COMPARATIVE INVERTEBRATE EMBRYOLOGY
Zool. 536b, Friday Harbor Laboratories
June 10 - July 13, 2002

Instructors: Billie J. Swalla, George von Dassow, Yale Passamanec (T.A.)
Lectures: 9:40 AM and 4:00 PM in the Commons near Dorms

Required text:
M. F. Strathmann (1987) Reproduction and Development of Marine Invertebrates of the
Northern Pacific Coast. Univ. Washington Press. (Royalties to FHL scholarships).

Recommended text:

Changes in schedule for non-spawning in some groups and unexpected opportunities are likely.
Day starts about 8:30 on Mon to Sat in Lab 4 for maintenance of cultures or start of new ones.

<table>
<thead>
<tr>
<th>Tide Date</th>
<th>Lecture and Lab</th>
<th>Instructors</th>
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<tbody>
<tr>
<td>10:25 Mon, 10 June</td>
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<tr>
<td>-2.1 10:25 Mon, 10 June</td>
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<tr>
<td>8:30 Lab Orientation and Purpose of the course in Lab 4</td>
<td>BJS, GvD</td>
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<td>9:40: Film in Commons &quot;A Dozen Eggs&quot;</td>
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<td>10:30 Tour of FHL</td>
<td>YP</td>
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<td>11:00 Blanche Bybee on stockroom; buy books and tools</td>
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<td>11:30 Craig Staude on boat and computer use</td>
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<td>11:45 Library - Maureen</td>
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<tr>
<td>1:00 Lab – Inducing spawning, handling of gametes and embryos, fertilization and first cleavage in sand dollars, <em>Dendraster excentricus</em></td>
<td>GvD</td>
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<td>4:00 Lecture: Echinoid Fertilization and Early Development</td>
<td>GvD</td>
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<td>7:00 pm Lab: Start more Dendraster cultures</td>
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<td>We will have a mixer 'round the sea-tables in Lab 4 while we work</td>
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-2.6 11:00 Tue, 11 June |
| 8:30 Check cultures, draw embryos (and each morning hereafter, and every other spare moment between lectures, meals, labs, etc.!) |
| 9:40 Lecture: Overview of Metazoan Phylogeny | BJS |
| 10:40 Field trip: Argyle Lagoon to collect various invertebrates, including brittle star *Amphipholis squamata* and turbellarian *Kaburakia* (take box lunches) |
| 1:00 Lab: fertilization and cleavage pattern in echinoids *Strongylocentrotus purpuratus* and *droebachiensis* | GvD |
| 4:00 Lecture: Evolution of Echinoid Larval Development | BJS |
**-2.8 11:39 Wed, 12 June**

9:40 **Lecture**: Oocyte Maturation, the Cell Cycle, and Cytokinesis  
10:40 **Field trip**: collect *Ophiopholis* at Snug Harbor (take box lunches) (also collect *Paranemertes* and *Cucumaria*, etc.)

1:00 Lab: asteroids *Orthasterias koehleri*, *Pisaster ochraceus*, *Luidia foliolata*, *Pteraster tesselatus*, as available

4:00 **Lecture**: Fluorescent Probes and Confocal Microscopy

Evening: start cultures of *Ophiopholis*

**-2.8 12:20 Thurs, 13 June**

9:40 **Lecture**: Development with Feeding vs. Non-feeding Larvae

10:40 Lab: Dissect *Amphipholis* to recover brooded embryos

1:00 Lab: holothuroid *Parastichopus californicus*; possibly *Cucumaria*


**-2.5 1:05 Fri, 14 June**

10:40 Lab: Plankton tows in the harbor to look for echinoderm larvae; continue working with echinoderm cultures

1:00 **Field trip**: Nugget trip to dredge for *Boltenia villosa*, *Terebratalia*, et al.

**-1.9 1:54 Sat, 15 June**

8:30 Lab: continue observations of echinoderm embryos and larvae

9:00 Get cars and van in ferry line

10:30 **Field trip**: Padilla bay to collect hemichordates (take box lunches)

**Mon, 17 June**

9:40 **Lecture**: Ascidian Larval Development

10:40 Lab: Solitary ascidians *Boltenia villosa*, *Corella inflata*, et al.

1:30 Lab: Ascidian dechorionation, blastomere separation, fixations  
Phalloidin staining, PI nuclear staining, etc.

4:00 **Meeting with Dr. Margaret McFall-Ngai**

10:00 pm Night-light for larvaceans

**Tues, 18 June**

9:40 **Lecture**: Evolution of Tailed vs. Tailless Molgulid Ascidians

10:40 **Field trip**: to Roche Harbor or Fisherman's Bay to collect *Botrylloides*

1:00 Lab: colonial ascidians *Aplidium*, *Distaplia*, *Botrylloides*

Confocal viewing: phalloidin staining, PI nuclear staining, etc.

