Bi480 Evolution of Development

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Class meets: T,R 8:30am – 9:50am, 189 Prince Lucien Campbell

Course Description

This course is about the evolution of developmental mechanisms. It requires the integration of information from embryology, developmental biology, evolutionary biology, population genetics, molecular genetics, genomics, and other areas of research. In this course you will learn about the interface of the two fields of Developmental and Evolutionary Biology, giving you a unique perspective on how evolution of developmental mechanisms gives rise to phenotypic and functional diversity.

The format of this course mimics what scientists do. Scientists study the literature, investigate hypotheses, conduct original research, write research papers, write grant proposals, and give talks at meetings to their peers.

Required Reading

Text: **From DNA to Diversity:** Molecular Genetics and the Evolution of Animal Design by Sean B. Carroll, Scott Wetherbee, Jen Grenier (=CWG)

Papers: Will be available on Blackboard.

Assignments:

1. **Journal**. Prepare a *one page, single-spaced, 12pt font* typed analysis of the readings you do for the course, each lecture assigned. Journal entries are due before the lecture. Entries submitted after the lecture will be docked 10% per day overdue. Please use a spell checker for your entries. For each reading you should enter:

A. Summary & Analysis. A short summary and analysis of the paper with the following sub-headings:

- *General problem*. (What was the general issue the authors addressed?)
- *Hypothesis*. (What was the specific hypothesis the authors addressed?)
- *Action*. (What experiments did they *do* to answer the question?)
- *Results*. (What happened in the experiments?)
- *Retrospective significance*. (How does the work help reinterpret past work?)
- *Prospective significance*. (What does the result mean for future work?)
- *Critique on approach*. (Did the authors experiments address the most important question? In your opinion, did they perform the best experiments to solve the problem?)
- *Critique on interpretation*. (Did the authors over- or misinterpret their results?)

B. Question. A question that comes to your mind from reading the paper. The purpose of this is to give an opportunity for in class discussion of the items that you may need for background, or to identify future research questions that arise from the work.

C. WOW factor: A point you didn't know before that's especially interesting to you. The purpose of this is to find something that connects to you more personally from the work. Different people will have very different entries for this.

2. **Genomics**. We will learn how to search genomic databases to find homologs of developmentally important genes in several species, to construct and use phylogenetic trees as an aid to determine which homologs are likely to be orthologs, to analyze conserved syntenies, and to investigate conserved non-coding elements. You will need to select a gene family to investigate and send an email message to April on January 17 for her ok. You will need to download some

software to your laptop and bring it to class for these sessions, and will hand in a short report on the phylogeny, conserved synteny, and conserved non-coding elements for your family.

3. **Presentation**. You will work in groups of two to investigate a *live* issue in the evolution of development. The team will make an oral PowerPoint or Keynote presentation of the issue to the class. You will be graded individually.

An issue is a question (a sentence with an interrogative word at the beginning and question mark at the end) on which informed people disagree. The presentation should suggest experiments that would help resolve the issue. It's often fun if one person advocates one side of the issue and another the opposite side. An alternative is that one person provides general background and the other proposes cutting experiments that should be done to resolve the issue.

4. **Proposal**. You will write a research proposal similar to one you'd send to National Institutes of Health on your Presentation topic, due on (or before) March 14. A portion of the NIH guide will be on Blackboard for you to follow. The basic outline will be:

Abstract

Background:

Define the issue. Start with a brief definition of the problem you will investigate. Often some background has to be provided (for example, some vocabulary, explanation of morphologies, definition of terms) before the problem can be clearly stated.

Frame the problem. Give historical background. Bring reader up to speed about our current understanding of the developmental and evolutionary biology of the system so that we can appreciate what the problem is and why it is important.

The issue. State the issue in the form of a question. Experts will disagree on the answer to the question, i.e., it is a live issue.

Specific Aim 1

Tell briefly why you want to do the first experiment you will propose, tell what you will do, how you will interpret it, what experimental difficulties might frustrate your work, and the significance of the particular experimental result you hope to get. Headings will be:

Rationale, Experimental design, Expected results and interpretation, Potential problems, Significance.

Specific Aim 2

Give briefly why you want to do the second experiment you will propose, tell what you will do, how you will interpret it, what experimental difficulties might frustrate your work, and the significance of the particular experimental result you hope to get. Headings will be:

Rationale, Experimental design, Expected results and interpretation, Potential problems, Significance.

Significance The retro- and prospective significance of the proposed experiments.

References Use the format used by the journal *Evolution & Development*. (http://www.blackwellpublishing.com/submit.asp?ref=1520-541X&site=1).

The paper should be approximately 4-5 pages long, double-spaced.

5. **Participation**. We expect active intellectual participation in the class. That means attending class, asking questions, volunteering ideas, and contributing to discussions. For example, you should come to class each day prepared to ask or answer a question or make a comment about the reading.

6. **Final exam.** This exam will be on March 14 (last class meeting). You will bring your laptop and will write answers in an MSWord file that you will email to me. So open book, open computer

exam. It will be essay exam with several questions, each requiring thought and one-paragraph answers.

