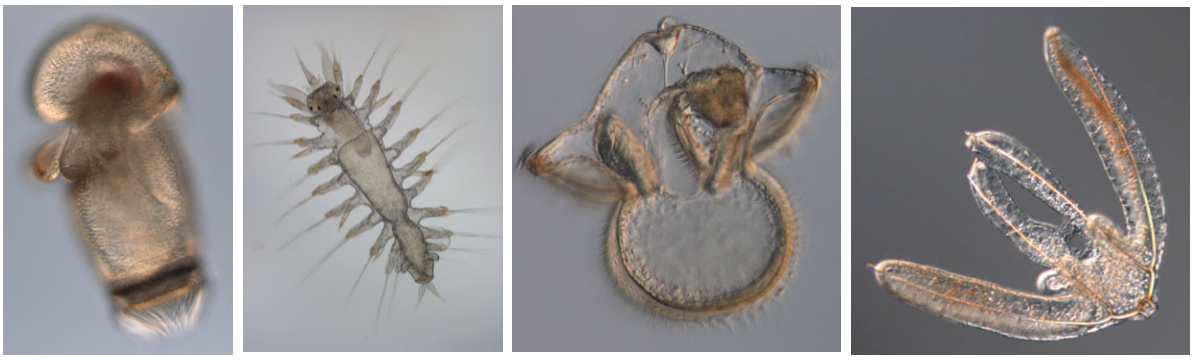

Comparative Embryology and Larval Biology
OIMB Spring 2013 Syllabus

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. All students participate in creating the content for the educational website on Invertebrate Embryology.

Learning goals:

1. Be able 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. Learn to make meaningful labeled drawings of embryos and larvae, and create a comprehensive notebook of drawings illustrating the development of species covered by this course.
3. Write and "publish" 2 to 3 blog entries describing and illustrating developmental stages or processes you learned about in this course. These will contribute to the website on Invertebrate Embryology which serves as a source of images, knowledge and inspiration to others.
4. Be familiar with the 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: Wednesday, 8:00 am - 5:00 pm, McConnaughey Lab, OIMB.
We will have a 1 hour break for lunch at noon. On May 1 we plan a field trip 10:00 - 13:00, so will need to make arrangements for lunch. On May 8th we will begin at 6 am to catch a low tide (see below), so will need to plan ahead for breakfast.

Office Hours: Drop by anytime.

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 3 Echinoderms (echinoids)
April 10 Echinoderms (asteroids, ophiuroids)
April 17 Plankton
April 24 Spiralians (mollusks and annelids)
May 1 Spiralians (nemerteans and flat worms)
May 8 Bryozoans
May 15 Phoronids
May 22 Crustaceans
May 29 Cnidarians
June 5 Ascidians, Lab clean up
June 12 Final Exam

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 (30%) 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. Embryology blog posts (20%). Instead of a traditional class paper, each student will contribute to a course web blog: http://invert-embryo.blogspot.com/ This blog serves as a resource for other students, researchers, and members of the public and promotes appreciation of invertebrate embryos and larvae. In the process students will practice scientific writing and photomicrography (taking pictures through a microscope). Each **undergraduate** student will create **two** posts on the embryological topic of their choice. Each **graduate** student will create an additional post that could describe one of the class field trips, or focus on one the groups covered later in the course (Weeks 8-10). *See separate handout on blog assignment.*

3. Weekly quizzes (20%). Every week we will have a short vocabulary quiz based on the material learned the previous week.

