Experience

Yours
### Program

#### Invertebrate Zoology Course

1956

(Subject to Change to suit weather)

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 28, T.</td>
<td>9:00-9:30</td>
<td>Introductory remarks</td>
</tr>
<tr>
<td></td>
<td>9:30</td>
<td>Protozoa. (Waterman, Lucas, Crowell)</td>
</tr>
<tr>
<td>July 29, W.</td>
<td>9:00-10:16-11:00</td>
<td>LACKLEY'S BAY. Start, Low tide, Back</td>
</tr>
<tr>
<td>July 30, Th.</td>
<td></td>
<td>Forifera. (Sayles, Lucas)</td>
</tr>
<tr>
<td>July 31, F.</td>
<td></td>
<td>Coelenterata (Nelsen, Crowell)</td>
</tr>
<tr>
<td>Aug. 1, S.</td>
<td></td>
<td>Coelenterata (Nelsen, Crowell)</td>
</tr>
<tr>
<td>Aug. 2, M.</td>
<td>9:00</td>
<td>Special Lecture. Ecology (Sayles)</td>
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<tr>
<td>Aug. 4, T.</td>
<td>9:00</td>
<td>Coelenterata. (Nelsen, Crowell)</td>
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<tr>
<td>Aug. 5, W.</td>
<td>9:00</td>
<td>Coelenterata. (Nelsen, Crowell)</td>
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<tr>
<td>Aug. 6, Th.</td>
<td>9:00</td>
<td>Phatyhelminthes: (Hadley, Lucas)</td>
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<tr>
<td>Aug. 7, F.</td>
<td>9:00</td>
<td>Phatyhelminthes (Hadley, Lucas)</td>
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<tr>
<td>Aug. 8, S.</td>
<td>9:00</td>
<td>Phatyhelminthes (Hadley, Lucas)</td>
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<tr>
<td>Aug. 9, M.</td>
<td>9:00</td>
<td>Annelida. (Sayles, Crowell)</td>
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<tr>
<td>Aug. 10, T.</td>
<td>9:00</td>
<td>Mollusca. (Matthews, Lucas)</td>
</tr>
<tr>
<td>Aug. 11, W.</td>
<td>9:00</td>
<td>Mollusca. (Matthews, Lucas)</td>
</tr>
<tr>
<td>Aug. 12, Th.</td>
<td>9:00</td>
<td>Special Lecture. Phylogeny (Matthews)</td>
</tr>
<tr>
<td>Aug. 14, F.</td>
<td>9:00</td>
<td>Arthropoda. (Kille, Crowell)</td>
</tr>
<tr>
<td>Aug. 15, S.</td>
<td>9:00</td>
<td>Arthropoda. (Kille, Crowell)</td>
</tr>
<tr>
<td>Aug. 16, M.</td>
<td>9:00</td>
<td>Mollusca. (Matthews, Lucas)</td>
</tr>
<tr>
<td>Aug. 17, T.</td>
<td>9:00</td>
<td>Arthropoda. (Kille, Crowell)</td>
</tr>
<tr>
<td>Aug. 18, W.</td>
<td>9:00</td>
<td>Arthropoda. (Kille, Crowell)</td>
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<tr>
<td>Aug. 20, Th.</td>
<td>9:00</td>
<td>Echinoderms. (Bissonnette, Lucas)</td>
</tr>
<tr>
<td>Aug. 21, F.</td>
<td>9:00</td>
<td>Echinoderms. (Bissonnette, Lucas)</td>
</tr>
<tr>
<td>Aug. 22, S.</td>
<td>9:00</td>
<td>Echinoderms. (Bissonnette, Lucas)</td>
</tr>
<tr>
<td>Aug. 23, M.</td>
<td>9:00</td>
<td>Echinoderms (Bissonnette, Lucas)</td>
</tr>
<tr>
<td>Aug. 24, T.</td>
<td>9:00</td>
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<tr>
<td>Aug. 26, W.</td>
<td>9:00</td>
<td>Echinoderms (Bissonnette, Lucas)</td>
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<tr>
<td>Aug. 27, Th.</td>
<td>9:00</td>
<td>Echinoderms. (Bissonnette, Lucas)</td>
</tr>
<tr>
<td>Aug. 28, F.</td>
<td>9:00</td>
<td>Echinoderms. (Bissonnette, Lucas)</td>
</tr>
<tr>
<td>Aug. 29, S.</td>
<td>9:00</td>
<td>Echinoderms. (Bissonnette, Lucas)</td>
</tr>
<tr>
<td>Aug. 30, M.</td>
<td>9:00</td>
<td>Echinoderms (Bissonnette, Lucas)</td>
</tr>
<tr>
<td>Sept. 1, T.</td>
<td>9:00</td>
<td>Hadley Harbor. 10:00-2:17-4:00.</td>
</tr>
<tr>
<td>Sept. 2, W.</td>
<td>9:00</td>
<td>Chordata. (Waterman, Crowell)</td>
</tr>
<tr>
<td>Sept. 3, Th.</td>
<td>9:00</td>
<td>Chordata. (Waterman, Crowell)</td>
</tr>
<tr>
<td>Name</td>
<td>Seat No.</td>
<td>College</td>
</tr>
<tr>
<td>-----------------------</td>
<td>----------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>Allen, Thomas Hunter</td>
<td>26</td>
<td>State Univ. Iowa</td>
</tr>
<tr>
<td>Babcock, Ruth Helen</td>
<td>2</td>
<td>N. J. State Teachers</td>
</tr>
<tr>
<td>Badger, Joan Elizabeth</td>
<td>1</td>
<td>N. J. State Teachers</td>
</tr>
<tr>
<td>Bishop, David W.</td>
<td>28</td>
<td>U. of Pennsylvania</td>
</tr>
<tr>
<td>Bonnet, David Dudley</td>
<td>33</td>
<td>Harvard</td>
</tr>
<tr>
<td>Bowen, William Jones</td>
<td>53</td>
<td>Johns Hopkins</td>
</tr>
<tr>
<td>Burlington, Mary</td>
<td>50</td>
<td>McGill</td>
</tr>
<tr>
<td>Bush, Mrs. Aeleta Nichols</td>
<td>49</td>
<td>Emory</td>
</tr>
<tr>
<td>Carson, Hampton</td>
<td>20</td>
<td>U. of Pennsylvania</td>
</tr>
<tr>
<td>Cassidy, Morton Harding</td>
<td>52</td>
<td>Mass. State</td>
</tr>
<tr>
<td>Caylor, Richard Lee</td>
<td>55</td>
<td>Delta State Teachers</td>
</tr>
<tr>
<td>Copeland, Donald Eugene</td>
<td>35</td>
<td>Amherst</td>
</tr>
<tr>
<td>Cregan, Sister Mary Bertha</td>
<td>45</td>
<td>St. Xavier, Chicago</td>
</tr>
<tr>
<td>Croasdale, Hannah Thompson</td>
<td>32</td>
<td>Dartmouth Med.</td>
</tr>
<tr>
<td>Dawson, Ralph Ward</td>
<td>51</td>
<td>U. of Minnesota</td>
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<tr>
<td>Doyle, Winfield Goldsmith</td>
<td>37</td>
<td>Oberlin</td>
</tr>
<tr>
<td>Faben, Ann Reed</td>
<td>6</td>
<td>Goucher</td>
</tr>
<tr>
<td>Farraday, Clayton L.</td>
<td>16</td>
<td>Swarthmore</td>
</tr>
<tr>
<td>Granger, Barbara Samson</td>
<td>9</td>
<td>Mt. Holyoke</td>
</tr>
<tr>
<td>Grave, Caswell II.</td>
<td>38</td>
<td>Washington U., St. Louis</td>
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<tr>
<td>Griffoul, Doris A.</td>
<td>46</td>
<td>Teachers Coll. Columbia</td>
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<tr>
<td>Grobstein, Clifford</td>
<td>17</td>
<td>C. C. N. Y.</td>
</tr>
<tr>
<td>Harris, W. Alfred</td>
<td>22</td>
<td>DePauw</td>
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<tr>
<td>Hill, David Leal</td>
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<td>State Univ. Iowa</td>
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<tr>
<td>Hogan, Sister Stella Maria</td>
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<td>St. Xavier, Chicago</td>
</tr>
<tr>
<td>Hoyt, John Southgate Yeaton</td>
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<td>Washington &amp; Lee</td>
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<tr>
<td>Huntington, Margaret Orr</td>
<td>13</td>
<td>Swarthmore</td>
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<tr>
<td>Johnson, Reuben Botsford</td>
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<td>Connecticut State</td>
</tr>
<tr>
<td>Kimball, Richard Fuller</td>
<td>54</td>
<td>Johns Hopkins</td>
</tr>
<tr>
<td>Knoth, Sibyl Charlene</td>
<td>4</td>
<td>Peabody</td>
</tr>
<tr>
<td>Koster, Rudolf</td>
<td>34</td>
<td>Harvard</td>
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<tr>
<td>Moyer, Elizabeth King</td>
<td>10</td>
<td>Mt. Holyoke</td>
</tr>
<tr>
<td>Morgan, Gwendolynnn Whitney</td>
<td>12</td>
<td>Sarah Lawrence</td>
</tr>
<tr>
<td>Norris, Charles Hamilton</td>
<td>56</td>
<td>Hamilton</td>
</tr>
<tr>
<td>Potts, Hugh E.</td>
<td>21</td>
<td>N. Y. U.</td>
</tr>
<tr>
<td>Ray, David Tobias</td>
<td>27</td>
<td>U. of Pennsylvania</td>
</tr>
<tr>
<td>Reed, Mary Valedia</td>
<td>14</td>
<td>Smith</td>
</tr>
<tr>
<td>Roxby, John Byers, Jr.</td>
<td>24</td>
<td>Wesleyan</td>
</tr>
<tr>
<td>Saslow, George</td>
<td>23</td>
<td>N. Y. U.</td>
</tr>
<tr>
<td>Seaton, Mary Jane</td>
<td>18</td>
<td>Penn. Coll. for Women</td>
</tr>
<tr>
<td>Sensenig, Wayne, Jr.</td>
<td>19</td>
<td>Haverford</td>
</tr>
<tr>
<td>Shelton, Meredith</td>
<td>11</td>
<td>Sarah Lawrence</td>
</tr>
<tr>
<td>Spratt, Nelson Tracy, Jr.</td>
<td>41</td>
<td>Emory</td>
</tr>
<tr>
<td>Stokes, Miriam</td>
<td>8</td>
<td>Mt. Holyoke</td>
</tr>
<tr>
<td>Stevenson, James Harold</td>
<td>42</td>
<td>Oberlin</td>
</tr>
<tr>
<td>Stump, Alexander Bell</td>
<td>44</td>
<td>U. of Virginia</td>
</tr>
<tr>
<td>Swift, Katharine Whitin</td>
<td>15</td>
<td>Smith</td>
</tr>
<tr>
<td>Twichel, Allen Reid</td>
<td>30</td>
<td>Wabash</td>
</tr>
<tr>
<td>Waterman, Talbot Howe</td>
<td>36</td>
<td>Harvard</td>
</tr>
<tr>
<td>Weinberg, Stanley L.</td>
<td>43</td>
<td>Columbia</td>
</tr>
<tr>
<td>Weierbach, Lily Amelia</td>
<td>5</td>
<td>U. of Pennsylvania</td>
</tr>
<tr>
<td>Weir, Ellen Hatfield</td>
<td>47</td>
<td>Wilson</td>
</tr>
<tr>
<td>Wheeler, Norman C.</td>
<td>29</td>
<td>Purdue</td>
</tr>
<tr>
<td>Wilkinson, Grace Walborne</td>
<td>7</td>
<td>Howard</td>
</tr>
<tr>
<td>Wood, Elizabeth Clark</td>
<td>3</td>
<td>N. J. State Teachers</td>
</tr>
</tbody>
</table>
INVERTEBRATE ZOOLOGY COURSE