Basis for grades:

• Journal of Readings (12)	24% (2% each)
• Genomics (4)	12% (3% each)
• Presentation Oral	15%
• NIH proposal	15%
• Participation	19% (1% for each class in which student participates actively)
• Critique of oral pres:	5%
• Exam	10%
Total	100%

Grades:

A+ 97-100%, A 94-96%, A- 90-93%

B+ 87-89%, B 84-86%, B- 80-83%

C+ 77-79%, C 74-76%, C- 70-73%

D+ 67-69%, D 64-66%, D- 60-63%

NP <60%

Lecture topics, readings, and assignments

Wk	Date	Topic	Note	Readings	Due	Lecture
1 L01	Jan 8	Animal phylogeny		CWG c1		AD
1 L02	Jan 10	Metazoan Toolkit:		CWG c2, 3 Srivastava'10		AD
2 L03	Jan 15	Toolkit: Hox		CWG c4 Freitas'06	Journal 1 (Jan 14)	AD
2 L04	Jan 17	Evolvability		Allen'08	Journal 2 (Jan 16) Email gene family	AD
3 L05	Jan 22	Modularity		Hlusko'11	Journal 3 (Jan 21) Choose partner	AD
3 L06	Jan 24	Heterochrony		Albertson'09	Journal 4 (Jan 23)	John Postlethwait
4 L07	Jan 29	Plasticity		Pizzo'08	Journal 5 (Jan 28) Set talk schedule	AD
4 L08	Jan 31	Genomics1: Seqs Phylogeny lecture	Bring laptop	Hoffmann'10	Journal 6 (Jan 30) Genomics 1	Ingo Braasch &AD
5 L09	Feb 5	Genomics2: Trees	Bring laptop		Email talk/NIH Topic Genomics 2 (Feb 6)	Ingo Braasch
5 L10	Feb 7	Genomics3: Conserved syntenies	Bring laptop	Wade'09	Journal 7 (Feb 6) Genomics 3 (Feb 8)	AD
6 L11	Feb 12	Origin of vertebrate innovations		CWG c7 Minguillon'09	Journal 8 (Feb 11)	AD
6 L12	Feb 14	Genes&Phenotypic change		Miller'07	Journal 9 (Feb 13) Email talk outline	AD
7 L13	Feb 19	Human enhancer evo		Prabhakar'08	Journal 10 (Feb 18)	AD
7 L14	Feb 21	Conserved non-coding sequences		Elgar'08	Journal 11 (Feb 20)	AD
8 L15	Feb 26	Genomics4: CNC	Bring laptop	Handout	Email NIH proposal outline	Angel Amores

					Genomics 4 (Feb 27)	
8 L16	Feb 28	Evo gene regulation	Bring laptop	Wittkopp'08	Journal 12 (Feb 27)	Braedan McCluskey
9 L17	Mar 5	Presentations 1-4			Present	AD
9 L18	Mar 7	Presentations 5-8			Present	AD
10 L19	Mar 12	Presentations 9-11			Present	AD
10 L20	Mar 14	Exam	Bring laptop!		NIH Proposal due	AD

Readings.

Albertson, R C., Y Yan, T A Titus, E Pisano, M Vacchi, P C Yelick, H W DetrichIII, J H Postlethwait (2010) Molecular pedomorphism underlies craniofacial skeletal evolution in Antarctic notothenioid fishes. *BMC Evolutionary Biology* 10:4.

Allen CE, Beldade P, Zwaan BJ, Brakefield PM. (2008) Differences in the selection response of serially repeated color pattern characters: standing variation, development, and evolution. BMC Evol Biol. 8:94.

Elgar G, Vavouri T. (2008) Tuning in to the signals: noncoding sequence conservation in vertebrate genomes. Trends Genet. 24:344-52.

Freitas R, Zhang G, Cohn MJ. (2006) Evidence that mechanisms of fin development evolved in the midline of early vertebrates. Nature. 442,1033-7.

Hoffmann FG, Opazo JC, Storz JF. (2010) Gene cooption and convergent evolution of oxygen transport hemoglobins in jawed and jawless vertebrates. Proc Natl Acad Sci U S A. 107:14274-9.

Hlusko LJ, Sage RD, Mahaney MC. 2011. Modularity in the mammalian dentition: mice and monkeys share a common dental genetic architecture. J. Exp. Zool. (Mol. Dev. Evol.) 316:21–49.

Miller CT, Beleza S, Pollen AA, Schluter D, Kittles RA, Shriver MD, Kingsley DM. (2007) cis-Regulatory changes in Kit ligand expression and parallel evolution of pigmentation in sticklebacks and humans. Cell. 131,1179-89.

Minguillon, C., Gibson-Brown, J.J., Logana, M.P. (2009) Tbx4/5 gene duplication and the origin of vertebrate paired appendages. Proc Natl Acad Sci U S A. 106:21726-30.

Pizzo et al., (2008) Rapid shape divergences between natural and introduced populations of a horned beetle partly mirror divergences between species Evol&Devel 10,166 –175

Prabhakar, S., et al., (2008) Human-Specific Gain of Function in a Developmental Enhancer. Science 321,1346 – 1350

Srivastava M et al., (2010) The Amphimedon queenslandica genome and the evolution of animal complexity. Nature. 466:720-6.

Wade CM, et al. (2009) Genome sequence, comparative analysis, and population genetics of the domestic horse. Science. 326:865-7.

Wittkopp PJ, Haerum BK, Clark AG. (2008) Regulatory changes underlying expression differences within and between Drosophila species. Nat Genet. 40:346-50.