



Comparative Embryology and Larval Biology
BI 457/557
OIMB Spring 2014

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, differentiation, morphogenesis, reproductive and developmental strategies, 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 (a) culture embryos and larvae of a wide variety of marine invertebrates in the lab; (b) use a microscope for observation and documentation; (c) identify, and understand the morphology of embryos and larvae introduced in the course
2. Create a comprehensive notebook of biologically accurate and informative labeled drawings of the developmental stages of species covered by the course
3. Demonstrate knowledge of developmental concepts and vocabulary covered by the course (as assessed by quizzes and the final exam).

Instructor: Dr. Svetlana Maslakova svetlana@uoregon.edu

Teaching Assistant: Terra Hiebert terrah@uoregon.edu

Meets: Wednesdays, 8:00 am - 5:00 pm, McConnaughey Lab, OIMB.

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

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

Required reading: See Blackboard for handouts, lecture notes and assigned reading. Students are responsible for downloading and reading weekly assignments.

Important note: 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 if they devote time to observing and caring for cultures outside of regular class hours.

April 2 Echinoderms I (echinoids)

April 9 Echinoderms II (asteroids, ophiuroids)

April 16 Bryozoans

April 23 Spiralian I (mollusks and annelids)

April 30 Spiralian II (nemertean and flat worms)

May 7 Plankton (including crustaceans)
May 14 Phoronids
May 21 Cnidarians
May 28 Ascidians
June 4 Final Exam, Lab clean up, Notebooks due.

Recommended texts: 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. A few copies will be available in class.

ASSESSMENT

1. Notebook (44%) 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 (16%). Every week we will have a short quiz based on the material learned the previous week. Each of 8 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, including the final lab clean up. 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.

Day	Tide	Time	Activities
Week 1 April 2	-0.56ft	8:00	Course orientation: introductions, handouts, Blackboard, grading, notebook. Lab. 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.
	8:45	9:30	
		10:30	Lecture. Fertilization and development in echinoids.
		13:00	Lab. 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	DEMO: crowd control, changing water, cleaning bowls, feeding (TA).
		15:00	Lab. Continue observation, draw developmental stages of echinoids

CLEAN, FEED, OBSERVE YOUR CULTURES EVERY 2-3 DAYS

Day	Tide	Time	Activities
Week 2 April 9	1:36ft 15:10	8:00	Quiz 1. Fertilization and development of echinoids.
		8:15	Lecture. Oocyte maturation, fertilization in starfish.
		8:45	Lab. Inject starfish <i>Pisaster ochraceus</i> and <i>Evasterias troschelii</i> with 1-methyl adenine to induce spawning. Excise ovaries and testis. Observe GVBD, fertilization. Start cultures (students choose one or the other, TA - use both).
		10:00	DEMO: Taking pictures through the microscope.
		11:00	Lecture. Larval development in asteroids, and other echinoderms.
		13:00	Lab. 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 in asteroids. Notebook advice: students meet individually with instructor to get feedback on their notebooks.
Week 3 April 16	-0.57ft 7:41	7:00	Field trip to South Cove to collect bryozoans (<i>Crisia sp.</i> , <i>Flustrellidra corniculata</i> , <i>Dendrobaenia lichenoides</i>), gastropod <i>Calliostoma</i> , nudibranchs, <i>Nucella</i> egg masses, other molluscs as available. ARRANGEMENT WITH DINING HALL - EARLY BREAKFAST? Assemble and BE READY to leave WITH RAIN GEAR, RUBBER BOOTS, BUCKETS etc. in front of the open tank area at 6:55 am.
		10:00	Lecture. Bryozoan development
		11:00	Lab. Brooded coronate larvae (<i>Schizoporella</i> , <i>Bugula</i>), planktotrophic cyphonautes larvae, <i>Crisia</i> - polyembryony, brooded pseudocyphonautes of <i>Flustrellidra</i> as available.
		13:00	Quiz 2. Larval development in echinoderms.
		13:15	Lecture. General patterns in the evolution of life histories.
		14:30	Lab. Continue with bryozoans, catch up on echinoderm cultures. Individual meetings with instructor to get advice on notebooks.
Week 4 April 23	0.37ft 13:58	8:00	Quiz 3. Bryozoan development
		8:15	Lecture. Spiral cleavage and nomenclature. Lab. During lecture: "bowling" for <i>Calliostoma</i> (a gastropod) to induce spawning.
		9:30	Lab. Start cultures of <i>Calliostoma ligatum</i> . Avoid polyspermy and overcrowding!

