Evolution of Development

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Evolution of Development: where you will encounter chickens, eggs, and other biological forms while researching how the egg came first!

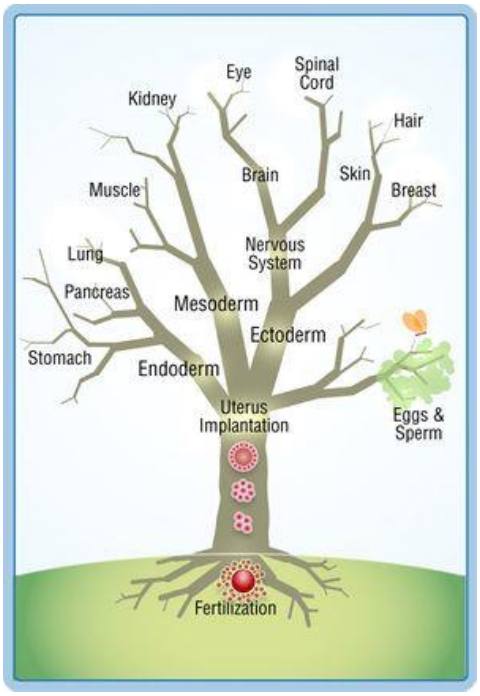
Description and Goals

If you are interested in evolution, development, or theoretical approaches to biology, this course should be of great interest to you. Evolution of Development (or Evo-Devo) will provide a broad overview of how developmental processes evolve. Evo-Devo is a rather new subfield of biology, with many empirical and theoretical opportunities for novel research advances. This diverse research landscape includes an exploration of key model systems, concepts, and mechanisms that define this field. We will spend the first third of the semester becoming familiar with relevant model organisms as proposed by the scientific literature. Moving on to mechanisms, we will then delve into the major features of the evo-devo process across species. Finally, we will become familiar with higher-level concepts that unify developmental processes with population-level and multi-generational processes.

Schedule

		WEEK
MODEL SYSTEMS	Transitional Fossils (mosaic traits)	1
	Squid (eye development I)	2
	Cavefish (eye development II)	3
	Stickleback (spine morphology)	3
	Fruit Flies (Homeotic gene expression)	4
	Butterflies (wing modularity)	4
	Midterm I	**5**
MECHANISMS	Stages of Development	6
	Genetic Regulation	7
	Molecular Signaling	8
	Neural and Morphological Plasticity	9
	Epigenetic Inheritance	10
	Midterm II	**11**

HIGHER-LEVEL CONCEPTS	Developmental Variation, Reaction Norms	12
	Heterochrony	12
	Pleiotropy	13
	Modularity, Evolvability, and Robustness	13
	Eco-Evo-Devo	14
	Morphogenesis and Developmental Phylogenetic Characters	14
	Term Projects Due	**15**



Grading

COMPONENT	TIME	% FINAL GRADE
Midterm I	Week 5	20
Midterm II	Week 11	20
Term Project	Week 15	40
Homework/Quiz I	Week 7-9	5
Homework/Quiz II	Week 12-13	15
TOTAL		**100**

Grades will be based on two midterm exams, two homework/quizzes, and a term project. Midterm exams will be a combination of multiple choice, conceptual, and analytical material, while the Homework/Quiz assignments will consist of a quiz in the first half of the term and a homework assignment in the second half of the term. The term project will be a more extensive research report on a topic of the student's choice and in consultation with the lecturer.

Wiki/Blogging Assignment (HW #2): The student will be assigned a current topic or model organism about which to produce a 1500-2000 word Wiki entry or blog post. More details will be provided in the #evodevo Slack channel. Your grade will reflect how well you summarize current and historical knowledge on your assigned subject, in addition to hyperlinks and visual presentation. Fair-use images can be found at Wikimedia Commons (https://commons.wikimedia.org/wiki/Main_Page) and Getty Images (http://www.gettyimages.com/). Please follow fair-use attribution rules for images, and properly cite all references. Provide a URL to the lecturer as evidence that you have completed this assignment.

Term Project: The student will also choose a topic and prepare a 20-page research paper that includes a) a clear problem/thesis statement and b) an appropriate-length bibliography of books and articles. The topic should combine either a model system with a higher-level concept or a mechanism with a higher-level concept. The scope of acceptable topics includes behavioral, biological, systems biology, sociology of science, or philosophical approaches. An "A+" term paper will deftly present an area related to evo-devo that builds upon the current state of knowledge rather than merely summarizing it. All submissions will be checked for plagiarism.

Readings

Main Texts

These are the main readings for the course. While the course materials do not necessarily correspond to the structure of these books, they will be useful on a daily basis. These books should be available through the University library or an online vendor (e.g. Amazon).