SEATING PLAN

1936

31. Wightman (Assistant)
32. Croasdale

33. Bonnet
34. Koster
29. Wheeler
30. Twichel
27. Ray

36. Waterman
35. Copeland
28. Bishop

37. Doyle
38. Grave
25. Hill
26. Allen
23. Saslow

40. Johnson
39. Hoyt
24. Roxby

41. Spretz
42. Stevenson
21. Potts
22. Harris
19. Sensenig

44. Stump
45. Weinberg
20. Carson

48. Hogan
47. Griffoul
17. Grobstein
18. Seaton
15. Swift

49. Bush
50. Burlington
13. Huntington
12. Morgan

52. Cassidy
51. Dawson
14. Reed
11. Shelton

53. Bowen
54. Kimball
9. Granger
10. Moyer

56. Norman
55. Caylor
8. Stokes
7. Wilkinson

6. Faben
5. Weierbach
1. Bader

2. Babcock

Seating Plan:
- Numbers above in each team correspond to numbers for each team in the schedule of equipment for each trip as given on the ORGANIZATION sheet.
- Each member of a team will please provide himself or herself with the proper equipment and report to the team instructor with the proper utensil before the team leaves the laboratory for the trip. Each member will also be responsible for the return of this piece of equipment to the store room or to the laboratory after the trip is over. This is most important.
- Teams meet in the laboratory after the trip at specified times to turn in the specimens brought in in the AM and to finish identifications and learn the names and characteristics of forms found, and identified.
## INVERTEBRATE ZOOLOGY COURSE
### FIELD TEAMS
#### 1936

<table>
<thead>
<tr>
<th>Team I</th>
<th>Team II</th>
<th>Team III</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Grave</td>
<td>5. Stevenson</td>
<td>5. Caylor</td>
</tr>
<tr>
<td>7. Meyer</td>
<td>7. Griffoul</td>
<td></td>
</tr>
<tr>
<td>8. Stokes</td>
<td>8. Weir</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Team IV</th>
<th>Team V</th>
<th>Team VI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Twichel</td>
<td>2. Potts</td>
<td>2. Stump</td>
</tr>
<tr>
<td>5. Allen</td>
<td>5. Harris</td>
<td>5. Farraday</td>
</tr>
</tbody>
</table>

N.B. - Numbers above in each team correspond to numbers for each team in the schedule of equipment for each trip as given on TEAM ORGANIZATION sheet.

