BIOLOGY 664 SYLLABUS

COURSE: Biology 664, Development; summer, 2013

OBJECTIVES:

Developmental Biology is a course about how living organisms in all of their complexity come into being from two single gamete cells. Studying the emergence of life, from the point of fertilization through cell communication and cell/tissue differentiation, and coming to know it at quite a sophisticated level is an awe-inspiring privilege. The remarkable events that each must occur in perfect sequence so that we ourselves become functional human beings are extremely complex. It is no less than a miracle that we each began as a single fertilized cell. The main objective of this course is to study and understand the processes that take place to allow development from a molecular, genetics, and tissue level.

In addition, the knowledge of developmental events have become increasingly important in our understanding of the mechanism by which evolution can occur, particularly on a macroevolution scale. We will not be studying evolution in all its aspects (fossil record, phylogeny, etc.) as that will be reserved for a separate course (Evolutionary biology). However, we will take our knowledge of embryonic development and apply this to gain a better understanding of evolution. As part of this, we will be reading and discussing a wonderful book by a leading authority in Evo/Devo, "Endless Forms Most Beautiful", by Sean Carroll.

Learning Outcomes: Besides these ultimate objectives, will be able to:

- Perform experimental investigations and observations of various model organisms in development including the design and implementation of an independent, novel experiment.
- Understand and describe the specifics of fertilization, gene expression, cell signaling, and tissue differentiation, and how these events relate to our development from a single fertilized cell into a fully developed organism.
- Summarize the events that occur during development of higher level organs, including neuronal development, cardiovascular systems, and limb development.
- Relate the events that occur during development to the mechanisms of evolution
- Critically evaluate and present primary research literature identifying the research purpose, the important methodology, results and conclusions to an audience relatively knowledgeable in biology.

INSTRUCTORS: Dr. Mike Dorrell
Rohr Science 107, 619-849-2962, mdorrell@pointloma.edu

I am here to help you learn and excel. I am available by appointment, and you are free to ask questions via email. I will answer in as timely a manner as possible.

BOOKS:

1. **Text**: *Developmental Biology*. 9th Edition. Scott F. Gilbert, Sunderland MA: Sinaur Associates, 2006. ISBN: 978-0-87893-384-6
2. **Evo/Devo discussion book**: Endless Forms Most Beautiful, by Sean Carroll

GRADING:

Final exam	25%
Quizzes	10%
Scientific American Article summaries (~400 – 500 words)	10%
"Just In" Discussion Moderator Role	10%
Participant Role	4%
Student led learning	10%
Endless Forms Most Beautiful Moderator Role	10%
Participant Role	4%
Laboratory participation	5%
Teratogen experiment write-up	12%
Total	100%

ATTENDANCE:
This is an accelerated course and as such, attendance at lectures and lab sessions is required. Obviously things can happen that are out of anyone's control, but absences will only be accepted in extenuating circumstances. Wherever possible, these should be discussed with the professors in advance. In addition to attendance, you are expected to participate in class discussions. There are aspects of the course that are designed for you to lead discussion. For each of these, regardless of whether you are leading, you are expected to be prepared and ready to participate in the discussion. In addition, both professors lecture in a discussion style manner and thus you are expected to be prepared and willing to participate by volunteering to answer questions as we go and asking questions whenever you are confused. You should read ahead so that you can participate effectively and for your own benefit of learning.

***JUST OUT* (JOURNAL CLUB):**
A major aspect of keeping up to date with current scientific findings entails reading current primary literature and discussing the findings with colleagues. There will be 5 primary articles assigned throughout the three weeks. Most of these will be fairly recent (within the last few years), although a couple will be seminal articles in stem cell and developmental biology research from the last decade. We will be discussing these articles together in class. Each person will be assigned to a group of 2-3 that will be in charge of presenting the major findings of the article in a journal club / discussion style format. Each group will be assigned one article to lead. ***All students who are not presenting are expected to have read the article. A big part of this evaluation will be based on participation in the discussion, even when you are not assigned to present the article.***

STUDENT LED LEARING:
There will be 5 topics throughout the semester where the students will be presenting the topic. Some of these topics are background review that are important for the more advanced material that we will be studying that day, and other topics may be an introduction or basic part of a developmental topic we are covering. Students will be assigned to groups of 2-3 and each group will be assigned one topic. On your day of presentation, you are expected to bring material that teaches / presents the background to the other students. This may be in the form of a powerpoint lecture / discussion, class activities, etc. It should be set for ~45 minutes to 1 hour.