Grenier, Weatherbee, and Carroll
From DNA to Diversity: Molecular Genetics and the Evolution of Animal Design. Wiley, 2004.

Gilbert and Epel.
Ecological Developmental Biology. Sinauer, 2015.

General Interest

These are supplementary readings useful for a more in-depth understanding of course topics. All books should be available through the University library or an online vendor (e.g. Amazon).

Books

Arthur.
Evolution: A Developmental Approach, Wiley, 2011.

Carroll.
Endless Forms Most Beautiful. W.W. Norton, 2006.

Hall and Olson.
Keywords and Concepts in Evolutionary Developmental Biology. Harvard University Press, 2003.

Laubichler and Maienschein.
From Embryology to Evo-Devo: a history of developmental evolution. MIT Press, 2007.

Sanes, Reh, Harris.
Development of the Nervous System. Academic Press, 2011.

Shubin.
Your Inner Fish. Vintage Press, 2008.

West-Eberhard.
Developmental Plasticity and Evolution. Oxford University Press, 2003.

Review Articles

Gilbert, S.F. (2003). The morphogenesis of evolutionary developmental biology. International Journal of Developmental Biology, 47, 467–477.

Gilbert, S.F. Opitz, J.M., Raff, R.A. (1996). Resynthesizing evolutionary and developmental biology. Developmental Biology, 173, 357–372.

Higher-level Concept Readings

Here are a few readings for each higher-level concept presented in the course schedule. These readings might serve as guidance towards a term paper topic and your own literature search.

Developmental Variation/Reaction Norms:
Abzhanov, A.; Protas, M.; Grant, B.R.; Grant, P.R.; Tabin, C.J. (2004). *Bmp4* and Morphological Variation of Beaks in Darwin's Finches. Science, 305(5689), 1462–1465.

Ellis, R.E. (2017). Evo-devo: Developmental constraints. Nature Ecology and Evolution, 1, 0128.

Forsman, A. (2015). Rethinking phenotypic plasticity and its consequences for individuals, populations and species. Heredity, 115, 276–284.

Heterochrony:
Klingenberg, C.P. (1998). Heterochrony and allometry: the analysis of evolutionary change in ontogeny. Biological Reviews of the Cambridge Philosophical Society, 73(1), 79-123.

McNamara, K.J. (2012). Heterochrony: the Evolution of Development. Evolution: Education and Outreach, 5(2), 203-218.

Pleiotropy:

Paaby, A.B. and Rockman, M.V. (2012). The many faces of pleiotropy. Trends in Genetics, 29(2), 66–73.

Solovieff, N., Cotsapas, C., Lee, P.H., Purcell, S.M., and Smoller, J.W. (2013). Pleiotropy in complex traits: challenges and strategies. Nature Reviews Genetics, 14, 483–495.

Modularity, Evolvability, and Robustness:

Depew, M.J., Lufkin, T., and Rubenstein, J.L. (2002). Specification of jaw subdivisions by *DLX* genes. Science, 298(5592), 381–385.

Gerhart, J. and Kirschner, M. (2007). The theory of facilitated variation. Proceedings of the National Academy of Sciences, 104(S1), 8582–8589.

Munteanu, A., Sole, R.V. (2008). Neutrality and Robustness in Evo-Devo: emergence of lateral Inhibition. PLoS Computational Biology, 4(11), e1000226.

Wagner, G.P., Pavlicev, M., and Cheverud, J.M. (2007). The road to modularity. Nature Reviews Genetics, 8, 921-931.

Eco-Evo-Devo:

Abouheif, E., Fave, M.J., Ibarrarán-Viniegra, A.S., Lesoway, M.P., Rafiqi, A.M., and Rajakumar, R. (2014). Eco-Evo-Devo: developmental symbiosis and developmental plasticity as evolutionary agents. Advances in Experimental Medicine and Biology, 781, 107-125.

Gilbert, S.F., Bosch, T.C.G., and Ledon-Rettig, C. (2015). Eco-Evo-Devo: developmental symbiosis and developmental plasticity as evolutionary agents. Nature Reviews Genetics, 16, 611–622.

Morphogenesis and Developmental Phylogenetic Characters:

Cohn, M.J. and Tickle, C. (1999). Developmental basis of limblessness and axial patterning in snakes. Nature, 399(6735), 474–479.

Laurin, M. and Germain, D. (2011). Developmental characters in phylogenetic inference and their absolute timing information. Systematic Biology, 60(5), 630–644.

Pichaud, F. and Desplan, C. (2002). *Pax* genes and eye organogenesis. Current Opinion in Genetics and Development, 12(4), 430–434.

Rivera-Pomar, R. and Jackle, H. (1996). From gradients to stripes in *Drosophila* embryogenesis: filling in the gaps. Trends in Genetics, 12(11), 478–483.