Each member of a team will please provide him- or herself with the proper equipment and report to the team instructor with the proper utensil before the team leaves the laboratory for the trip. Each member will also be responsible for the return of this piece of equipment to the store room or to the laboratory after the trip is over. This is most important.

Teams meet in the laboratory after the trips at specified times to go over the specimens brought in in the ARK and to finish identifications and learn the names and characteristics of forms found, and identified.
### FIELD TRIPS

<table>
<thead>
<tr>
<th>Location</th>
<th>Date</th>
<th>Time</th>
<th>FHB</th>
<th>SC</th>
<th>CEH</th>
<th>FRK</th>
<th>AML</th>
<th>SAM</th>
<th>OEN</th>
<th>LPS</th>
<th>AJW</th>
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<tbody>
<tr>
<td>Lackeys Bay</td>
<td>July 29, Wed.</td>
<td>9:00--10:16--11:00</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>0</td>
<td>5</td>
<td>6</td>
<td>0</td>
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<tr>
<td>Nobska</td>
<td>Aug. 1, Sat.</td>
<td>1:30--1:51--4:00</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>0</td>
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<tr>
<td>Kettle Cove</td>
<td>Aug. 3, Mon.</td>
<td>10:30--12:12--4:00</td>
<td>3</td>
<td>4</td>
<td>0</td>
<td>6</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>5</td>
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<tr>
<td>Lagoon Pond Bridge</td>
<td>Aug. 11, Tue.</td>
<td>9:30--12:36--3:30</td>
<td>4</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
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<td>Cuttyhunk</td>
<td>Aug. 15, Sat.</td>
<td>10:00--1:09--3:00</td>
<td>5</td>
<td>6</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>3</td>
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<tr>
<td>North Falmouth</td>
<td>Aug. 17, Mon.</td>
<td>9:30--2:41--3:30</td>
<td>6</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>1</td>
<td>4</td>
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<tr>
<td>Dredging</td>
<td>Aug. 24, Mon.</td>
<td>9:30--12:00 and</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>6</td>
<td>2</td>
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<tr>
<td>Tarpaulin Cove</td>
<td>Aug. 28, Fri.</td>
<td>9:00--10:47--3:30</td>
<td>0</td>
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<td>6</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>0</td>
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</tr>
</tbody>
</table>

#### Studen' Leaders

**Wednesday, July 22: Symbiotic Commensal and Parasitic Protocols**

Among the variety of protosor commensal or parasitic in marine animals of this vicinity, the following are available for study because of their relative abundance.
The following directions are merely indicative of the plan of the work and variations or deviations are acceptable. The organisms mentioned below are either marine or brackish water protozoa with the exception of the intestinal flagellates of the Termites.

Tuesday, July 28. Free Living Protozoa

Morning- Examine old colonies of Obelia, Tubellaria, Sertularia or Pennaria for representatives of the class Suctoria. Identify and draw carefully Ephelota, following the directions given in Drew, page 30. Two others may commonly be found, Podophyra and Acineta. Identify and study these. Compare with Ephelota.

Afternoon- Examine cultures of protozoa from marine and brackish water habitats. Identify and make recognizable sketches of as many different protozoa as time allows. Include data on the source of the cultures and classify according to Pratt, revised edition, 1935.

Wednesday, July 29. Symbiotic Commensal and Parasitic Protozoa

Among the variety of protozoa commensal or parasitic in marine animals of this vicinity, the following are available for study because of their relative abundance.
### Morning - Commensals

<table>
<thead>
<tr>
<th>Example</th>
<th>Host</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Folliculina sp.</td>
<td>Bdelloura</td>
<td>Egg cases</td>
</tr>
<tr>
<td>Lichenophora</td>
<td>Crepidula</td>
<td>Egg cases</td>
</tr>
<tr>
<td>Ancistruma mytili</td>
<td>Mytilus edulis</td>
<td>Mantle cavity</td>
</tr>
<tr>
<td>Ancistruma isseli</td>
<td>Modiola modiolus</td>
<td>Mantle cavity</td>
</tr>
<tr>
<td>Conchophthirius mytili</td>
<td>Mytilus edulis</td>
<td>On muscles and foot</td>
</tr>
<tr>
<td>Boveria sp.</td>
<td>Teredo Navalis</td>
<td>Gills</td>
</tr>
<tr>
<td>Chilodonella hyalina</td>
<td>Orchestia agilis</td>
<td>Carapace</td>
</tr>
<tr>
<td>Allospaherium palustris</td>
<td>Orchestia palustris</td>
<td>Carapace</td>
</tr>
</tbody>
</table>

Study carefully and draw at least two of the above forms, only one from any particular host. Examine as many of the others as time permits. Include with each drawing the following data: classification, host, and location in host.

### Afternoon - Parasites

<table>
<thead>
<tr>
<th>Example</th>
<th>Host</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anoplophrya orchestii</td>
<td>Orchestia agilis</td>
<td>Lacunae or blood vascular spaces</td>
</tr>
<tr>
<td>Trichodina (?) sp.</td>
<td>Thyone briareus</td>
<td>Intestine</td>
</tr>
<tr>
<td>Schizocystis sipunculi</td>
<td>Phascolosoma gouldi</td>
<td>Intestine</td>
</tr>
<tr>
<td>Haplozoan (Dinoflagellato)</td>
<td>Clymenella</td>
<td>Intestine</td>
</tr>
<tr>
<td>A sporozoan and a ciliate</td>
<td>Hydroides</td>
<td>?</td>
</tr>
</tbody>
</table>

**Symbionts**

| Trichonympha agilis      | Termites                    | Intestine              |
| Dinonympha               | "                           | "                      |
| Pyrsonympha              | "                           | "                      |
| Spirotrichonympha        | "                           | "                      |
It is understood, of course, that these symbiotic flagellates are not exclusively marine.

Directions for the afternoon are similar to those of the morning.

All drawings and reports are due Thursday, July 30 at 9 A. M.

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 sycamore dish and examine with low power. If Lissamphora are present they can be transferred to a slide by means of a pipette. Another ciliate is present which should be studied on a slide.

Mediola modulans

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

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

**Orchestia agilis**

Crush the animal on a slide and add 5% saline solution or sea water. Anaplophrya orchestii is small but abundant in the infected host.

**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 syracuse dish and examine with low power. If Lichnophora are present they can be transferred to a slide by means of a pipette. Another ciliate often is present which should be studied on a slide.

**Nodiola modiolus**

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

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

**Suctoria, Folliculina, Heliozoa**

These will be found attached to the old Hydroid colonies such as Tubularia, Sertularia, Pennaria, Obelia, etc. Examine pieces in a syracuse dish or on a slide with low power, or on a slide. Another method is to stick glass slides down into the mass of hydroids in the culture dish several days before desired. Among the material attached to the slides will be found (perhaps) Suctoria, Folliculina, Radiolaria and Heliozoa. Another method is to suspend glass slides in the Eel Pond. Folliculina may also be found on the egg cases of Bdelloura on the gill books of the Horse-shoe crab - Limulus.

