University of Wisconsin-Madison
Zoology 470 ~ Introduction to Animal Development
Spring 2018
3 credits
URL

Course Designations & Attributes
Level - Intermediate
Breadth - Biological Sciences, counts toward the Natural Sciences requirement
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Counts toward 50% graduate coursework requirement
Honors Optional

Meeting Time & Location
MWF, 1:20-2:10 pm, 168 Noland Hall
Optional discussion section: TBD, 342 Noland Hall

Instructional Mode
All face-to-face

Credit Hours
This class meets for three 50-minute class periods each week over the semester and carries the expectation that students will work on course learning activities (reading, writing, problem sets, studying, etc) for about 2 hours out of classroom for every class period. The syllabus includes additional information about meeting times and expectations for student work.

Instructor
Jeff Hardin, Professor and Chair, Department of Integrative Biology
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Office Hours: Tu 2:30-4 pm, Th 4:30-5:30 pm, 145 Noland Hall, or by appointment

Teaching Assistant
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Endocrinology and Reproductive Physiology Program
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Office Hours: by appointment

Course Description
This course introduces students to the major features and mechanisms of early embryonic development in animals, including (1) the major stages of early development, (2) how form arises in the embryo (morphogenesis), (3) how differences arise between cells in the embryo, and (4) how specific genes control these processes.

Prerequisites & Recommendations

Because there are few course offerings in biology at the intermediate level, **the only official prerequisite for this course is an introductory course in animal biology (Zoo 101/Botany 130, Bio 151/152, or the Biocore curriculum).** However, ***experience has shown that if the only course you have had is Zoo 101 or Bio 151, you must make sure that you have mastered the concepts covered in that course***. In particular, ***the basic concepts of the "central dogma" (how DNA encodes proteins) and the basic concepts of cell structure and function must be well understood for this course to make sense.*** If you're unsure about your preparation, please schedule an appointment with us now to get guidance about how to bolster your preparation. An "Intro Bio Jump Start", with a list of suggested reinforcement readings, keyed to Campbell and Reece, *Biology*, 10 and 11e (Pearson), is on the course web site for those who need a refresher. In addition, there are several excellent introductory biology websites with synopses of key ideas that are helpful for this course.

Course Learning Outcomes

Zoo 470 is designed to provide an overview of the major features of early embryonic development in animals, and the mechanisms that underlie them. Detailed, specific learning objectives will be listed for each topical subdivision of this course prior to each lecture/topic. These learning objectives are a crucial study aid for successful students; they have been constructed by "reverse design" from assessments, especially exams. Through mastery of these detailed learning objectives, by the end of this course students should achieve several key learning outcomes:

(1) Explain and use key concepts in developmental biology. By the end of this course, students will be able to define key concepts in developmental biology, including differentiation, morphogenesis, pattern formation, induction, genomic equivalence, the stem cell concept, etc., and use these key concepts to analyze novel examples of embryonic development.

(2) Explain how developmental biologists study embryos, and devise experiments to study developmental processes. Students should be able to explain classical, modern molecular, and cellular techniques that developmental biologists use to study embryonic development, and should be able to use these tools to study novel developmental problems.

(3) Explain how gene expression, regulated by cell signaling and localized molecules, controls development. Students should be able to explain how gene expression is regulated at multiple levels, including transcription, translation, and post-translational modification, and how the regulation of specific genes influences the ways in which parts of the embryo become different, using specific examples. Students should be able to analyze novel examples of regulated gene expression in developmental contexts.

(4) Explain the steps by which an animal embryo arises from a fertilized egg. Students should be able to explain the cellular and molecular mechanisms of key developmental events in animal embryos, including how gametes arise (gametogenesis), fertilization and egg activation, cleavage (early embryonic cell division), and gastrulation (how the basic body plan arises due to dramatic cell movements).

