



**Comparative Embryology and Larval Biology**  
**BI 457/557**  
**OIMB Spring 2017**

*In this class we survey embryonic and larval development in a broad selection of marine invertebrate phyla, including but not limited to Cnidaria (jellyfish), Ctenophora (comb jellies) Platyhelminthes (flatworms), Annelida (segmented worms), Mollusca (snails, clams etc.), Nemertea (ribbon worms), Phoronida (horseshoe worms), Echinodermata (starfish, sea urchins etc.), Bryozoa, Arthropoda (crustaceans), and Urochordata (sea squirts etc.). Lectures cover major developmental concepts and processes such as fertilization, cleavage and cell fate specification, morphogenesis, reproductive strategies, developmental modes, and larval function. Students explore the diversity of marine embryos and larvae by culturing dozens of representative species in the laboratory. Almost every week we go on field trips to visit local marine habitats and collect live material for the class. Students become proficient in using microscopes, and hone their observation and scientific illustration skills.*

**Learning outcomes**

1. Demonstrate the ability to:
  - culture embryos and larvae of a wide variety of marine invertebrates in the laboratory
  - effectively use a microscope for observation and documentation
  - identify and compare key developmental features of marine invertebrate groups covered by the course
2. Create a comprehensive notebook of biologically accurate and informative drawings of the developmental stages of species covered by the course

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**Meets: Wednesdays, 8:30 am - 5:00 pm, McConnaughey Lab, OIMB** (Exceptions: depart at 7 am on 4/26 and 5/10 from open tank area, and start at 9:30 on 6/7 and 6/14).

We will have a 1 hour break for lunch at noon.

**Office Hours:** Drop by any time, or by appointment.

**Required reading:** See CANVAS for handouts, study guides, lecture notes, and required reading. Students are responsible for downloading and reading weekly assignments.

**Important notes:**

- The schedule below is tentative because embryological lab work depends in part on reproductive timing of animals, which we do not control. Changes in schedule for unexpected opportunities or disappointments are likely.
- Because we only meet once a week, but the development goes on in between - students will only be successful in this course if they devote time to observing and caring for cultures outside of regular class hours.
- Pay close attention to the class start time each week: normally we will start at 8:30, but **on April 26th and May 10th we start at 7:00 am to catch a low tide.** To compensate for the early start on those days we will begin **at 9:30 on June 7th and June 14th.**

**April 5** Echinoderms I (echinoids)  
**April 12** Echinoderms II (asteroids, ophiuroids)  
**April 19** Spiralian I (mollusks and annelids)  
**April 26** Spiralian II (bryozoans)  
**May 3** Spiralian III (nemerteans and flat worms)  
**May 10** Plankton  
**May 17** Spiralian IV (phoronids)  
**May 24** Cnidarians  
**May 31** Crustaceans  
**June 7** Ascidians  
**June 14** Final Exam, Notebooks due

#### **Especially helpful books on the subject:**

- 1) M. F. Strathmann (1987) *Reproduction and Development of Marine Invertebrates of the Northern Pacific Coast.* Univ. Washington Press.
- 2) S. F. Gilbert and A. M. Raunio, eds (1997) *Embryology: Constructing the Organism.* Sinauer.
- 3) Young, Sewell and Rice (Eds). 2006. *Atlas of Marine Invertebrate Larvae.* Academic Press.
- 4) Shanks, A, ed. (2002) *An identification guide to the larval marine invertebrates of the Pacific Northwest.* Oregon State University Press. Individual chapters are available as pdfs from UO Scholar's Bank: <https://scholarsbank.uoregon.edu/xmlui/handle/1794/6123>

A few copies will be available in class.

#### **ASSESSMENT**

**1. Notebook (42%)** All students are expected to maintain a high-quality laboratory notebook. The notebook should contain labeled drawings of eggs, embryos, and larvae raised by you, and organized by species. The notebook should also include notes on where and how the animals were collected, and which techniques were used to procure embryos. The notebook should not contain lecture notes, handouts, or reading assignments. The drawings must be sufficiently detailed and well-labeled to demonstrate understanding of the subject, and must include indications of size. For more information refer to a separate handout about keeping a notebook, and examples of good embryology notebooks in the class. *During second week of class instructor will review notebooks, and offer individual advice.*

**2. Weekly quizzes (18%).** Every week we will have a short quiz based on the material learned the previous week. Each of the nine quizzes is worth 2% of the total grade.