**Teredo navilis**

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

**Phascolosoma gouldi**

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

**Clymenella Torquata**

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

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

Hydroides

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


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

Marine Protozoa will be found in cultures taken from the bottom of the Eel Pond, from wharf scrapings and in the buckets of old Hydroid material.
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Make a habit sketch of Leucosolenia.

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

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

** **

Afternoon

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

** **

References

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


All records of your work on the Porifera are due not later than Friday, July 31, 1936 at 9:00 A.M.
INVERTEBRATE ZOOLOGY, 1936

LABORATORY DIRECTIONS

Class Turbellaria:

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

1. **The Proboscis Mechanism**:
   Place several worms in a finger bowl half full of sea-water. Add several pieces of freshly-cut Limulus gill. Watch for the eversion of the pharynx. Draw a worm in this position under a dissecting microscope with special attention to the morphology of the pharynx. (The eversion of the pharynx may also be accomplished by placing worms in 7% solution of alcohol in sea-water and is often very striking in young worms freshly liberated from cocoons).

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

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

**OPTIONAL**:

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

Class Trematoda:

1. **Adult Digeneic Trematode—Cryptocotyle lingua** (Gull fluke)
   For convenience of supply, this fluke has been introduced in quantity into the intestine of the domestic cat by feeding a cat with meals of eel or mackerel containing the metacercariae of the worm. Careful study of a small portion of the cat intestine furnished by the assistant will reveal several of these small, colorless flukes in living condition. Remove these flukes carefully and mount for observation in warm-blooded Ringer's solution.
   Watch a few moments for egg discharge and then study the structure of the fluke for the following features: suckers, mouth, pharynx, osophagus, intestinal trunks, genital pore, uterus, ovary, seminal receptacle, vitelline receptacle, testes, vitellaria, excretory tubes, and excretory pore.
   Stained, mounted specimens will show some morphological details not easily seen in fresh mounts.

2. **Egg discharge**:
   Procure one or more living frog lung flukes (Pneumoneces) from the assistant. Place these in cold, fresh water which will cause a discharge of most of the eggs from the uterus. Notice the
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B. 3.

pr o d1.;.ced by this method upon the worm as a whole.
N. B. No records of this latter observation are required.

3. **Larval Forms of a Digenetic Trematode:**

A. **Redia:**

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

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

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

B. **Cercariae:**

**Morphology:**

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

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

C. **Metacercariae:**
Study and draw metacercariae of Cryptocotyle as they appear encysted in a cunner fin.

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

1. **Scolex:**

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

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

2. Mature Proglottid (optional):

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

3. Egg Cases and Hexacanth Embryos:

Obtain cestode egg cases developed from eggs discharged 4 or 5 days previously. The mechanical stimulation produced by handling with a pipette should cause larvae to escape from their cases. Identify (a) chitinous cases containing larvae; (b) empty cases with "lids" at the point of exit of the larvae; (c) hexacanth embryos still enclosed within their ciliated embryophores and resembling very active balls of cells; (d) escaped, active embryos creeping on the bottom of the dish.

4. Plerocercous (Cysticercoid):

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

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

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

Phylum Nematathelminthes—Class Nematoidea:

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

Phylum Platyhelminthes—Class Nematodea:

Amphiporus:

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

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

Preparation for Examination:

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

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

The Digestive System:

Note that the posterior end tapers very rapidly and is slightly curved. The anterior end tapers gradually. Along the sides of both ends are numerous sensory setae. At the truncated extremity of the anterior end is seen the mouth opening. Behind it is a short pharynx in which there are three sharply-pointed teeth, the onchia. The thick-walled tube running backward from the pharynx is the oesophagus. At its posterior end is a sphincter valve marking the beginning of the intestine, which is a yellowish-brown tube running throughout nearly the entire length of the body. Careful focussing on the anterior part of the intestine will show that its wall is composed of typical columnal epithelium. The inner ends of most of the epithelial cells are filled with granules which give the color to the intestinal wall. About halfway along the tapering tail 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 shows internally the three slightly swollen ampullae of the three candal glands. The cement-like secretion of these glands is poured out of a minute pore at the extreme tip of the tail to be used in temporarily cementing the worm by the tail to the substratum. A spinneret valve (hemispherical posteriorly and tapering anteriorly) is fastened by a contractile fiber to the ampullae and the contraction of this fiber withdraws the valve to allow outflow of the secretion. The candal glands are ellipsoidal, arranged in tandem fashion from a point about five body diameters anterior to the anus to a point about 10 body diameters anterior to the anus.
The Excretory System:

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

The Nervous System:

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

The Female Reproductive System:

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

The Domanian System:

This system is found only in the female. It consists of the following structures: A short distance anterior to the rectum are two large, clear, cross-striated tubes, the moniliform glands, which open posteriorly by separate pores. Anteriorly these tubes unite near the conspicuous, rosette-like uvette. From the uvette a tube runs to the intestine, and another tube, starting as a wide ampulla, soon narrows rapidly to form a thin tube, which joins the uterus in the vicinity of the vulva. The 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, pristionurus (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 vas deferens which connects with the ejaculatory duct which in turn opens posteriorly through 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 vas deferens. Draw to show the male genital organs and the extreme posterior end of the male worm.

3. The gonospheres (male and female) are gonospheres formed vertically just behind the genital system. There are vertical tubes, or number of gonospheres, in this system, connected in series as a multiple spiral. Examine in the male worm, the next posterior to the testes, and a gonosphere under higher power using the marks, gonospheres cavity, sex contents, etc. (7) Study a female colony. The female gonospheres are readily distinguished from those of the male. They consist of clusters of peculiarly modified (2) gonospheres attached to the hydranth or to the stem. They are orange in color. Draw a cluster of gonospheres under low power, and a single gonosphere under higher power. Observe the distally bifurcated apical portion extending the gonosphere.

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

5. Study an individual hydranth. Note the arrangement of the filiform and capitulate tentacles. The latter have an oval sheath, nematocyst in their distal end. Observe the relation of the nematocysts to the hydranth body. Draw and label a hydranth.

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

CLASS: HYDROZOA.

1. Examples of the GYMNOSTREPTA. (Anthomedusae).

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

A. EUDENDRILLUM.

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

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

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

B. PENNARIA.

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

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

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

4. Obtain male and female colonies. Observe the gonophores. Those are borne on the hydranth just distal to the filiform tentacles, and consist of medusae with rudimentary tentacles. The female gonophores when mature contain several opaque or pinkish eggs. The gonophores of the male are whitish in
Tease apart male and female gonophores and examine the germ cells. Draw and label male and female gonophores, noting rudimentary tentacle bulbs, velum, manubrium, radial canals, etc.

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

C. TUBULARIA.

Study as outlined in your text.

D. HYDRACTINIA AND PODOCORYNE

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

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

E. CLAVA.

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

F. BOUGAINVILLEA.

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

II. Examples of the CALYPTOBlastEa. (Loptomodusae).

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

A. OBELIA.

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

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

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

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

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

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

C. SERTULARIA.

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

D. THURIARI A.

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

E. SCHIZOTRICHIA.

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

Observe the manner of growth in Schizotrichia and refer to section III below.
III. The Growth of Hydroid Colonies.