(5) Explain the cellular mechanisms underlying morphogenesis ("body building"). Students should be able to classify morphogenetic events and explain at a basic level how such events occur at the cellular level

(6) Explain how axis specification is regulated, using specific examples. Students should be able to explain the basic events of embryonic axis specification in select model organisms, including nematodes, fruit flies, echinoderms, amphibians, and mammals.

(7) Explain how organ rudiments arise in vertebrates. Students should be able to explain how key organ systems arise in vertebrates, including the basic formation of the central nervous system, axial and other mesoderm, endoderm, neural crest, and limbs.
(8) Explain the importance of modern developmental biology to society. Although this is a science course, the science we will study has many implications for society. Students should be able to articulate why modern developmental biology contribute to knotty ethical knotty problems when applied to humans, including stem cell, preimplantation diagnosis, and gene editing.

Required Materials

Text: S. Gilbert and S. Barresi, *Developmental Biology*, 11th ed. Sinauer and Associates, 2016
Also acceptable: Gilbert, *Developmental Biology*, 10th ed.
We will seek to place copies on reserve at Steenbock and College Libraries.

Additional Required Materials: Lecture handouts and additional readings will be available online, and will be announced in class and via email.

Schedule of Lectures/Readings

Because developmental biology is a field that is undergoing so much change, be prepared for some flexibility! The daily topics and associated readings are a guide to your study, but we may stop for breaking news when appropriate. This makes developmental biology an exciting field, because we are in a period in which a lot of the "stories" are getting written. In addition, there will be additional readings that touch on the ethical and newsworthy aspects of developmental biology. We'll remind you where you should be in the readings each week, and we'll provide text readings to accompany the various sections of your reading packet. **A detailed list of readings is at the end of this handout. Important study tip:** *When there is a difference in the level of detail of coverage for a particular unit, you should always use the level of presentation in lecture as your guide.* Sometimes the text will be less detailed than lecture; in other cases, it will be more detailed.

Course materials: Zoo 470 course materials are available via Learn@UW.

Readings: Assigned readings will often reinforce lecture material. In other cases, they will supplement your text in specific areas (such as the intersection of developmental biology and ethics, or to provide more information on a technique or biological process). **In some cases, you will be directly responsible for readings not covered in lecture. *You will always be told when this is going to happen*.** Additional handouts will supplement your texts, and will be available on the course website.

Assignments (ugh!)

Non-graded activities to aid student learning: We will be doing some interactive problem-solving exercises in class. Although these will not be graded, these are designed to aid your learning, and for us to assess how you are mastering key concepts prior to exams. Some of these exercises may involve actual exam questions from previous years. These will often occur on Wednesdays when there is no quiz.

Exams: There will be 3 (**three) exams**; each carries equal weight. The third exam is during the final exam period; it will be largely non-cumulative, but may contain a few integrative questions that do not require detailed knowledge of material in prior units. Review sessions, **including my wife's brownies**, will be held before each exam (times to be announced), and review guides will be handed out prior to each

exam to help you organize your study time (these will also be posted on the course web site). In order to allow more time for those who need it, exams will be scheduled in the evenings on the dates listed. Exam times and room locations will be announced well prior to each exam, and will depend on available lecture hall space, but will always be in the evening. **Exams in Zoo 470 are not multiple-choice exams**; they contain a mixture of short answer, true/false, and matching. The exams strike a balance between factual knowledge and the ability to analyze experiments. **Your best preparation for the exams is to download and digest the previous exams posted on the course web site.**

If you know you have an exam conflict, or if you need extra time due to documented learning differences via the McBurney Center, see Dr. Hardin well in advance to arrange for an alternate exam time.

Quizzes

There will be 6 machine-graded quizzes, typically on Wednesdays, designed to assess your understanding of basic facts regarding several areas: (1) molecular biology techniques; (2) molecular signaling pathways; (3) cleavage patterns; (4) morphogenetic movements; (5) basics of anterior-posterior axis patterning in flies; (6) basics of gastrulation in frogs. These are designed to make sure that you are conversant with key ideas in these areas.