ENDLESS FORMS MOST BEAUTIFUL:
Along with the text, we will be reading a wonderful book that artfully presents the basic ideas of evolutionary developmental biology by one of the premier Evo/Devo scientists, Sean Carroll. This book does a wonderful job of tying together the major concepts of the course. We will be reading, and discussing this book throughout the course. As with the other two student-led discussions, each person will be assigned (within a group) one discussion to lead. This is expected to be a discussion with every member of the class, but the assigned group is expected to be ready with some prepared slides of the major concepts, and discussion questions to help keep the discussion focused and moving. You are expected to read the text even when you are not presenting in order to be able to participate in the discussions (a component of your grade). This supplementary reading will also help you understand the main aspects of the material.

LAB REPORTS:
Most of the laboratory activities are mainly to expose you to the methods and model systems by which developmental biology is studied. We hope that you will share in our awe at being able to observe embryogenesis with your own eyes. For some of the labs, you may be expected to turn in your observations and drawings, along with some answered questions regarding the labs. However, I realize that this is a very difficult and accelerated 3-week course so I will not be making you write lab reports except for the one self-designed lab. For this lab, you will identify a teratogen of choice (think about things that pregnant women are supposed to steer clear from, or look up common teratogens online, etc.) that you wish to study using the zebrafish development. You will design the experiment, including the appropriate controls, determine a physiologically relevant concentration of the teratogen, and implement the experiment to determine any affects of the teratogen on embryonic development. You are expected to write a full formal report for this one experiment (abstract, background, materials and methods, results, and discussion).

SCIENTIFIC AMERICAN ARTICLES:
We will be reading and discussing 3 relatively simple overviews that relate to particular developmental topics. These are designed give you an overview of what we are discussing, even while we are diving into some of the more intimate details. This may also be useful for you as you think about how to teach or present some of this material to your own students. You will be expected to write and turn in a short summary of each of these (~500 words) that 1) summarizes the article and its main points, 2) discusses how this fits into our understanding of development and / or evolution, and 3) a short reflection (one short paragraph) on your own thoughts of the topic having read the article. This last part can be in the form of several options such as … a brief summary of what you learned, what this made you consider, your thoughts on the evidence presented, and/or how you might use this to teach your own students.

QUIZZES / TAKE-HOME EXAMS:
There will be periodic quizzes throughout the course covering the assigned reading and the recent topics discussed in class. Quizzes are meant to help keep you on track and to ensure that you are understanding the material as we go. They should help you sort out that which you understand well from that which you still need to study more thoroughly. For all of these, you may use all available materials, but you may not consult with each other, unless otherwise instructed at the beginning of the quiz / exam.

FINAL EXAM:
The course will culminate in a final take-home final exam. My goal is to get this exam to you on the Wednesday of the last week of class allowing you to bring specific questions to us on Thursday (the last day of class). This exam will be open book and is intended to make you think about, connect, and integrate all the material that we have covered in the class. As an accelerated course, much of the material will fly by quickly and this will force you to revisit the material, think about it more thoroughly, and unify the different concepts discussed throughout the course. You are allowed to use any resources for this exam except each other. You may not work together or discuss the exam while you are taking it. You will have until Monday morning at 8:00 a.m. to finish the exam. Our goal in developing the exam will be develop questions that the typical student will be able to complete in 8 to 12 hours. Some will take a little longer to produce a product with which they are pleased, others may be able to accomplish the same task in less time, but that's the approximate time frame we will have in mind for the final exam.