Hydroid colonies, in general, proceed in their growth and development along various lines:

1. In certain forms, such as Hydractinia, Podocoryne, and clava, the polyp or zooids grow out singly from a common stoloniferous coenosarc. There is no branching in this type of colony-growth.

2. In colonial gymnoblastic forms, the oldest hydranth of the main stem or of a branch is the distally situated hydranth. The younger hydranths develop proximally. The oldest hydranth of such a colony is the one situated at the distal end of the main stem and theoretically represents the original hydranth which developed from the actinula, planula or stolon.

3. Certain Campanularidae manifest a type of colony-growth distinct from that of Gymnoblastea in that the oldest hydranth of the colony is that situated nearest the hydrorhiza or stoloniferous roots of the colony. New Hydranths, coenosarc of the hydrocaulus, and branches represent outgrowths which occur immediately proximal of the hydranth or hydranths already formed. The oldest hydranths of a given colony (unlike those of the gymnoblastea) are proximally situated in the colony.

4. In the Sertularidae and Plumularidae there occurs a type of growth somewhat different from that of the Campanularidae in that the tip of the main stem (or branches) grows and the hydranths arise as coenosarcal evaginations just proximal of this growing tip, whereas in the Campanularidae, the coenosarcal evagination which grows out from the basal region of the coenosarc situated immediately proximal of an existant hydranth always culminates in the production of a hydranth.

Study the figures on the chart illustrating the last three types of growth, and carefully observe and draw the growing colonies of Bougainvillea, Obelia (Campanulario), Schizotricha and Sertularia.

F. GONIONEMUS.

You will study this from in the medusoid generation only. Consult your text for directions. Make whatever drawings you think necessary.

CLASS: SCYPHOZOA.

1. An example of the DISCOPHORIDAE.

1. Select a specimen of the jelly-fish, AURELIA. Follow directions in your text, making all drawings necessary to show the anatomical features. Attend carefully to the structure of the tentaculocyst.

II. An example of the STAUROMEDUSAE.

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

CLASS: ACTINOZOA.

I. An example of the ACTINIARIA.

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

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

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

II. An example of the MADREPORARIA.

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

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

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

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

b. The septa. Each septum forms a radiating partition which proceeds inward toward the center of the cup. It may
join with another septum before uniting with a central portion known as

c. The columella.
Observe these features under the dissecting microscope and draw.

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

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

Directions for the Work on Ctenophora

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

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

A. General Features:

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

2. Symmetry. What is meant by biradial symmetry?

3. Ctenophoral plates or combs. Observe number, extent, and general structure. In what direction is the beat propagated along the plates? What relation does this fact have on the direction of movement of the animal as a whole?
4. **Oral pole.** Observe the two oral lobes and four auricles. The latter are fringed by cilia more or less fused to form a membrane. The mouth is slit-like, and at right angles to its long axis it has two mobile structures, the oral lappets. Aborally to each oral lappet, and situated in the region between the auricles you will observe... 

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

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

7. **The gastrovascular system.** This system is complex. The mouth opens into the stomodaenum or stomach, a slit-like chamber leading aborally toward the apical sense-organ. It is lined by cells of ectodermal origin. Just below the sense-organ, the stomach opens into the infundibulum or funnel, the beginning of the entodermal portion of the gastrovascular system. The infundibulum is compressed laterally and at right angles to the stomodaenum. Extending aborally toward the sense-organ from the funnel is a tubular structure, the funnel-tube. It enlarges below the sense-organ. This enlargement can be studied to best advantage in lateral and aboral views. The infundibulum gives origin to eight canals, viz., four interradial, two paragastric and two tentacular canals. Each interradial bifurcates into two adradial canals which lead to the ciliary combs. The adradial canals leading to the bases of the auricles are known as the subtentacular meridional canals whereas the canals lying beneath the combs extending over the oral lobes are designated as the sub-ventral meridional canals. Each paragastric canal extends orally along the flattened surface of the stomodaenum to the oral lappet where it terminates blindly. Just before its termination the paragastric canal gives origin to two laterally extending vessels. Each of the latter vessels curves aborally and ultimately anastomoses with the subtentacular meridional canal at the base of the auricle. After making this anastomosis it continues distally over the inner aspect of the oral lobe where it eventually unites with a similar vessel from the other side of the animal. The branches of the paragastric canals, therefore, anastomose with the subtentacular canals and also form a continuous vessel surrounding the oral area of the animal. Each tentacular canal courses distally to the tentacular pocket and bulb, and bifurcates in the substance of the tentacular bulb. The two sub-ventral meridional canals of each oral lobe course distally over the outer surface of the lobe where they pass inward toward the mouth and soon unite on the inner aspect of the lobe.
8. The apical sense-organ. The apical sense-organ lies at the bottom of a deep depression at the aboral end of the animal. It does not lie within the animal and is a specialization of the ectoderm. The sense-organ consists of a specialized area, the pole plate, and a small mass of concretions, the lithocytes, lying in a small depression of the elongated pole plate. These concretions are supported and covered by cilia. The covering cilia are fused and form a covering for the statocyst concretions. The apical sense organ is best observed from lateral and aboral views.

B. Special Features.

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

9. The mouth and its surrounding structures.

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

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

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

Make drawings showing the above features.
GLOSSARY.

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

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

ACRASPEDODE M之一A-- A medusa without velum or diaphragm. Typical of the Scyphozoa.

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

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

ACTINOSTOME-- The external mouth of the actinopharynx.

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

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

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

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

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

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

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

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

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

CNIDA-- Synonymous with nematocyst.

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

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

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

-2-

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

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

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

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

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

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

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

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

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

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

EXUMBRELLA-- The aboral side of a medusa.

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

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

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

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

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

GONOZOID-- A reproductive zooid. See blastostyle.

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

GYMNOSBLASTIC-- A condition in which the hydrotheca and gonotheca are not formed around the hyd ranths and gono zooids, respectively.

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

HYDROCAULUS-- The stem of a hydroid colony.

HYDROCLADIUM-- The polyp bear ing branchlets in the Plumulariidae.

HYDROPHORE-- Saucer shaped hydrotheca in Halocidae.

HYDROPHYLLUM-- See Cor midium.

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

HYPOSTOME-- The projection of the hyd ran th body which bears the mouth.

HYDROTHECA-- The chitinous covering for a hyd ranth in calyp toblastic hydroids.

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

LITHOCYST-- A marginal sense organ in campanularian medusae.

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

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

a). Perfect mesentery-- one that joins the actinopharynx.

b). Imperfect mesentery-- one that does not join the throat or actinopharynx.

c). Primary mesentery-- same as perfect mesentery.

d). Accessory mesentery-- same as imperfect mesentery.

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

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

NEMATOCYST-- The stinging organ contained within the cnidiblast.

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

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

NODE-- A joint in a branch or stem.

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

OTOCYST-- Same as lithocyst.

PEDICEL-- The stalk supporting a hydranth or gonozoid.

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

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

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

POLYPITE-- Same as hydranth.

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

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

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

SESSILE HYDRANTH-- Not having a pedicel.

SIMPLE STEM OR BRANCH-- One not fascicled.

SPIRAL ZOOID-- Defensive person found in Hydraclixidial colony.

