BIOLOGY 6064: Developmental Biology / Evo - Devo

COURSE: Biology 6064. Biology Graduate course (3 units)

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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.

COURSE DESCRIPTION: Concepts emerging from the union of the two disciplines of evolution and development that help us better understand both the process of development and of the diversity of life forms are central to this course. Emphasis will be placed on the concepts of modularity, developmental master control genes (toolkit genes) and genetic switches that are the keys to explaining how the diversity within the body plans of animals develop. These topics will be addressed from the perspective of teaching for conceptual understanding.

COURSE OBJECTIVES:

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 are 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 the emerging field of Evo - Devo.

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

- Prepare lab reports demonstrating in-depth observations and analysis of the process of development after performing experiments using various model organisms.
- 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. [PLO #1]
- Summarize the events that occur during development of higher level organs, including neuronal development, cardiovascular systems, and limb development. [PLO #1]
- Design and conduct an independent investigation testing the effects of a teratogen on development using a model organism. [PLO #1]
- Critically evaluate and present primary research literature identifying the research purpose, the important methodology, results and conclusions to an audience relatively knowledgeable in biology.
- Articulate and defend a position on how ‘endless forms most beautiful’ have evolved from a basis of understanding of the importance of development, developmental switches, and genetic mutations (Evo/Devo). [PLO #3]

REQUIRED AND RECOMMENDED BOOKS:

1. **Lab Manual (<u>required</u>):** *Reader from University Reader*
2. **Related text (<u>required</u>);** *Endless Forms Most Beautiful.* Sean B. Carroll. Norton Pub.
3. **Text (required)**: *Developmental Biology*. 12th Edition. Scott F. Gilbert. Sinaur Associates, 2020. ISBN: 9781605358222. **(the course follows this text closely so this is a great resource for learning and studying. I recommend renting unless you want to go into Developmental Biology in which case this is a great resource to own and keep)**

PLNU MISSION: To Teach ~ To Shape ~ To Send

Point Loma Nazarene University exists to provide higher education in a vital Christian community where minds are engaged and challenged, character is modeled and formed, and service becomes an expression of faith. Being of Wesleyan heritage, we aspire to be a learning community where grace is foundational, truth is pursued, and holiness is a way of life.

Major projects and assignments:

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. We will be discussing these articles together. Each person will be assigned one article to present in groups of 3 – 4. This group will be in charge of presenting the major findings of the article in a journal club style format on the assigned week. How you divide the material within your group is up to you. You will be evaluating the other members of your group for participation and their input. I will be evaluating the group on your understanding and presentation of the material. **All students who are not presenting are expected to have read the article.** A significant portion of this evaluation will be based on participation in the discussion, questions asked, etc., even when you are not presenting.

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 journal club (primary literature article), 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 briefly review the major concepts covered in those chapters (~20 minutes), and have prepared 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 discussion (a graded component). This supplementary reading will also help you understand the main aspects of the material.

REFLECTION ON EVOLUTION AND DEVELOPMENT

Over the course of the semester, we will be relating development to the mechanisms of evolution. During this time, we will also discuss the theological implications of these topics. As part of this section, we will be reading the book "Endless Forms Most Beautiful" ('*EFMB*'), by Sean Carroll. This is an excellent book which I feel ties together the concepts of developmental biology and does a great job of relating them to our current understanding of evolution. As part of this section, you will be expected to write a ~2500 word reflection of development and evolution that incorporates aspects of

your learned knowledge of developmental biology, our reading of EFMB, and our discussions throughout the course. These discussions are designed to present the evidence from developmental biology in support of evolution, and to discuss how science and religion can tie together rather than conflict, they are not designed to force any particular stance on this topic. Your stance can shine through in this reflection, regardless of what your viewpoint may be (in fact, I encourage that), as long as your ideas are clearly stated and supported, and a clear understanding of what we've learned in developmental biology is apparent.

BRIEF SUMMARIES OF SCIENTIFIC AMERICAN AND NAUTILUS ARTICLES

Periodically throughout the semester, I will be distributing some relatively simple overviews that relate to particular topics (6 total are planned). These are designed give you an overview of what we are discussing, even while we are diving into some of the more intimate details. They are also designed to give you some extra historical background information, or make you think about the context of the information we are learning as it applies to human life and our beliefs. You will be expected to write and turn in a short summary of each of these (~500 words) that summarizes the article, its main points, and how it fits into our topics.

LAB

We will be performing multiple lab experiments during class, using various model organisms to observe normal development, and to test the effects of teratogens on development. For each of the smaller labs, you will be required to write a specific portion of a lab report to practice and get feedback on those parts. You will then be designing, implementing, and analyzing your own "self-designed" teratogen experiment, which will culminate in writing one full lab report implementing everything you've learned.