COURSE SCHEDULE: ***Week 1:***

Purple = lab activity, Green = student led learning presentation, Blue = EFMB book discussion, Maroon = Journal club article, Black = class lecture / professor-led discussion

<table>
<tr><th>Week 1</th><th>Monday</th><th>Tuesday</th><th>Wednesday</th><th>Thursday</th></tr>
<tr><td>12:00 – 1:00</td><td></td><td></td><td></td><td></td></tr>
<tr><td>1:00 - 1:30</td><td rowspan="2">Introduction to the course and developmental biology; fundamental questions, evo/devo rap</td><td>Student led learning (group 1); fate mapping; Page 17 - 23.</td><td>Just out (Group 1); (Honeybee epigenetics; SCIENCE; VOL 319, 28 MARCH 2008</td><td rowspan="2">Ch. 3 Induction and competency</td></tr>
<tr><td>1:30 – 2:00</td><td rowspan="3">Anatomy of a gene; importance of enhancers.</td><td rowspan="2">Specification (pages 109 - 119)</td></tr>
<tr><td>2:00 – 2:30</td><td>History of developmental biology (text pp. 12 - 17)</td><td>Just Out (Group 2)- human induced pluripotent stem cells. Cell 131, 861–872, November 30, 2007</td></tr>
<tr><td>2:30 – 3:00</td><td rowspan="2">Set up chick embryonic development lab. Discuss teratogens / teratogen experiment</td><td rowspan="2">Zebrafish observations</td><td rowspan="3">axolotl development and retinoic acid lab (during incubation, go over ways to study development)</td><td>Observe chick embryos / discuss teratogen experiment</td></tr>
<tr><td>3:00 – 3:30</td><td rowspan="2">Ch. 3 continued; cell adhesion and cell communicatioin</td></tr>
<tr><td>3:30 - 4:00</td><td rowspan="3">Stages of development; Developmental genetics (pp 6 - 11). Intro to epigenetics and gene compaction (pp. 31 - 35)</td><td>Student led learning (group1 cont.) : Discussion of Sci. Am.</td></tr>
<tr><td>4:00 - 4:30</td><td rowspan="2">EFMB group 1; EFMB discussion on chapters 1 - 2;</td><td rowspan="2">EFMB Group 2; Chapters 3 - 4</td></tr>
<tr><td>4:30 - 5:00</td></tr>
<tr><td>5:00 – 5:30</td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="4">Reading for the next day:</td><td>EFMB; Chapters 1 - 2</td><td>Science article (on Eclass)</td><td>Cell Article on IPS cells</td><td rowspan="2">Nature article on Nanog and pluripotency</td></tr>
<tr><td>Text: Ch 1: Ch. 2 (pgs 30 - 52)</td><td>Text; Pgs 109 - 119</td><td>Text; Chapter 3 Pgs 69 - 84</td></tr>
<tr><td rowspan="2">Scientific American article (Developmental Switches)</td><td>axolotl lab</td><td>EFMB chapters 3 - 4</td><td>Text; Ch4, Ch. 5 Pgs 159 - 165</td></tr>
<tr><td>think about teratogen</td><td>think about teratogen</td><td>Quiz #1</td></tr>
<tr><td></td><td></td><td></td><td>Due: summary of Sci Am article</td><td></td></tr>
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Monday:
Main topics: Introduction to, and history of, evolutionary developmental biology. Stages of Development.
Lab activity: Chick embryonic development (begins),
Discussing the self-designed teratogen experiments
In-class student presentations / discussion leading: none
Readings for the next class:
Endless Forms most beautiful (EFMB), Chapters 1-2.
Developmental biology text, Ch. 1, Ch. 2, Pages 30 – 52
Scientific American Article #1 (Developmental Switches)

Tuesday:
Main topics: Anatomy of a gene; Importance of enhancers during Development
Lab activity: Zebrafish embryo observations / think about and discuss your teratogen ideas
In-class student presentations discussion leading:
1) Student led learning; Fate mapping & Scientific American article
2) EFMB discussion; Chapters 1 - 2
Readings for the next class:
Developmental biology text, Pages 109 - 119
Just Out article: *Science* **319**, "Nutritional control of reproductive status in honeybees via DNA methylation." (available through Eclass)
Axolotl lab (available on Eclass)

Wednesday:
Main topics: Epigenetics; Types of specification
Lab activity: axolotl development and the effects of retinoic acid,
In-class student presentations / discussion leading:
Just Out (journal club); Science article; [epigenetics]
Readings for the next class:
Endless Forms most beautiful (EFMB), Chapters 3 - 4.
Developmental biology text, Ch. 3 pages 69 – 84.
Just out article: Cell 139, "Human Induced Pluripotent Stem Cells"
Due: 400 – 500 word summary of the Scientific American Article: "Switches"

Thursday:
Main topics: Cell communication in development; Induction and Competency
Lab activity: Observe chick embryonic development
Finalize teratogen plans / experiment
In-class student presentations / discussion leading:
1) Just out article: Cell (human iPSCs)
2) EFMB discussion: Chapters 3 – 4
Readings for the next class:
Developmental biology text, Ch. 4, Chapter 5 pages 159 - 165
Just Out article: *Nature*. 2012 "Control of Ground-state Pluripotency by Allelic Regulation of Nanog." (available through Eclass)
Suggestion: Work on the introduction and materials / methods section for your teratogen experiment write-up over the weekend.