SPIROCYST-- One of the types of nematocysts in sea anemones. The
ejected thread does not penetrate but adheres.
SPOROSAC -- A sac that contains the generative cells -- an undeveloped (possibly degenerate) modusa.

STOLON -- Same as root-stalk.

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

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

ZOOIDS -- One of the individuals, more or less independent, that go to make up a colony. Zooids may be nutritive, generative, defensive, or sensory.
A KEY TO THE MORE COMMON HYDROIDS IN THE VICINITY OF WOODS HOLE

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

1. Hydranths unprotected by hydrothecae.
   Sub-order Gymnoblastea. A.

2. Hydranths protected by hydrothecae.
   Sub-order Calyptoblastea. B.

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

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

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

   b. Hypostome (proboscis) conical.

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

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

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

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

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

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

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

b. Hydrothecae arranged on both sides of branches. 
   Family Sertularidae. IX.

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

aa. Hydrothecae not sessile, a pedicel being present.

c. Hydrothecae well developed.

d. Hydrothecae bell-shaped (campanulate); hypostome of hydranth trumpet-shaped. 
   Family Campanularidae. XI.

dd. Hydrothecae tubular or turbinate; hypostome not trumpet-shaped. 
   Family Campanulinidae. XII.

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

I. Family Clavidae. Key to Genera

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

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

II. Family Hydractinidae.

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

III. Family Podocorynidae.

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

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

aa. Hydranths with prominent hypostome and with 15-20 tentacles; colony approximately 2-8 inches high medusae with brick-red manubrium.  
B. carolinensis.

Found on piles, rock-weed, etc.

V. Family Eudendridae
Genus Eudendrium.

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

b. Branches and pedicles slightly annulated.

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

Found on piling, Fucus, etc.

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

Found on piles, etc. also dredged.


Dredged - sand and gravel bottoms.

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

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

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

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

VI. Family Tubularidae.

Genus Tubularia.

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

aa. Perisarc of stems not extensively annulated.

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

   Found on piles, wharfs, etc.

VII. Family Syncorynidae.

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

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

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

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

VIII. Family Pennaridae.

Genus Pennaria.

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

IX. Family Sertularidae.


aa. Hydrothecae not strictly opposite; slightly alternate.
b. **Hydrothecae** bottle-shaped; margin usually without tooth; operculum of a single adcaulino flap.

**Genus Abiotinia.**

The species *A. abiotina* thrives in deeper waters of Vineyard Sound.

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

**Genus Thuiaria.**

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

X. **Family Plumulariidae.**

One species, *Schizotrichia tenella*, commonly taken. Found on pilos and wharves as a white floccy growth of about 1-2 inches high.

XI. **Family Campodulariidae.**

a. Margin of hydrothecae ornamented with teeth.

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

**Genus Clytia.**

c. Stem unbranched or slightly branched; margin of hydrothecae with 12-16 teeth not deeply cut.

C. *johnstoni.*

Grows on *Fucus*, etc.

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

C. *edwardsii.*

Grows on wharf piling.

bb. Colony branches profusely; gonangium not corrugated; Sessile medusa produced which are ultimately extruded from the gonangium but remain attached to the blastostyle to form "extra capsular sporangia" extending from the top of the gonangium.

**Genus Gonothyroa.**

Our species, *G. loveni*, found generally in the Woods Hole region. The margin of the hydrotheca is ornamented with 12-14 deeply and pointedly cut teeth.
aa. Margin of hydrotheca without tooth; gonangium not corrugated (in Woods Hole species).

d. Gonangium with distal end produced into a definite collar-like aperture.
   **Genus Obelia.**
   high
   c. Colony small, inch or less; stem of zig-zag appearance with little branching; pedicles alternate and borne on shoulder processes of the internodes.
      **C. goniculata.**
      Found on Fucus, Laminaria, etc.

cc. Colony large and bushy; much branching
   **C. commissurals.**
   Found on wharf-piles, etc.

dd. Gonangium without collar-like aperture.
   **Genus Campanularia.**
   
f. Stem and main branches fascicled; pedicles arranged in verticils.
      **C. verticillata.**

ff. Stem and branches not fascicled.

g. Colony small - one inch or less, little branching; distal end of gonangium open and not constricted, free medusae not produced; pedicles strongly annulated.
   **C. fluxuosa.**
   Found on Ascophyllum, Fucus, etc.

gg. Colony 2-3 inches or more; distal end of gonangium constricted into a beak-like structure; hydranth has a trumpet shaped hypostome with about 20 tentacles.
   **C. calceolifera.**
   Found attached to hytillus on piles, on wharfs, etc.

XII. Family Campanulinidae.

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

XIII. Family Halocididae.

One species, Halocium halciniun, generally encountered. Grows throughout the Woods Hole region attached to stones, shells and piles in shallower waters.

Other species of Halocium sometimes found.
ANNE\L IDA

Monday, August 10, 1936

1. Using Drew (pp. 91-95) as a guide, study the external features of a living Nereis viron which has been narcotized. Be sure to have a clear understanding of the following terms: ANNULUS, PROSTOMIUM, PERISTOMIUM, PALP, TENTACLE, PARAPODIUM, NOTOPODIUM, NEUROPODIUM, SETA, ACICULUM, CIRRI (PERISTOMIAL & PARAPODIAL, ventral and dorsal).

2. Identify various species of annelids provided in the Laboratory, using the key to commoner Woods Hole polychaetes. Make careful drawings of a few types to show clearly the diagnostic features.

* * *

Tuesday, August 11, 1936

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


3. Study the Trochophore larva of Hydroides. Mount on a slide, using lens paper to entangle the larvae. What is the shape of the larva? Under the high power of the microscope, see if you can identify the following parts: APICAL PLATE, APICAL TUIT, PROTOTROCH, MOUTH, DIGESTIVE TRACT, ANUS, EYE SPOTS. The addition of a carmine suspension will aid in the study of the digestive tract.

4. Make a special study of the reactions of Nereis viron and Diopatra cuprea. What types of movement can you distinguish? What is the significance of each? Which worm is better adapted for a pelagic life? Locate any respiratory structures which may be present. What structural differences can you see which may be correlated with different habits? Place a glass tube in the dish and gently move the head of the worm so that the anterior end projects into the tube. Observe results. Study the activities of the worm after it has been in the tube a few minutes. Are these identical with the movements of the worm when free in the water? Supply a diopatra in a glass tube with bits of sea weed or shells and observe the method of tube formation.