4. Final Exam (20%). Cumulative.

5. Participation in class (10%). 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 Tue April 3	0.0 13:17	8:00	Course orientation: introductions, handouts, Blackboard, grading, notebook. **Lab.** Inject sea urchins *Strongylocentrotus purpuratus* and sand dollars *Dendraster excentricus* with KCl to induce spawning. Use and care of microscopes. Making slide preps. Using ocular micrometer. Documenting *normal* development.
		9:30	**Lab.** Fertilization on the slide. Students start individual cultures of both species. TA: start a class culture of *Dendraster* right before lunch and leave at RT.
		10:30	**Lecture.** Fertilization and development in echinoids.
		13:00	**Lab.** Observe and draw: early cleavage stages, micromere formation, blastula, primary mesenchyme, gastrula, prism.
		14:00	**DEMO:** crowd control, changing water, cleaning bowls, feeding (TA). **CLEAN AND FEED (IF NECESSARY) YOUR CULTURES EVERY 2-3 DAYS**
Week 2 Tue April 10	-0.26 7:00	8:00	**Quiz.** Fertilization and development of echinoids.
		8:15	**Lecture.** Oocyte maturation, fertilization in starfish.
		8:45	**Lab.** Inject starfish *Pisaster ochraceus and Evasterias troschelii* 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	**BLOG ASSIGNMENT.** **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 *Amphipholis squamata.* Externally brooded larvae of six-armed starfish *Leptasterias hexactis*. Observe cleavage in asteroids. **Notebook advice:** students meet individually with instructor to get feedback on their notebooks.
Week 3 Wed April 17	+1.0 12:00	8:00	**Quiz.** Larval development in echinoderms.
		8:15	**Lecture.** Marine zooplankton.
		9:30	**Boat trip** to collect plankton.

Day	Tide	Time	Activities
		11:00	**Lab.** Dilute plankton, begin sorting. **Extra credit given for rarities -** finding and keeping alive particularly interesting specimens for class use (see point "price list"). Take pictures for the blogs.
		13:00	**Lecture.** General patterns in the evolution of life histories.
		14:00	**Lab.** Continue sorting plankton. Practice taking pictures; draw. Pay attention to echinoid and asteroid cultures. **Continue meetings with instructor to get individualized advice on notebook.**
		15:00	Plankton tow on the incoming tide off the F dock, continue sorting.
Week 4 Tue April 24	-0.2 6:00	8:00	**Quiz.** Plankton
		8:30	**Lecture.** Spiral cleavage and nomenclature. **Lab.** During lecture: "bowling" for *Calliostoma* (a gastropod) to induce spawning.
		9:30	**Lab.** Start cultures of *Calliostoma ligatum.* Avoid polyspermy and overcrowding!
		10:00	**Field trip to the large boat basin docks** to collect jingle shells (*Pododesmus cepio*), polychaete *Serpula columbiana*, nudibranchs, and their egg masses.
		11:00	**Lab.** Start cultures of *Serpula.* Inject *Pododesmus* to induce spawning.
		13:00	**Lab**. Observe equal spiral cleavage in *Calliostoma,* and identify cells according to spiralian nomenclature. Polar lobe and encapsulated veligers in *Nassarius* (gastropod) or *Pododesmus* (bivalve) (as available) and nudibranchs.
		14:00	**Lecture.** Equal vs. unequal cleavage. Development of annelids and mollusks.
		15:00	**Lab**. Continue with spiralian cultures. Follow cleavage in *Calliostoma* at least until 16-cell stage. Gastropod egg masses (*Nucella, Lacuna, Nassarius,* others as available). **Note:** *Calliostoma* 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 near the bottom. **FIRST BLOG ENTRY DUE on Friday, April 26th**