**3. Final Exam (20%).** Cumulative.

**4. Participation in class (20%).** Students are expected to keep track of class schedule and participate in all class activities. If you are unable to attend some activity for a respectable reason, notify the instructor as soon as possible and discuss how you will make up for it. Tardiness and absences without a good reason will negatively effect the grade.

**5. Extra credit (up to 5%).** See extra credit assignment on Canvas.

97-100 A+  
93-96.9 A  
90-92.9 A-  
87-89.9 B+  
83-86.9 B  
80-82.9 B-  
77-79.9 C+  
73-76.9 C  
70-72.9 C-  
67-69.9 D+  
63-66.9 D  
60-62.9 D-  
<59.9 = F

Day	Tide	Time	Activities
<b>Week 1</b> Apr 5	0.3 ft 14:49	8:30	Course orientation: introductions, handouts, Canvas, grading, notebook. <b>Lab.</b> Inject sea urchins <i>Strongylocentrotus purpuratus</i> and sand dollars <i>Dendraster excentricus</i> with KCl to induce spawning. Use and care of microscopes. Making slide preps. Using ocular micrometer. Documenting <u>normal</u> development.
		9:30	<b>Lab.</b> Fertilization on the slide. Students start individual cultures of both species.
		10:30	<b>Lecture.</b> Fertilization and development in echinoids.
		13:00	<b>Lab.</b> Observe and draw: early cleavage stages, micromere formation and advanced stages (started days ahead by instructor and TA: blastula, primary mesenchyme, gastrula, prism).
		14:00	<b>DEMO:</b> crowd control, changing water, cleaning bowls, feeding (TA).
		15:00	<b>Lab.</b> Continue observation, draw developmental stages of echinoids
			<b>CLEAN, FEED, OBSERVE YOUR CULTURES EVERY 2-3 DAYS</b>

Day	Tide	Time	Activities
Week 2 Apr 12	0.0 ft 7:47	8:30	<b>Quiz 1.</b> Fertilization and development of echinoids.
		8:45	<b>Lecture.</b> Oocyte maturation, fertilization in starfish.
		9:00	<b>Lab.</b> Inject starfish <i>Pisaster ochraceus</i> with 1-methyl adenine to induce spawning. Excise ovaries and testis. Observe GVBD, fertilization. Start cultures.
		10:00	<b>DEMO:</b> Taking pictures through the microscope.
		11:00	<b>Lecture.</b> Larval development in asteroids, and other echinoderms.
		13:00	<b>Lab.</b> Dissect and observe internally brooded embryos of brittle star <i>Amphipholis squamata</i> . Externally brooded larvae of six-armed starfish <i>Leptasterias hexactis</i> . Observe cleavage (note the difference between sea star and sea urchin 16 cell stage), and more advanced stages of <i>Pisaster</i> : blastula, gastrula, coelom formation (cultures started earlier by instructor and TA)  <b>Notebook advice:</b> students meet individually with instructor to get feedback on their notebooks.
Week 3 April 19	1:06 ft 13:06	8:30	<b>Quiz 2.</b> Larval development in echinoderms.
		8:45	<b>Lecture.</b> Spiral cleavage and nomenclature. <b>Lab.</b> During lecture: “bowling” for <i>Calliostoma</i> (a gastropod) to induce spawning.
		9:45	<b>Lab.</b> Start cultures of <i>Calliostoma ligatum</i> . Avoid polyspermy and overcrowding!
		10:30	<b>Field trip to the large boat basin docks</b> (bring gloves to protect hands against barnacle cuts) to collect polychaete <i>Serpula sp.</i> , nudibranchs (and their egg masses), and sample plankton. <b>Small boat basin</b> to look for the polyclad <i>Pseudoceros</i> and its egg masses on colonial ascidian <i>Distaplia</i> .
		13:00	<b>Lab.</b> Observe equal spiral cleavage in <i>Calliostoma</i> , and identify cells according to spiralian nomenclature. Start cultures of <i>Serpula</i> . Look through plankton for bryozoan cyphonautes, spiralian trochophores and veligers, and other planktonic curiosities (see ‘extra credit’ list).