* * *

Thursday, August 13, 1936

Make a thorough study of Arenicola, following the directions given in Drew, pp. 102-107
A Key to the more common Polychaetes of the Woods Hole Region

KEY

Scale worms - Scales on dorsal side of body.............................. 1

Parapodial cirri broad and leaf-like; 4 pairs of
peristomial cirri; color of worms, greenish......................... II

Peristomial and dorsal cirri long and slender; 3
tentacles; 4 eyes; small worms.................................. III

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

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

Dorso-ventrally flattened, brownish worms with 5
prostomial tentacles in a row; small parapodia............ VI

Head with reduced or no appendages; parapodia small

A. Segments very long............................................. X

B. Segments relatively short................................... VII

Two long peristomial cirri, usually curving over
back like a pair of horns........................................... VIII

Long, slender filaments as respiratory organs; branching
gills on one to three anterior segments....................... IX

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

Worms identifiable by their hard cases.......................... XII

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

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

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

III
a. Tentacles and cirri segmented..............SYLLIS
   aa. Tentacles and cirri unsegmented..........AUTOLYTUS

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

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

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

VII
a. Parapodia small; no gills; anterior
   end of prostomium rounded
   b. No eyes on prostomium....................LUMBRINEREIS
   bb. 4 eyes on prostomium....................ARABELLA
   aa. Parapodia of medium size with gills;
       very pointed anterior end (prostomium)...GLYCERA
   b. Each parapodium with one dorsal and
      one ventral unbranched gill.............GLYCERA DIBRANCHIATA
   bb. Each parapodium with only a dorsal,
       branched, retractile gill..............GLYCERA AMERICANA
   aaa. Parapodia and their unbranched gills
        form several rows down dorsal side of
        animal
       b. Anterior region round in cross-section..SCOLOPLOS
          c. Gills begin on 26th segment..........SCOLOPLOS ROBUSTUS
             cc. " " " 16th " .....................SCOLOPLOS FRAGILIS
          bb. Anterior region flattened dorso-
            ventrally; gills begin on 6th segment..ARICIA ORNATA
Polychaete Key

VIII

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

IX

a. Tentacular filaments (head region only)
   b. Slender worms; blood-red; no branching gills
      c. Setae on first 25 segments only;
         parapodia small..................................POLYCIURUS
      cc. Setae on all segments; branching,
          red parapodia in mid-body region........ENOPLOBRANCHUS
       bb. Not slender; branching gills dorsal
           among filaments, on one or more
           anterior segments.
          c. 3 pairs of branching gills
             d. Setae on anterior part of body only..AMPHITRITE
                e. Setae on first 40 segments..............AMPHITRITE ORNATA
                   ee. Setae on first 25 segments........AMPHITRITE BRUNNEA
              dd. Setae extend to posterior end........LEPRAEA
       cc. 2 pairs of branching gills
          d. Setae on 4th-20th segments..........PISTA
             dd. Setae on third segment to posterior
                 end of body; the "Hydra-worm".......THELEPUUS
       ccc. 2 pairs of gills on a single base;
            look like one gill with four parts......TEREBELLIDES

aa. 4 to 14 pairs of elongate dorsal cirri,
    beginning on 2nd segment; body usually
    brownish anteriorly changing to
    yellowish posteriorly...........................DODECAGERIA

aaa. Head bare; long dorsal cirri as gills
     on many segments of the body, especially
     numerous near the anterior end.............CIRRATULUS

** ** ** ** ** ** ** ** ** **

X

a. Segmentation indistinct; branching
gills on middle segments..................ARENICOLA
   b. 11 pairs of gills.........................ARENICOLA CRISTATA
      bb. 13 " " "..........................ARENICOLA MARINA

aa. Segmentation distinct; no branching
gills; bamboo-appearance
   b. Anus dorsal to a flattened, smooth,
      caudal plate; worms dark brown; live
      in mud-tubes..................................MELDANE
      bb. Anus enclosed in collar with 20-25
cirri; 22 segments, 18 setigerous;
      live in sand tubes..........................CLYMENELLA

** ** ** ** ** ** ** ** ** **

XI..................................................TROPHONIA
Polychaeta Key

XII

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

*** *** *** *** ***

XIII

a. Peristomium asetigerous
   b. Collar notched dorsally; worms form small, encrusting sand-tubes ..... PARASABELLA
   bb. Collar without dorsal notch; live in small, parchment tubes among shells; dredged with Hydroides ..... PSEUDOPOTAMILLA

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

1936

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

Friday, August 14

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

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

Tuesday, August 18

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

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

III. The foot of Polynices

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

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

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

A. The foot of Busycon.

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

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

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

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

Wednesday, August 19

A.M. I. Finish dissection of lamellibranch.

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

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

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

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

A. Function of the siphons.

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

Thursday, August 20

A.M. Anatomy of a Cephalopod.

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

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

Note that after study of the "ventral" view of the opened female the nidamental glands must be removed. In both sexes the digestive and circulatory systems must be worked out concurrently: After observing the anterior vena cara 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.

Notebooks are due on Friday, August 21, at 9:00 A.M.
Friday, August 21:

A study of Homarus (or Callinectes and Pagurus). Refer to Drew.

Injected specimens will be available in the afternoon for the detail of the circulatory system.

Saturday morning, August 22:

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

Saturday afternoon, August 22:

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

The anatomy of Lepas.

Monday morning or afternoon, August 24:

The activities of Balanus.

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

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

The megalops larva of the crab.

Tuesday, August 25: A study of Limulus.

Larval stages.

Feeding reactions, method of locomotion, external anatomy. (Use small specimen, refer to Drew).

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

Wednesday morning, August 26, 9 o'clock.

Laboratory records in the form of labelled drawings, tabulations and brief notes are due.
A COMPARATIVE STUDY OF SOME COMMON MALACOSTRACA

(DIVISION EUMALACOSTRACA)

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

<table>
<thead>
<tr>
<th>Tribe</th>
<th>Order</th>
<th>Suborder</th>
<th>Genus</th>
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<tr>
<td>Amphipoda</td>
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<td>Natantia</td>
<td>Decapoda</td>
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<td>PALAEMONETES</td>
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<tr>
<td>Eucarida</td>
<td>Repantia</td>
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<td>LIBINIA</td>
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</table>

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, sub-chelate, non-chelate?

**Abdomen:** number and kind?

**Gills:** location and number?

**Eyes:** stalked or sessile?
AUTOTOMY IN UCA.

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

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

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

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

Examine the end of the stump which remains after autotomy.

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

(Dissect or hemisect for the nervous system)

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

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

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

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

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

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. (An Artemia, 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. (A thumb-like endopodite, a larger subconical exopodite, 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 (by means of a gnathobase) in the larva. They will form the second pair of antennae in the adult.
   c. The third pair are biramous. (By the time of hatching in Artemia the third pair has lost its biramous character. 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, rectum and anus.
6. Muscles which move the appendages. They originate in a mid-dorsal region.
STAGES IN DEVELOPMENT ON CRUSTACEA

Nauplius

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

Metanauplius

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

Cypris

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

Protozoöa

Body: Distinctly separated into cephalothoracic and abdominal regions. Former covered by carapace; latter imperfectly segmented and lacks appendages.
Eye: 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.

Zoë

Body: Abdomen distinctly segmented.
Eye: Paired, compound, stalked.
Appendages: As in Protozoöa.
Occurrence: In many Malacostraca. First larval form in Callinectes and in Carcinides.

Metazoöa

Body: Abdomen distinctly segmented.
Eye: Paired, compound, stalked.
Occurrence: First larval stage in nearly all Brachyura.