EVALUATION AND GRADING

Summary: The activities described above will contribute to your total course grade based on the following percentages (these are subject to change slightly):

Exams I, II, III, and final exam (given with exam 3)	50%
Lab work and lab reports	10%
Journal club presentation / participation in discussion	10%
Reflection on *EFMB* evo / devo	13 %
Leading EFMB reflection discussion	5%
Scientific American and Nautilus article summaries (homework)	7 %
class participation / asynchronous work activities	5 %
Total	**100%**

A = 93-100	B- = 80-83	D+ = 67-70
A- = 90-93	C+ = 77-80	D = 63-67
B+ = 87-90	C = 73-77	D- = 60-63
B = 83-87	C- = 70-73	F = 0 - 60

Policies

ATTENDANCE AND PARTICIPATION:

We are only meeting once a week, for 3 hours each. 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 students 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, I 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 or curious. **You should read ahead so that you can participate effectively and for your own benefit of learning.**

FERPA POLICY

In compliance with federal law, neither PLNU student ID nor social security number should be used in publicly posted grades or returned sets of assignments without student written permission. This class will meet the federal requirements by (Note: each faculty member should choose one strategy to use: distributing all grades and papers individually; requesting and filing written student permission; or assigning each student a unique class ID number not identifiable on the alphabetic roster.). Also in compliance with FERPA, you will be the only person given information about your progress in this class unless you have designated others to receive it in the "Information Release" section of the student portal. See Policy Statements in the (undergrad/ graduate as appropriate) academic catalog.

Tentative Schedule:

Week	Date	Topic	Textbook Ref.
Week 1 (1-13)	**Hr 1**	Intro to Dev Bio;	Chapter 1 (Pgs. 1 – 30)
	Hr 2	Chick embryo development (lab)	
	Hr 3	Questions of Dev. Bio, History, Stages of Development, and Fate Mapping	
	On own	***Asynchronous:*** Genetic equivalence, induced pluripotent stem cells, and DNA compaction ***Reading:*** Scientific American Article 1: Developmental Switches, ***Lab prep:*** Axolotl development and the effects of retinoic acid or cyclopamine	Ch. 3 (pg 55 – 60, 67-68, 70 – 72) Ch. 5 (pg 170 – 176)
Week 2 (1-20)	**Hr 1**	***Lab:*** adding teratogens to axolotls ***Class work:*** Differential gene expression (cont.)	Chapter 3 (all except 69, 76-77,
	Hr 2	***Class work:*** Differential gene expression (cont.) Discuss Sci. American Article #1	
	Hr 3	***Lab: Washing teratogens / Chick observations***	
	On own	***Asynchronous:*** Cell – Cell communication (juxtacrine and paracrine signaling) ***Reading:*** **Primary literature article 1**: Science article on epigenetics and honeybees	Ch. 4 (pg 99- 108, 114 – 128)
Week 3 (1-27)	**Hr 1**	***Class work:*** Article 1 presentation. Cell communication- induction and competency.	Chapter 4 (Pgs 108 – 115, 137-141)
	Hr 2	***Lab:*** Analysis of axolotl teratogen effects.	
	Hr 3	***Class work:*** Signaling cascades and juxtacrine inhibition	
	On own	***Asynchronous:*** Specification ***Reading:*** Endless Forms Most Beautiful (Intro and Chapters 1 – 3) and Nautilus article #1: inherited epigenetics (500 word summary due before class)	Ch. 2 (39 – 46, 48 – 50)
Week 4 (2-3)	**Hr 1**	***Class work:*** Cell-cell communication in development (cont.)	Chapter 4 (Pgs 108 – 115, 137-141)
	Hr 2	***Lab:*** Lab techniques lecture / activity	
	Hr 3	***Class work:*** **Endless Forms Most Beautiful presentation and discussion** (Intro – Ch. 3)	
	On own	***Study for exam 1.***	
Week 5 (2-10)	**Hr 1**	Exam 1 (covers Chapters 1 – 4): 2 hours	
	Hr 2		
	Hr 3	***Class work:*** Early development; autonomous specification in snails, C-elegans, and tunicates	Ch. 8 (251 – 254, 260 – 266). Ch. 10 (318-322)
	On own	***Asynchronous:*** Fertilization part 1 ***Reading:*** Primary Lit #2; iPS cells and SMA	Chapter 7 (Pgs. 213 – 224)