Day	Tide	Time	Activities
		10:00	Field trip to the large boat basin docks to collect polychaete <i>Serpula columbiana</i> , nudibranchs (and their egg masses); also sample plankton to look for bryozoan cyphonautes, spiralian trochophores and veligers, and various planktonic curiosities (see the “wanted alive” poster).
		11:00	Lab. Start cultures of <i>Serpula</i> . Look through plankton.
		13:00	Lab. Observe equal spiral cleavage in <i>Calliostoma</i> , and identify cells according to spiralian nomenclature.
		14:00	Lecture. Equal vs. unequal cleavage. Development of annelids and mollusks.
		15:00	Lab. Continue with spiralian cultures. Follow cleavage in <i>Calliostoma</i> at least until 16-cell stage. Gastropod egg masses (<i>Nucella</i> , <i>Lacuna</i> , <i>Nassarius</i> , others as available). Observe polar lobe (if available). Continue looking at plankton. Note: <i>Calliostoma</i> has non-feeding development. Its cultures are especially prone to bacterial and ciliate infestations and die off. Transfer normal embryos into a clean bowl at each water change. But the shell is very pretty, so they are worth it! These veligers do not swim well - normal ones are usually rest on the bottom, until they begin to crawl.
Week 5 April 30	-1.15ft 7:43	7:00	Field trip to a Mudflat in Charleston to collect <i>Cerebratulus</i> and <i>Micrura</i> (nemerteans), <i>Phoronopsis harmeri</i> (phoronid) and <i>Owenia collaris</i> (polychaete). TA: ARRANGEMENT WITH DINING HALL - EARLY BREAKFAST? Assemble and BE READY to leave WITH RAIN GEAR, RUBBER BOOTS, BUCKETS etc. in front of the open tank area at 6:55 am.
		10:00	Lecture. Flatworm development.
		11:00	Lab. Examine polyclad flatworm egg plates, müller’s larvae (as available).
		13:00	Quiz 4. Spiral cleavage (basics)
		13:15	Lecture. Nemertean development.
		15:00	Lab. Students start individual cultures of <i>Micrura</i> or <i>Cerebratulus</i> (as available) and <i>Owenia</i> . Observe advanced pilidium larvae (<i>started by TA/instructor ahead of time</i>). Catch up on other cultures - echinoderms, <i>Calliostoma</i> , encapsulated veligers, <i>Serpula</i> .
Week 6 May 7	1.26ft 13:09	8:00	Quiz 5. Spiral cleavage (larval development)

Day	Tide	Time	Activities
		8:15	Lecture. Marine zooplankton.
		9:15	Field trip to collect plankton. Boat trip (led by TA), and parallel sampling off the docks at Charleston Marine - high tide (led by instructor).
		10:30	Dilute plankton, begin sorting. Extra credit given for rarities - finding and keeping alive particularly interesting specimens for show and tell (see "wanted alive list").
		13:00	Lecture. Nemertean larval diversity (Terra Hiebert)
		14:00	Volunteers collect plankton off the dock (low tide). Lab. Continue sorting plankton. Observe and document larval stages of crustaceans (nauplius, zoea, cyprid larva, megalopa as available).
Week 7 May 14	-1.09ft 6:41	8:00	Quiz 6. Plankton (esp. crustaceans)
		8:15	Lecture. Development of phoronids.
		9:30	Lab. Dissect females of <i>Phoronopsis harmeri</i> , and start cultures. Observe spermatophores and sperm.
		13:00	Lecture. How larvae feed (guest lecture by George von Dassow).
		14:30	Lab. Observe cleavage (morning cultures), advanced developmental stages from cultures started ahead of time, and actinotroch larvae from plankton (as available). Catch up on other cultures.
Week 8 May 21	0.00 12:23	8:00	Quiz 7. Development of phoronids
		8:15	Lecture. Development of cnidarians
		9:30	Lab. Look for eggs and embryos of hydrozoan medusae. Observe unilateral cleavage (as available). Observe advanced developmental stages (holoblastula, planula) from earlier spawnings of hydromedusae.
		11:00	Field trip to large boat basin docks to collect hydrozoan polyps (<i>Tubularia sp.</i> , <i>Obelia sp.</i> , corynids), <i>Aurelia scyphistomae</i> , and plankton.
		13:00	Lecture. Development of ctenophores

Day	Tide	Time	Activities
		14:00	Lab. 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> (as available). Observe budding medusae in corynid polyps (<i>Coryne</i> sp., <i>Sarsia</i> sp. or related species).
Week 9 May 28	-1.27 6:46	8:00	Quiz 8. Cnidarian and ctenophore development.
		8:15	Lecture. Development of ascidians.
		9:30	Lab. Start cultures of solitary ascidians (<i>Styela</i> spp.). Remove broods of <i>Molgula pugetiensis</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	Lab. Observe cleavage in <i>Styela</i> . Catch up on other cultures. Polishing up the notebook (labels).
Week 10 June 4		9:00- noon	FINAL EXAM, LAB CLEAN UP, NOTEBOOKS DUE