Problem Sets: You will be assigned **three** take-home problem sets during the course of the semester, typically due on Mondays. Problem sets are due at the end of class on the dates listed. Problem sets will be distributed approximately one week before they are due. **Problem sets are designed to be answered in 1-2 handwritten pages.**

Ethics position paper and discussions: There will be opportunities for in-class discussions of ethics material in this class. **Attendance at the main ethics discussion will be logged and will be used as participation points for final grade assignments**. If you know you will miss this session for a valid reason, contact us. **In addition, there will be a one-page graded assignment on bioethics.** The position paper is designed to stimulate you to think about ethical issues in developmental biology, but should not require a great deal of time to complete.

Total points:

Exams (60%)+ Problem sets (15%) + quizzes (20%) + ethics participation (1%) + ethics position paper (4%) = 100%

Grading policy: **This course is graded on a scale, NOT a curve**; the following scale guarantees certain whole-letter grades, but we reserve the right to adjust grade cutoffs to benefit students when necessary, depending on overall class performance. You may find the following useful as a guide:

A: 100-90% B: 80-89% C: 70-79% D: 60-69% F: below 60%

Note that these are minimum targets; if there is any adjustment, it will always benefit you. The mean in this course is typically a low “B”.

Study Aids

Optional discussion section: This year, we will again be holding a weekly optional discussion section, where you can come to have questions answered, discuss topics of interest to the course, and to interact with other students who have questions like you. **The optional discussion section will meet in Noland Hall, room and time TBA.**

Computer tutorials: Several award-winning interactive multimedia modules are available on the course web site as a reinforcement for lecture material. There are links from the main course page to these tutorials. We will announce when you should be perusing these materials.

Academic Policies

ACADEMIC INTEGRITY

By enrolling in this course, each student assumes the responsibilities of an active participant in UW-Madison's community of scholars in which everyone's academic work and behavior are held to the highest academic integrity standards. Academic misconduct compromises the integrity of the university. Cheating, fabrication, plagiarism, unauthorized collaboration, and helping others commit these acts are examples of academic misconduct, which can result in disciplinary action. This includes but is not limited to failure on the assignment/course, disciplinary probation, or suspension. Substantial or repeated cases of misconduct will be forwarded to the Office of Student Conduct & Community Standards for additional review. For more information, refer to https://conduct.students.wisc.edu/academic-integrity/

ACCOMMODATIONS FOR STUDENTS WITH DISABILITIES

McBurney Disability Resource Center syllabus statement: "The University of Wisconsin-Madison supports the right of all enrolled students to a full and equal educational opportunity. The Americans with Disabilities Act (ADA), Wisconsin State Statute (36.12), and UW-Madison policy (Faculty Document 1071) require that students with disabilities be reasonably accommodated in instruction and campus life. Reasonable accommodations for students with disabilities is a shared faculty and student responsibility. Students are expected to inform faculty [me] of their need for instructional accommodations by the end of the third week of the semester, or as soon as possible after a disability has been incurred or recognized. I will work either directly with the student [you] or in coordination with the McBurney Center to identify and provide reasonable instructional accommodations. Disability information, including instructional accommodations as part of a student's educational record, is confidential and protected under FERPA." http://mcburney.wisc.edu/facstaffother/faculty/syllabus.php

DIVERSITY & INCLUSION

Institutional statement on diversity: "Diversity is a source of strength, creativity, and innovation for UW-Madison. We value the contributions of each person and respect the profound ways their identity, culture, background, experience, status, abilities, and opinion enrich the university community. We commit ourselves to the pursuit of excellence in teaching, research, outreach, and diversity as inextricably linked goals. The University of Wisconsin-Madison fulfills its public mission by creating a welcoming and inclusive community for people from every background - people who as students, faculty, and staff serve Wisconsin and the world." (https://diversity.wisc.edu/)

Zoology 470 – 2018
Lecture Schedule & Reading Assignments

Note: Chapter references are from **Gilbert, 10e or Gilbert & Barresi, 11e.** Please omit *Sidelights & Speculations* (S&S) sections unless instructed otherwise. "Supplementary Readings" are available via Learn@UW.

