immerse the slide in a petri dish of sea water.

b) Study Didemnum. This white, incrusting, composite tunicate is found on wharf piles, under stones, etc. What is the surface appearance? By crushing and teasing a small piece, determine the type of spicule. Can anything be seen regarding the structure and grouping of the individuals?

SECOND DAY - A.M.

Study isolated adult individuals of Amaroucium (Urochorda) according to the directions in Drew, page 240. These may be secured by cutting the common gelatinous tunic vertical to the surface of the colony, or by strongly squeezing the mass into a dish of sea water and thus forcing out the animals. Remove to a syracuse dish and examine until a complete animal is found. This can then be transferred to a glass slide for closer examination. Add sea water and cover. Is there any structural difference between the individuals of A. stellatum and A. constellatum?

Often when the colony is squeezed, the tadpoles are also liberated. Carefully study one. Slides of stained tadpoles are available if no living ones are found. If the living tadpoles are transferred to a syracuse containing a couple of drops of sea water, they will sometimes attach and undergo metamorphosis.

Compare a tadpole of Amaroucium with one of Molgula or Botryllus.

Occasionally young individuals in various stages of metamorphosis are available for study. When possible these will be prepared by the instructor a few days in advance. Details of structure are more easily seen than in the adult especially ciliary action in the branchial basket and heart beat. Are the characteristics of the heart beat similar to those of the heart of Perophora?

SECOND DAY - P.M.

a) Study the external structure of a living Dolichoglossus (Hemichorda), following the directions in Drew, page 233. Devote about and hour or less to this. In some animals the posterior region of the trunk may have been broken off. Stained serial sections of the animal are available, if desired.

Laboratory Study of the Protochordates.

b) The remainder of the afternoon should be spent in an examination of the simple ascidian. Molgula manhattensis (Urochorda), following the directions given in Drew, page 234. Compare the zooid of Perophora viridis with that of Molgula (or with Ciona, another simple ascidian). Even though you may have studied this animal before from preserved material, fresh material possesses certain advantages. Remove a portion of the branchial basket wall to a slide and observe the action of the cilia.

c) If however you feel familiar with Molgula, (1) endeavor to secure some of the blood on a slide in sea water and study the types of cells to be found. There are both ameboid and pigmented cells of several different types which are quite unlike the blood cells of Vertebrates. The cells survive and are active in sea water. Or (2) study the transparent simple ascidian, Ciona intestinalis.

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 Amaroucium 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. The dishes may then be placed bottom up in a crystalizing dish of running sea water. This obviates daily change of sea water.

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. It should be done in a very small amount of sea water. After a little while add more 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.

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

Young individuals, stages in metamorphosis, or young stages of colony formation of Perophora, Ciona, Amaroucium and Botryllus may be easily secured by placing syracuse dishes bottom up in glass container, i.e. crystalizing dish, in running sea water. Place numerous adult individuals or pieces of the colony of one species only in each container about one to three weeks before desired. When used for study, remove the dishes, wipe the bottom clean, turn over and fill with about one-eighth inch of sea water. The individuals may be found in the bottom of the syracuse dish.

Ciona. This simple ascidian may be easily studied by removing the transparent tunic and placing the animal in a finger bowl of sea water. The removal of the tunic does not injure the animal and in fact, if given a sufficient length of time, it will regenerate a new one. Morphological details, such as oesophagus, gonad ducts, heart, ganglion, branchial clefts, etc., are particularly clear. Do not keep the animals in running sea water as air bubbles accumulate in their bodies; this causes them to float and they soon die. When kept in finger-bowls in a cool place and the water changed once or twice daily, they will live as long as wanted. They possess remarkable powers of regeneration, and if one of the siphons is tied off, the animal will form a new one.

Eggs of Ciona may be fertilized by removing the gonads of several animals to a dish containing a small amount of sea water and cutting them up. By examining the culture frequently thereafter the phenomena of fertilization, the dividion of the fertilized egg and the development of the embryo may be followed. The tadpole stage will have formed by the following day. Avoid self-fertilization.

About the only place to secure adult Ciona at Woods Hole is in the sea water tanks on the top of the main brick building. Very rarely are they found on the collecting trips as they are deep water animals. Sometimes they may be found growing in aquaria or culture dishes which have remained undisturbed for some time and into which sea water has been running.

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. Brange and 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.

Amoroucium pellucidum

Colonial ascidian, transparent tunic, compact body, zpoids 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 combination 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 granualr 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, siphons arise near together and are long, divergent and retractile. 6 branchial folds, stigmata curved. On piles, stones, seaweed. Very common.

Molgula manhattensis

Simple. Body rounded, apertures flush with surface and not contiguous, 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 occurring 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.

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