COURSE SCHEDULE: *Week 2:*

Purple = lab activity, Green = student led learning presentation, Blue = EFMB book discussion, Maroon = Journal club article, Black = class lecture / professor-led discussion

Week 2	Monday	Tuesday	Wednesday	Thursday
12:00 – 1:00	Change rearing solution		Change rearing solution	
1:00 - 1:30	**Student led learning (Group 2); Meiosis, egg, sperm, and fertilization specificity (Text pages 121 - 134)**	**Early mammalian development (Pgs 287 - 310)**	**Maternal effect genes / autonomous specification**	**Segmentation and Hox genes (Pgs 218 - 235)**
1:30 – 2:00				
2:00 – 2:30	**Prevention of polyspermy, sea urchins and mammalian fertilization similarities**			
2:30 – 3:00		**Teratogen experiment (apply mutagen)**	**Zebrafish de-chorionation. Sand Dollar fertilization lab**	
3:00 – 3:30	**Set up Zebrafish matings**			**Teratogen follow-up; part 1**
3:30 - 4:00	**Catch-up / Cleavage and gastrulation (Pgs 159 - 165)**			
4:00 - 4:30				**EFMB group 4: Chapters 7 - 8**
4:30 - 5:00	**Just Out (Group 3)- Control of Pluripotency by Nanog; Nature, 22 March 2012**	**EFMB group 3; EFMB discussion on Ch 5-6.**	**Student led learning (Group 3); Morphogens: early anterior - posterior patterning plans (Pgs 218 - 226)**	
5:00 – 5:30				**Wrap-up of drosophila development**
Reading for the next day:	EFMB; Chapters 5 - 6	Text; Pgs 203 - 217	EFMB Chapters 7 - 8	Nature article, wing spots
	Text: Ch. 8 (pgs 287 - 298, 300 - 310)		Text; Chapter 6	Text; Pgs 311 - 320, 333 - 348.
				Sci. American. Article; "What makes us human"

Monday:
Main topics: Fertilization; species specificity and prevention of polyspermy.
Early development events; cleavage and gastrulation.
Lab activity: Set up zebrafish matings for teratogen experiment
Continue observations of chick embryos
In-class student presentations / discussion leading:
1) Student led learning on meiosis, sperm, egg, and species specificity
2) Just Out (journal club article); Nature 2012; [Nanog control of pluripotency]
Readings for the next class:
EFMB Chapters 5-6.
Developmental biology text, Ch. 8 pages 287 – 298, 300 - 310

Tuesday:
Main topics: Early mammalian development
Lab activity: Perform teratogen experiment
Continue observations of chick embryos
In-class student presentations discussion leading:
1) EFMB chapters 5 - 6
Readings for the next class:
Developmental biology text, Ch. 6 pages 203 - 217

Suggestion: Work on your teratogen lab write-up. You should be able to complete the introduction and materials / methods section.

Wednesday:
Main topics: Maternal effect genes: What they are, and localization in the unfertilized egg
Drosophila development
Lab activity: de-chorionation of zebrafish for teratogen lab
Sand Dollar fertilization
In-class student presentations / discussion leading:
1) Student led learn: morphogens and early dev. of the anterior –posterior axis in drosophila.
Readings for the next class:
Endless Forms most beautiful (EFMB), Chapters 7 - 8.
Developmental biology text, Ch. 6

Thursday:
Main topics: Development in Drosophila, Axis patterning, segmentation, and homeotic genes
Lab activity: Teratogen experiment follow-up
Continue observations of chick embryos
In-class student presentations / discussion leading:
2) EFMB discussion: Chapters 7 - 8
Readings for the next class:
1) Developmental biology text, Ch. 8 pages 311 – 320, Ch 9 pages 333 - 348
2) Just Out article: Nature: 464:1143; "Morphogenetic gradients and speciation", by Sean Carroll (available through Eclass)
3) Scientific American Article: "What Makes Us Human"
Suggestion: Work on your teratogen lab write-up. Determine what your results mean, how they can be best represented, and write a draft of the results and discussion sections.