Introduction: The Nature and Tools of Developmental Biology

Lecture	Date	Lecture Topic	Readings 10e	Readings 11e
1	1/24	Introduction	Ch. 1, pp. 1-11, 12-16; P2, pp. 107-116	Ch. 1, pp. 1-11, 17-22; Ch. 2, 29-38
2	1/26	Intro (cont); genomic equivalence	Ch. 2, pp. 31-35; 49-51	Ch. 3, pp. 45-52
3	1/29	Genomic equivalence (cont)	Supplemental readings part 1	Supplemental readings part 1
4	1/31	Human cloning; intro to stem cells	Ch. 8, pp. 298-303 (skip S&S, p. 300); P3, pp. 319-322; 327-330; Ch. 16, pp. 598-600	Ch. 12, pp. 391-393, 395-396, Ch. 5, 143-146, 167-177
5	2/2	Human ES cells (cont)	Supplemental readings part 2	Supplemental readings part 2
6	2/5	Intro to mol. bio. techniques	Supplementary handout/podcast on molecular biology	Supplementary handout/podcast on molecular biology
7	2/7	Intro to cell biology	Ch. 3, pp. 69-79, 84-86, 88-93	Ch. 4, pp. 95-102, 104-108
8	2/9	Cell biology (cont)	Ch. 3, pp. 99-102	Ch. 4, 115-130

Preparing to Make a Body: From Egg to Zygote

9	2/12	Gametogenesis; **Quiz 1: Molecular Biology Techniques**	Ch. 1, pp. 10-11 (meiosis review), Ch. 17, pp. 610-612; 616-623; Ch. 4, pp. 117-123	Ch. 6, 205-212
10	2/14	Gametogenesis (cont); Fertilization	Ch. 4, pp. 123-129; DD: sea urchin fertilization	Ch. 7, 218-223
11	2/16	Fertilization (cont)	Ch. 4, 143-146	Ch. 7, 223-233, 239-247
12	2/19	Egg activation; **Quiz 2: Cellular Signaling Pathways**	Ch. 4, pp. 130-140; DD: sea urchin materials on egg activation	Ch. 7, 233-239
13	2/21	Egg activation (cont);	Ch. 4, pp. 146-147	Ch. 7, 247-248
14	2/23	Cleavage; **Problem set #1 due**	Ch. 5, pp. 153-158, 161-163; 179-182; Ch. 7, pp. 217-219; 242-244; 273-275; 286-287 DD materials	Ch. 1, pp. 11-13; Ch. 8, pp. 255-258; Ch. 10, pp. 312-]314; 326-327; Ch. 11, pp. 335-337; 368-369; Ch. 12 , pp. 381-382; 391-393 DD materials

Prelude to Axis Specification – Regulation of Gene Expression

15	2/26	Intro to gene expression; Transcriptional regulation	Ch. 2, pp. 36-39; 40-47, (+ *S&S on p. 46*)	Ch. 3, pp. 45-47; 50-66

Review session: Tuesday, February 27, 4:30-6 pm, TBA
Exam 1: Wednesday, February 28, 7:15-8:45 pm, TBA

16	2/28	Non-transcriptional regulation;	Ch. 2, pp. 51-65	Ch. 3. Pp. 69-85
17	3/2	Sex determination **Quiz 3: Cleavage patterns**	Ch. 14, pp. 519-532	Ch. 6, pp. 181-197
18	3/5	Sex determination; Germ plasm	Ch. 16, pp. 591-605	Ch. 6, pp. 202-205, Ch. 8, p. 267;
19	3/7	Germ plasm (cont.); Intro to morphogenesis	Ch. 5, pp. 158-161	Ch. 1, pp. 13