4:00 Guest Lecturer – Dr. Ed Munro – Analysis of Notochord Morphogenesis in Ascidians
5:00 Discussion with Dr. Ed
10:00 pm Night-light for larvaceans

**Wed, 19 June**
9:40 Lecture: Evolution of Development of Deuterostomes  
10:40 Lab: Larvacean development; solitary ascidian metamorphosis
4:00 Guest Lecturer – Dr. Anna DiGregorio – Promoter Analyses of Notochord Development in *Ciona* Embryos
5:00 Discussion with Dr. DiGregorio

**Thurs, 20 June**
8:30 Lab: Begin *In situ* hybridization pretreatments
   Demonstration on antisense probe preparation
1:00 Lab: Hemichordate spawning and development

**Fri, 21 June**
8:30 Lab: Begin *In situ* hybridization Washes
10:40 Lab: Continue Hemichordate spawning and development
4:00 Lecture: Hemichordate Development and Evolution

**Sat, 22 June**
8:30 Lab: Detection of *In situ* and discussion of results
11:00 Lecture: Ascidian Metamorphosis

**Mon, 24 June**
8:30 Field trip: to False Bay to collect *Owenia fusiformis*, *Micrura alaskensis*, *Haminaea vesicula* and *Melanochlamys diomedea* and their egg masses, etc.
1:30 Lab: nemertean *Micrura alaskensis*, if obtained in the morning; try spawning *Paranemertes*; examine egg masses collected in the morning.
4:00 Lecture: Spiral Cleavage and Spiralian Gastrulation

**Tues, 25 June**
9:30 Field trip: to Cattle Point or Lime Kiln for *Calliostoma ligatum*, limpets *Lottia* and *Tectura*, chitons *Katharina* and *Mopalia*, et al.
1:00 Brief trip to Labs’ beach to obtain *Littorina*; place them in tea-buoys
1:30 Lab: start cultures of limpets and *Calliostoma*
4:00 Lecture: Variations on the Spiralian Early Developmental Theme among the Molluscs

**Wed, 26 June**
9:40 Lecture: The Trochophore; Concepts of Larvae
10:40 Lab: examine various egg masses and encapsulated eggs; prosobranchs *Fusitriton, Ceratostoma, and Littorina*, as available; opisthobranchs *Tritonia, Haminaea, Melanochlamys, Archidoris, Doridella*, as available

1:00 Lab: spawn bivalves *Chlamys* and *Crassostrea* and observe polar lobes; dissect *Transenella tantilla* to recover brooded embryos

4:00 Guest Lecturer – Dr. Richard Strathmann – Functional biology of marine invertebrate larvae and evolution of larval forms

5:00 Discussion with Dr. Strathmann

**-2.0 12:19 Thurs, 27 June**

8:30 **Field trip**: *Nugget* trip to collect *Sabellaria cementarium*

1:30 Lab: try spawning chitons *Mopalia muscosa* and *Katharina tunicata*; try sipunculan *Phascolosoma* if available


10:00 pm Night-light for polychaetes: nereid epitokes, syllids, *Armandia brevis*

**-1.4 1:01 Fri, 28 June**

9:40: **Lecture**: Segmentation and Coeloms

10:40 Lab: *Sabellaria cementarium, Serpula vermicularis, other polychaetes (e.g. Owenia, Eudistalia)* if available

1:00 Lab: dissect spirorbids to recover brooded embryos

**-0.6 1:43 Sat, 29 June**

8:30 "Field trip" – collect *Ulva* blades by rowboat, pan for acoel *Childia* and look for extruded eggs to see the biggest meiotic spindles in the world; observe *Notoplana* and *Kaburakia* eggs if available; hunt for egg masses of *Vorticeros* on colonies of *Dendrobenia*

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**Mon, 1 July**

9:40 **Lecture**: Our Friends the Bryozoans and How to Know Them

10:40 "Field trip" to the docks to collect bryozoans *Membranipora, Dendrobenia, et al.* off the tires; start cultures of *Membranipora*

1:00 Lab: continue observations of bryozoans *Dendrobenia, Bugula, Schizoporella*, as available; observe metamorphosis in released larvae; examine entoprocts if we can find any

**Tues, 2 July**

9:40 **Lecture**: Development in Brachiopods and Phoronids

10:40 Lab: start cultures of brachiopod *Terebratallia*

1:00 Lab: extract brooded embryos from *Phoronis vancouverensis* colonies; start cultures from embryos extruded from oviduct
Mon, 8 July
9:40 Lecture: Development of Ctenophores BJS
10:40 Lab: group effort to find ctenophore embryos
1:30 "Field trip" to dock to collect medusae (including Stomotoca, Proboscidactyla, Phialidium, Aequorea, Aglantha, etc. as available) by dipper, and to collect hydroid colonies from tires and straps
2:30 Lab: examine hydroids Plumularia, Tubularia, etc. as available
4:00 Guest Lecturer – Dr. Claudia Mills – Diversity of Gelatinous Zooplankton
5:00 Reception with Dr. Mills

Tues, 9 July
9:40 Lecture: Development of Cnidarians GvD
10:40 Lab: observe embryos of hydrozoans
1:00 Lab: try to induce Anthopleura and Stomphia to spawn

Wed, 10 July
9:40 Lecture: Early Development of Arthropods GvD
10:40 Lab: continue observations on cnidarian embryos
4:00 Guest Lecturer – Dr. Laura Corley – Polyembryonic Wasps
5:00 Discussion with Dr. Corley

-3.0 11:22 Thurs, 11 July
9:30 Field trip: last of the course, best tide of the year! We'll go to Cattle Point to get religion, plus a few specimens of the gooseneck barnacle *Pollicipes* and hopefully some brooding crabs (take box lunches)
2:30 Lab: examine brooded embryos of *Pollicipes*, other crabs as available

Fri, 12 July
9:40 LAST LECTURE – To Be Announced BJS, GvD, YP
10:40 "Field trip" to take plankton tows in the harbor for copepods and crustacean larvae; some look for pycnogonids and brooding amphipods on the floats
Start lab clean up; examine notebooks

Sat, 13 July
Finish cleaning lab: both individual and group areas
*(Attendance required until done!!)*
11:30 Field trip to release cultures!