Megalopa

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

Mysis

Body: Cephalothorax, abdomen. Latter distinctly segmented.
Eye: 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 Michthei- mysids and in Nephausia.
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
- H --- hatching point
- mg --- megalopa
- mn --- metanauplius
- my --- mysis
- mz --- metazoada
- n --- nauplius
- pz --- protozoada
- z --- zoada

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<td>&quot; parasitic (a)</td>
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<td>mg-</td>
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Laboratory directions for study of Bryozoa

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

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

Morning study;-

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

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

Afternoon study;-

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

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

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

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

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

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

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

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

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

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

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

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

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

IX. No blood vessels nor blood fluid.

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

XI. No special sense organs yet found.

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

(2) Pedicellinidae;--Colonial. Marine. Stalked forms from a stolonlike stem.
(3) Urnatellidae;--Colonial. Freshwater on sides of stones.
Characteristics of Two Classes of Bryozoa
Compared and Contrasted.
B--Ectoprocta.

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

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

III. No epistome, but some have an operculum or comb-like 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 or in coelom.

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

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

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

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

XI. No special sense organs yet found.

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

(1) Gymolaemata; Marine forms with O-shaped lophophore.
(2) Phylactolaemata; Fresh-water forms. C-shaped lophophore.
(3) Stenolaemata,- Cyclostomata, Crisia and such forms. Marine. Round mouthed forms.
Directions for Laboratory Work for 1936

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

1st day. A. M. Asterias forbesi.

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

II. Behavior of the Animal.

A. Method of locomotion

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

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

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

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

B. Righting reactions.

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

C. Method of respiration.

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

2). In the laboratory are starfish which were injected with carmin 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 doral branchiae?

1st day P.M.

D. Method of surface protection.

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

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

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

1st Day P.M.

1. Asterias. Make a dissection of the "injected starfish". Follow directions in Draw. 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 brovispina.
2nd Day, A.M. & P.M.

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

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

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

Dissect *Thyone* and study its internal anatomy with special reference to homologies with other Echinoderms. Note vestigial character of the skeleton. Study blood cells—Amoebocytes on Mesentery. Hemocytes in W. V. S.

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

General Accounts.


Special Studies.


...
INVERTEBRATE ZOOLOGY

Laboratory Study of the Protochordata

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

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

September 2. Morning

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

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

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

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

September 2 Afternoon

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

**September 3. Morning**

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

**September 3. Afternoon**

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

Examine the dishes containing the Botryllus material for the tailed larvae. If present compare with those of Amaroucium.
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 Amarcocium colonies in fresh sea water. Tadpoles will be found on the bottom of the container. Pick out with the aid of a dissecting scope. 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 employed.

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

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

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

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


Bradway, N. 1936 The experimental alteration of the rate of metamorphosis in the tunicate, Clavelina huntsmani (Van Name) J. Exp. Zool., 72, 213.


See also the references given in Drow, Invertebrate Zoology revised edition, 1936.
CHECK LIST OF INVERTEBRATE ANIMALS

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

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

Woods Hole, Mass.
1936
PHYLUM PROTOZOA (not listed)

PHYLUM PORIFERA
Class Calcarea
*Leucosolenia botryoides
*Sycon cinereum

Class Demospongia
*Chelis arbuscula
*Ciona celata
*Walcottia panicea
*Microciona prolifera
*Suberites compacta
*Haeckelia graveida

PHYLUM COELENTERATA
Class Hydrozoa
*Abellaria abellina
*Bougainvillia
*C. carolinensis
*Campanularia
*C. calceoliformis
*C. flexuosa
*Clava leptostyla
*Clytia
*G. edwardsii
*G. johnsoni
*G. bioculata
*Corynactis agassizii
*Ectopleura ochracea
*Eudendrium
*E.Album
*E. carnea
*E. famosum
*E. tenuis
*Batina mina
*Geonemus surbachi
*Haliclona halecium
*Hydractinia echinata
*Kompoli bachei
*Obelia
*O. commissuralis
*O. homobositata
*O. oculata
*O. planulata
*Pomarina tiarella
*Phyllia pelagica
*Podocoryne
*P. carnea
*P. fulgurans
*Schizothrix tenella
*Sertularia pumila
*Thelastrella argentea
*Thouari
*T. crocea
*T. taylor

Class Scyphozoa
* Aurelia aurita
*C. capillata
*Dactylium cinquecirrhosa

PHYLUM COLLEMBOLATA (Cont'd)
Class Anostraca
*Alcyonium carneum
*Astroemia daniae
*E. elegans
*E. leidyi
*Elasmobranchia
*Elasmobranchia
*Metridium dianthus
*Sagartia
*S. luculena
*S. luciase
*C. modesta

PHYLUM Ctenophora
*Mnesiopala leidyi

PHYLUM PLATHELMINTHES
Class Turbellaria
Sub-class Acetabula
*Polychoera caudata
Order Tricladida
*Ediblea candida
*P. oblonga
*P. torquata

PHYLUM NEMERTES
Order Palaeonemertea
*Chelidonotus spiralis
*Order Heteronemertea
*Cerebratulus lacteus
*L. lineus
*L. bicolor
*L. ocellus
*L. ruber
*L. socialis
*Urocera leidyi
*Order Haplonemertea
*Amphiporus ochraceus
*Tetraselmis
*T. candidum
*T. verticillum

PHYLUM NEMASTOMATIDA
(not listed)

PHYLUM TROCHOZOIA
(not listed)

PHYLUM ANELIDA
Class Chaetopoda
Sub-class Polychaeta
*Ampharetas setosa
*Amphiporus ochraceus
*Amphiporus ochraceus
*Annelida
*A. brunnescens
*A. orbatis
*A. rubescens
*A. opisthoca
*A. mertensii
PHYLUM ANDELLIDA (cont'd)

Class Chaetopoda
Sub-class Polychaeta
Arctica ornata
*Antolytus sp.
Chaetopterus pergamentaeus
*Cirratulus grandis
*Ctenides Gouldi
Ophryoscolex curvispinus
Diopeстра suprema
Dodecaeris coralii
Euglobobranchus sanguineus
Balanus
*Enchytraeus albicans
Lumbriculus albus
*Phascolosoma gouldi
PHYLUM ARTHROPODA
Class Crustacea
Order Copepoda
*Balanus
B.balanoides
B.eburneus
*Chthamalus fragilis
Lepas
*Lepas
Polydora sp.
*Pseudopolyanus
troglodytes
*Salpida gracilis
Scoloplos
S.fragilis
S.robustus
Scopas setosa
*Spinorbis
*Sphenelais
S.palastris
*Spisula
Spisula sp.
*Thetys cincinnati
Travasa farbeai
Trophonella affinis
**PHYLUM ARTHROPODA (cont'd)**

**Class Crustacea**

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**PHYLUM ECHINODERMATA**

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**PHYLUM MOLLUSCIDA**

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**PHYLUM MOLLUSCIDA**

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Class Cephalopoda

| Loligo pealei | 1 | 1 | 1 |

**PHYLUM GHORDATA**

Sub-phylum Hemichorda (Enteropneusta)

| Dolichochela | 1 | 1 | 1 |

Sub-phylum Urochorda (Tunicata)

| *Ampharetidae* | 1 | 1 | 1 |
| *Doliocentrotus* | 1 | 1 | 1 |
| *Echinodermata* | 1 | 1 | 1 |

**PHYLUM MOLLUSCA (cont'd)**

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