From Egg to Embryo - Axis Specification in Selected Animals

20	3/9	Blastomere specification and gastrulation in *C. elegans*	Ch. 5, pp. 170-177; *C. elegans* cheat sheet	Ch. 8, pp. 265-273; *C. elegans* cheat sheet
21	3/12	*C. elegans* (cont); *Drosophila* anterior-posterior axis (intro)	Ch. 6, pp. 179-186;	Ch. 9, pp. 277-288
22	3/14	Anterior-posterior patterning in *Drosophila*: maternal genes; **Quiz 4: Morphogenetic movements**	Ch. 6, pp. 194-204	Ch. 9, pp. 289-293
23	3/16	*Drosophila*: segmentation;	Ch. 6, pp. 204-213	Ch. 9, pp. 294-303
24	3/19	Sea urchin patterning/gastrulation; **Problem Set #2 due**	Part II, pp. 112-116 (review); Ch. 7, pp. 217-232	Ch. 10, pp 311-318, 320-326
25	3/21	Sea urchins (cont); Intro. to amphibians; **Quiz 5: Fly A-P patterning**	Ch. 1, pp. 6-11; Ch. 8, pp. 241-244	Ch. 11, pp. 333-337, 343-348
26	3/23	Amphibian axis specification: early events	Ch. 8, pp. 252-261	Ch. 11, pp. 348-354

UW Spring Break March 24-April 1

27	4/2	Amphibians: early events (cont)	Ch. 8, pp. 251-265	Ch. 11, pp. 355-359
28	4/4	Amphibian axis specification (cont)	Ch. 8, pp. 266-271;	Ch. 11, pp. 359-364

29	4/6	Amphibian gastrulation	Ch. 8, pp. 245-251;	Ch. 11, pp. 337-343; 359-364
30	4/9	Gastrulation (cont); Organizer	DD: frog materials; frog axis cheat sheet	DD: frog materials; frog axis cheat sheet

Review session: Tuesday, April 10, 4:30-6 pm, TBA
Exam 2: Wednesday, April 11, 7:15-8:45 pm, TBA

31	4/11	Other vertebrates: zebrafish and chick;	Ch. 8, pp. 271-282; Ch 9, 285-297	Ch. 11, 365-377; Ch. 12, pp. 379-391
32	4/13	Other vertebrates (cont): mammals; **Quiz 6: Frog gastrulation**	Ch. 9, pp. 298-311 (including S&S)	Ch. 12, pp. 391-401, 408-410
33	4/16	Mammals (cont); Left-right axis specification	Ch. 8, pp. 270-271; 280-281; Ch 9, pp. 297-298, 314-315	Ch. 12, pp. 390-391; 404-406
34	4/18	Preimplantation diagnosis/**Ethics Discussion**	Supplemental readings part 4	Supplemental readings part 4

Building the Body: Organ Systems in Vertebrates

35	4/20	Neurulation, brains, and ectoderm	Ch. 10, pp. 333-345; 359-361	Ch. 13, pp. 413-434
36	4/23	Mesoderm;	Ch. 12, pp. 415-421; 420-426	Ch. 17, pp. 539-543, 548-549, 551-556
37	4/25	Mesoderm (cont); endoderm; **Ethics position paper due**	Ch. 12, pp. 432—434; Ch. 13, pp. 449-456; 457-458; 460-467;	560-562, 566-568, 572-574, Ch. 18., 591-594, 596-597, 600-605
38	4/27	Endoderm (cont); branching morphogenesis	Ch. 13, pp. 476-481; Ch. 12, pp. 434-435; 436-438	Ch. 20, pp. 653-661; Ch. 18, pp. 581-583, 585-586
39	4/30	Neural crest	Ch. 11, pp. 375-391	Ch. 15, pp. 463-468, 470-482
40	5/2	Axon guidance **Problem set #3 due**	Ch. 11, pp. 394-405; 404-412	Ch. 15, pp. 488-490, 493-502, 504-508
41	5/4	Limb patterning	Ch. 14, pp. 489-514 (+ *S&S* on p. 506)	Ch. 19, pp. 613-617, 620-624, 625-630, 635-642, 645-646

Review session: TBA
Exam 3: Monday 5/7/2018, 7:45AM - 9:45AM, Room TBA