		Lab: Results and discussion for axolotl lab	
Week 6 (2-17)	**Hr 1**	***Class work:*** Prevention of polyspermy	Chapter 7 (Pgs. 225 - 240)
	Hr 2	***Lab:*** Sand dollar fertilization lab	
	Hr 3	***Class work:*** **Presentation and discussion of primary literature article 2** (iPS cells and SMA)	
	On own	***Asynchronous:*** Early development; Sea Urchins ***Reading:*** Nautilus article on Sex and gender (500 word summary) **Lab:** Writeup of introduction and methods for fertilization lab	Ch. 10 (303 – 317)
Week 7 (2-24)	**Hr 1**	***Class work:*** Drosophila development	Chapter 9
	Hr 2	***Lab:*** Zebrafish observations and self-designed teratogen experiment (physiologically relevant concentration).	
	Hr 3	***Class work:*** Drosophila development (cont.)	Chapter 9
	On own	***Asynchronous:*** Early development in zebrafish ***Reading:*** Primary literature article 3… Generation of Novel wing pattern by wingless	Ch. 10 (303 – 317)
Week 8 (3-3)	**Hr 1**	***Class work:*** Drosophila development (cont.)	Chapter 9
	Hr 2	***Primary literature #3 presentation --- wingless***	
	Hr 3	***Class work:*** Drosophila development (cont.)	Chapter 9
	On own	***Asynchronous:*** Early development in birds and early mammalian development ***Reading:*** Endless Forms Most Beautiful (Ch 4 – 8)	Ch. 12 (pgs. 369 – 385, 394 - 396)
March 10		**No Class (Spring break)**	
Week 9 (3-17)	**Hr 1**	***catch-up / review (Ch. 7 – 11) and EFMB presentation and discussion. Ch. 4 – 8***	
	Hr 2	***Dry lab:*** CRISPR – Cas 9 lab	
	Hr 3	***Class work:*** Early development in mammals	Ch. 12 (385 – 390)
	3-18	***Study for exam 2.*** ***Reading:*** Nautilus Article #3 (zebrafish organizer) + 500 word summary	
Week 10 (3-24)	**Hr 1**	Exam 2 (Chapters 7 – 11); 1 ½ - 2 hours	
	Hr 2		
	Hr 3	***Class work:*** Early development in mammals	Chapter 12 (pgs. 390 – 398)
	On own	***Asynchronous:*** Ectoderm. Neurulation / brain growth ***Reading;*** Primary literature article #4—Nanog and ground state pluripotency	Ch. 13 (pgs 401 – 414)

Week 11 (3-31	**Hr 1**	***Class work:*** Ectoderm; Neural tube development	Ch. 13 and Ch. 14 (pgs 414 - 433)
	Hr 2	**Primary literature article #4 presentation and discussion; Nanog and ground state pluripotency**	Ch. 13 and Ch. 14 (pgs 414 - 433)
	Hr 3	***Class work:*** Ectoderm; CNS dev. cont.: The human brain	Chapter 14 (pgs 434 – 440)
	On own	***Asynchronous*:** Creativity and cooperation: roles in human evolution ***Reading:*** Scientific American Article; "What makes us human" + 500 word summary	
Week 12 (4-7)	**Hr 1**	***Class work:*** Neural Crest	Ch. 15 (441–447)
	Hr 2	***Lab:*** Make serial dilutions of teratogen for self-designed experiment	
	Hr 3	***Class work:*** Neural Crest	Chapter 15 (Pgs. 457 – 464)
	On own	***Asynchronous:*** Neural Crest – part 3 ***Reading:*** Endless Forms Most Beautiful (Ch. 9 – 11)	
Week 13 (4-14)	**4-14**	**No Class; Easter Break**	
	On Own	**Be working on Evo-Devo reflection papers Watch "What Darwin Never Knew" and complete short summary of video. - play with legos and take a picture of what you made.**	
Week 14 (4-21)	**Hr 1**	***Lab:*** Add teratogens to self-designed experiment	
	Hr 2	**Class work: Endless Forms Most Beautiful (Ch. 9 – 11) presentation and discussion / discussion of "What Darwin Never Knew".**	
	Hr 3	***Lab:*** Wash off teratogens for self-designed experiment	
	On own	***Asynchronous:*** Heart & blood vessel development ***Writing:*** Introduction and methods for Self-designed teratogen lab report	Ch. 18 (550 – 562)
Week 15 (4-28)	**Hr 1**	***Class work:*** Tetrapod limbs ***(Due: EFMB reflection paper – April 27th)***	Chapter 19 (pgs. 574 – 596)
	Hr 2	***Lab:*** Analyzing your data (teratogen exp.)	Chapter 19 (pgs. 574 – 596)
	Hr 3	***Class work:*** Tetrapod limbs part 2	
	On own	***Asynchronous (short):*** Making tetrapod limbs ***lab:*** *Self-designed teratogen lab report*	Chapter 19 (pgs, 600 – 604)
Week 16 (Final exam)		***Due: Self-designed teratogen lab report***	
		Final exam (Ch. 12 – 15, 18, 19) and cumulative	