Day	Tide	Time	Activities
		14:00	<b>Lecture.</b> Equal vs. unequal cleavage. Development of annelids and mollusks.
		15:00	<b>Lab.</b> Follow cleavage in <i>Calliostoma</i> until 16-cell stage (observe side view and animal pole view in dark field). Gastropod egg masses ( <i>Nucella</i> , <i>Lacuna</i> , <i>Nassarius</i> , various nudibranchs as available). Continue looking at plankton, examine a trochophore and a veliger.  <b>Note:</b> <i>Calliostoma</i> has non-feeding development. Its cultures are especially prone to bacterial and ciliate infestations, but the shell is very pretty, so they are worth it! Transfer individual normally-looking embryos into a clean bowl at each water change. These veligers do not swim well - normal ones usually rest on the bottom until they begin to crawl.
<b>Week 4</b> April 26	-1.0 ft 6:48	<b>7:00</b>	<b>Field trip to South Cove</b> to collect bryozoans ( <i>Crisia</i> , <i>Flustrellidra</i> , <i>Dendrobaenia</i> ), polyclad flatworms, externally brooding anemonies <i>Epiactis</i> (if on small rocks). Assemble and be ready to depart WITH RAIN GEAR, RUBBER BOOTS, BUCKETS, BUTTER KNIVES, gardening GLOVES, in front of the open tank area by 7:00.
		11:00	<b>Lecture.</b> Bryozoan development.
		13:00	<b>Quiz 3.</b> Spiral cleavage (basics)
		13:15	<b>Lab.</b> Observe brooded coronate larvae ( <i>Schizoporella</i> , <i>Bugula</i> ) and save a few larvae for settlement. Polyembryony in <i>Crisia</i> , pseudocyphonautes of <i>Flustrellidra</i> , planktonic cyphonautes, as available.  Catch up on echinoderm cultures.  Don't forget to look at <i>Serpula</i> (it has a classic trochophore larva), and take care of <i>Calliostoma</i>
<b>Week 5</b> May 3	0.1 ft 13:10	<b>8:30</b>	<b>Quiz 4.</b> Bryozoan development
		8:45	<b>Lecture.</b> Marine zooplankton.
		9:30	<b>Field trip</b> to Charleston Marina to sample plankton off the docks.

Day	Tide	Time	Activities
		11:00	Dilute plankton, begin sorting. <b>Extra credit given for rarities</b> - particularly interesting specimens for show and tell (see the list on Canvas). In order to receive credit you have to find it, save it, and give it to the instructor alive and undamaged.
		13:00	<b>Lab.</b> Continue looking at plankton with particular attention to the developmental stages of marine invertebrates. Draw at least three different organisms you have not otherwise seen during the course.
<b>Week 6</b> May 10	-0.4 ft 6:50	<b>7:00</b>	<b>Field trip to a mudflat in Charleston</b> to collect <i>Cerebratulus</i> and <i>Micrura</i> (nemerteans), <i>Phoronopsis harmeri</i> (phoronid) and <i>Owenia collaris</i> (polychaete).
		10:00	<b>Lecture.</b> Flatworm development.
		11:00	<b>Lecture.</b> Nemertean development.
		13:00	<b>Quiz 5.</b> Plankton
		13:15	<b>Lab.</b> Examine polyclad flatworm egg plates, Müller's larvae (as available). Students start cultures of <i>Micrura</i> or <i>Cerebratulus</i> (as available) and <i>Owenia</i> . Observe advanced pilidium larvae (cultures started by TA/instructor ahead of time or from plankton). Catch up on other cultures - echinoderms, <i>Calliostoma</i> , <i>Serpula</i> , observe young bryozoan colonies ( <i>Bugula</i> , <i>Schizoporella</i> ).
<b>Week 7</b> May 17	0.3 ft 11:22	<b>8:30</b>	<b>Quiz 6.</b> Spiral cleavage (flatworms and nemerteans, larval development of annelids and molluscs)
		8:45	<b>Lecture.</b> Development of phoronids.
		9:30	<b>Lab.</b> Dissect females of <i>Phoronopsis harmeri</i> , and start cultures. Observe spermatophores and sperm.
		13:00	<b>Lecture.</b> General patterns in the evolution of life histories.
		14:30	<b>Lab.</b> Observe phoronid cleavage (morning cultures), advanced developmental stages from cultures started ahead of time, and actinotroch larvae from plankton (as available). Catch up on other cultures.