COURSE SCHEDULE: *Week 3:*

Purple = lab activity, Green = student led learning presentation, Blue = EFMB book discussion, Maroon = Journal club article, Black = class lecture / professor-led discussion

Week 3	Monday	Tuesday	Wednesday	Thursday
12:00 – 1:00	Change rearing solution		Start wash on retinas.	
1:00 - 1:30	**Mammalian axis formation (Pgs 311 - 320)**	**Neural Crest; (Pgs 373 - 385)**	Just Out (Group 5)- GABA role in determining motor neuron numbers; PLoS One, Feb 2013	**Discussion on Sci. American article "Limb bud formation"**
1:30 – 2:00				**Limb bud formation (Pg 488 - 501)**
2:00 – 2:30	Just Out (Group 4)- Modes of Specification / Wing spots; Nature, April 2010		**Heart development (Pgs 445 - 454)**	
2:30 – 3:00		**Retina dissection and axolotl follow-up. (discuss the morphogenic reasons for cylops)**		**NOVA video on Evo / Devo; "What Darwin Never Knew"**
3:00 – 3:30	**teratogen follow-up; Part 2**		Student led learning (Group 5); Blood vessel growth and development (Pgs 455 - 463)	
3:30 - 4:00	Student led learning (group 4): Formation of the neural tube (Ch. 9 Pgs 333 - 343)			
4:00 - 4:30			**Retina mounting and imaging**	
4:30 - 5:00	**Follow-up on brain patterning / discussion of "What makes us human"**	**EFMB group 5; EFMB discussion on chapters 9-10.**		**Course wrap-up (EFMB Ch. 11)**
5:00 – 5:30				
Reading for the next day:	EFMB chapters 9 - 10	PLoS One article: GABA neurons	Sci. American. Article;	
	Text: Ch. 10 (pgs 373 - 385)	Text; Pgs. 445 - 454, 488 - 501	"Limb bud formation"	
			Watch first 45 minutes of	
			"What Darwin Never Knew"	
	Due: summary of Sci Am article		**DUE: Teratogen lab write-up**	

Monday:
Main topics: Mammalian axis formation. Neuronal development.
Lab activity: Examining hominid skulls
Teratogen follow-up
Continue observations of chick embryos
In-class student presentations / discussion leading:
1) Just Out (journal club article); Nature: 464:1143; [Drosophila wing spots]
2) Student led learning; Formation of the neural tube.
Readings for the next class:
Developmental biology text, Ch. 10; Pg 373 – 385
Endless Forms most beautiful (EFMB), Chapters 9 - 10.
Due: Summary of Scientific American Article: "What Makes Us Human"

Tuesday:
Main topics: Neural Crest.
Lab activity: Retina dissection and staining
Axolotl- retinoic acid mutagen follow-up (measurements)
Continue observations of chick embryos
In-class student presentations discussion leading:
1) Student Led Learning; "What makes us human" Scientific American article
2) EFMB discussion: Chapters 9 – 10
Readings for the next class:
Developmental biology text, Ch. 23
Just Out article: PLoS One Article: GABA neurons.

Wednesday: ***TERATOGEN LAB WRITE-UP DUE***,

Main topics: Cardiovascular system development
Lab activity: Retina mounting and imaging
In-class student presentations / discussion leading:
1) Just Out article (Journal Club); *Dev. Cell*; [developmental perspective]
2) Student led learning: Blood vessel development.
Readings for the next class:
Scientific American Article: "How Limbs Develop"
EFMB Chapter 11
Watch the first 45 minutes of "What Darwin Never Knew" (linked on Eclass)

BEGIN TAKE-HOME FINAL EXAM, Come with questions for tomorrow.

Thursday:
Main topics: Developmental mechanisms of evolutionary change / Course wrap-up
- play with Legos and create drawings
In-class student presentations / discussion leading: none
Readings for the next class:
CONGRATULATIONS, YOU ARE ALL DONE (EXCEPT FOR THE FINAL ☺. We hope you have learned a lot and have enjoyed the course!