Day	Tide	Time	Activities
Week 5 Tue May 1	-0.57 11:45	8:00	**Quiz.** Spiralians I.
		8:15	**Lecture.** Flatworm development.
		9:15	**Lab.** Examine polyclad flatworm egg plates. Polyclad flatworm Müller's larvae (if available).
		10:00	**Field trip to a Mudflat in Charleston** to collect *Cerebratulus* and *Micrura* (nemerteans), *Phoronopsis harmeri* (phoronid) and *Owenia collaris* (polychaete). TA: MAKE AN ARRANGEMENT WITH DINING HALL TO HOLD LUNCH UNTIL 1 pm (or arrange for sack lunches).
		14:00	**Lecture**. Nemertean development. TA - start lab cultures of nemerteans (*Micrura, Cerebratulus* as available), *Owenia* during lecture.
		15:00	**Lab.** Students start individual cultures of *Micrura* or *Cerebratulus* (as available) and *Owenia*. Observe advanced pilidium larvae (started by TA/instructor ahead of time.
Week 6 Tue May 8	-0.46 6:12	**6:00**	**Field trip to South Cove** to collect bryozoans (*Crisia sp., Flustrellidra corniculata, Dendrobaenia lichenoides*). ARRANGEMENT WITH DINING HALL - EARLY BREAKFAST?
		9:00	**Field trip to small boat basin** to collect *Bugula* and *Schizoporella*. TA - set up under bright lights and watch for larval release.
		10:00	**Lecture.** Bryozoan development
		11:00	**Lab.** Brooded coronate larvae (*Schizoporella*, *Bugula*), planktotrophic cyphonautes larvae, *Crisia* - polyembryony, brooded pseudocyphonautes of *Flustrellidra*
		13:00	**Quiz.** Spiralians II.
		13:15	**Lecture.** Nemertean larval diversity (Terra Hiebert)
		14:30	**Lab.** Continue with bryozoans, pay attention to other cultures.
Week 7 Tue May 15	0.29 10:30	8:00	**Quiz.** Development of bryozoans
		8:15	**Lecture.** Development of phoronids.
		9:30	**Lab.** Dissect females of *Phoronopsis harmeri*, and start cultures. Observe spermatophores and sperm.

Day	Tide	Time	Activities
		13:00	Volunteers take a plankton tow off the F dock, to search for actinotroch larvae, and other interesting things (potential subject for blogs).
		13:30	**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. Work on blogs.
			SECOND BLOG ENTRY DUE by Friday, May 17th
Week 8 Tue May 22	-0.13 4:46	8:00	**Quiz.** Development of phoronids
		8:15	**Lecture.** Development of crustaceans
		9:30	Volunteers take a plankton tow off the F dock, collect Dungeness crab megalopae using jelly scoop.
		10:00	**Lab.** Sort plankton and examine nauplius (copepod and barnacle) and cyprid larvae, decapod zoea larvae, megalopae, Cladoceran embryos (as available).
		13:00	**Lab.** Continue with crustacean plankton. Dissect and examine egg lamellae of gooseneck barnacle *Pollicipes polymerus.* Examine broods of caprellids and other amphipods, as available.
Week 9 Tue **May 29**	-1.29 10:25	8:00	**Quiz.** Crustacean development.
		8:15	**Lecture.** Development of cnidarians
		9:30	**Lab.** Look for eggs and embryos of hydrozoan medusae. Observe unilateral cleavage (if available). Observe advanced developmental stages (holoblastula, planula) from earlier spawnings of hydromedusae. Start *Nematostella* cultures.
		11:00	**Field trip to large boat basin docks** to collect hydromedusae (*Clytia gregaria, Stomotoca atra, Aquorea victoria, Polyorchis penicillatus*, as available), hydrozoan polyps (*Tubularia sp., Obelia sp.,* corynids*), Aurelia* scyphistomae, and plankton.
		13:00	**Lecture.** Development of ctenophores

Day	Tide	Time	Activities
		14:00	**Lab.** Set medusae in 1L beakers and watch for spawning at dusk. *Obelia* medusae (from plankton) and hydroids (look for gonozooids at the base of larger colonies). *Tubularia* - observe male and female gonophores, brooded and released actinula larvae. External brooding in anthozoan *Epiactis prolifera*. Observe budding medusae in corynid polyps (Coryne sp., Sarsia sp. or related species).
Week 10 **June 5**	-0.27 5:10	8:00	**Quiz.** Cnidarian and ctenophore development.
		8:15	**Lecture.** Development of ascidians.
		9:30	**Lab.** Start cultures of solitary ascidians (*Styela spp.*). Remove broods of *Molgula pugetiensis* and *Corella inflata*, and examine cleavage stages, tadpole larvae, metamorphosis (as available).
		13:00	**Lab.** Observe cleavage in *Styela*. Watch for released tadpoles from compound ascidian *Botrylloides* (as available).
		15:00	**Lab clean up**
Week 11 **June 12**		9:00	**FINAL EXAM**
			NOTEBOOKS DUE