Day	Tide	Time	Activities
<b>Week 8</b> May 24	1.5 ft 17:36	8:30	<b>Quiz 7.</b> Development of phoronids
		8:45	<b>Lecture.</b> Development of cnidarians
		9:30	<b>Lab.</b> Look for eggs and embryos of hydrozoan medusae. Observe unilateral cleavage and advanced developmental stages (holoblastula, planula) from earlier spawnings of hydromedusae.
		11:00	<b>Field trip to large boat basin docks</b> to collect hydrozoan polyps ( <i>Tubularia sp.</i> , <i>Obelia sp.</i> , corynids), <i>Aurelia scyphistomae</i> , and plankton. Bring a jelly scoop.
		13:00	<b>Lecture.</b> Development of ctenophores
		14:00	<b>Lab.</b> Observe <i>Obelia</i> medusae (from plankton) and hydroids (look for gonozooids at the base of larger colonies). <i>Tubularia</i> - observe male and female gonophores, brooded and released actinula larvae. External brooding in anthozoan <i>Epiactis prolifera</i> . Observe budding medusae in corynid polyps ( <i>Coryne sp.</i> , <i>Sarsia sp.</i> or related species), as available.
<b>Week 9</b> May 31	-0.5 ft 11:36	8:30	<b>Quiz 8.</b> Cnidarian and ctenophore development.
		8:45	<b>Field trip to large boat basin docks</b> to collect caprellid amphipods and plankton (bring scoops for megalopae).
		9:30	<b>Lecture.</b> Development of crustaceans.
		10:15	<b>Lab.</b> Sort plankton and identify and observe larval stages of crustaceans (nauplius, zoea, cyprid, megalopa).
		11:00	<b>Field trip to Light House beach</b> to look for brooding crabs ( <i>Cancer spp.</i> , <i>Petrolisthes</i> , <i>Hemigrapsus</i> , <i>Emerita analoga</i> ) and gooseneck barnacles ( <i>Pollicipes polymerus</i> ). BRING A SACK LUNCH (and a swimsuit if you wish - there is a nice swim hole nearby). Be ready to leave by 11 am.
		14:00	<b>Lab.</b> Dissect and examine egg lamellae of gooseneck barnacle <i>Pollicipes polymerus</i> . Examine broods of caprellid amphipods, crabs.

Day	Tide	Time	Activities
<b>Week 10</b> June 7	-0.4 ft 5:53	9:30	<b>Quiz 9.</b> Crustacean development.
		8:45	<b>Lecture.</b> Development of ascidians.
		9:45	<b>Lab.</b> Start cultures of solitary ascidians ( <i>Styela spp.</i> ). Remove broods of <i>Molgula citrina</i> and <i>Corella inflata</i> (as available), and examine cleavage stages, tadpole larvae, metamorphosis. Look for released larvae of colonial ascidians, try to prompt metamorphosis.
		13:00	<b>Lab.</b> Observe cleavage in <i>Styela</i> , metamorphosis in <i>Molgula</i> , <i>Distaplia</i> and <i>Botrylloides</i> (as available). Catch up on other cultures. Polishing up the notebook (organization, labels, scales etc.).
		16:00	LAB CLEAN UP: release remaining healthy animals, wash glassware and set to dry, clean sea tables and desks, put away microscopes and lights, download any files from the class computer.
<b>Week 11</b> June 14		9:30	<b>FINAL EXAM, NOTEBOOKS DUE</b>