Biology 95hfn Tutorial 2006-2007

From Genotype to Phenotype: how development shapes evolution

Brief description of the tutorial
Over the last three decades, an increasing number of biologists from a variety of subdisciplines have been working towards reintegrating development into evolutionary biology. In this tutorial we will examine some of the conceptual work driving this research, delve into its history, and discuss the key components of a theory of phenotypic evolution.

Instructor
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Assignments
There will be reading for each week and each student will write approximately 1 page of commentary, summarizing the reading or using the assignment as a touchstone to ask questions both about the readings and about biology itself. This will be due by email the day before the tutorial.

In the fall semester, each student will give an oral presentation on a particular historical controversy in biology which relates to the themes of the course. Students will meet with me individually to choose a topic of interest and identify background reading material for the topic. An example would be the debates between the biometricians and Mendelians around 1900.

In the spring semester, each student will write a critical review of a different current published paper that we did not read for the tutorial either from a list I provide or something they have found. They will also develop a short research proposal of the sort that could be submitted for Harvard College Research Program funding. The timing of these spring assignments depends upon whether the students intend to submit the proposals for summer funding (deadline in early April).

Grading
20% Research proposal
20% Historical controversy presentation
20% Paper review
20% Class discussion
20% Weekly written assignments
100% - A - 90% - B - 80% - C - 70% - D - 60%

Instruction Method
The course will meet for 1 ½ hours each week. Responses to the readings will be due by email the day before the tutorial. We will start the first hour discussing the readings and during the last ½ hour, I will lecture on the historical and biological context for the next week's readings.

Detailed syllabus and bibliography
Below I have listed topics, questions/objectives, and readings – a tentative syllabus for 23 weeks We may not cover all of it; we may cover more; we may substitute different topics for some of those listed below. Exactly what we cover and how long we spend on it is somewhat flexible, and I certainly welcome suggestions from students about related topics they would like to cover.
1. **Topic**
   Introduction to the course

2. **Topic**
   A survey of modern evolutionary theory and some difficulties for the synthesis of development and evolution.
   **Reading**

3. **Topic**
   An introduction to the concepts and themes we will explore through the course
   **Reading**

4. **Topic**
   Causality and explanation.
   **Questions/Objectives**
   What does it mean to “explain” something in biology? What sorts of causes can we actually investigate?
   **Reading**

5. **Topic**
   The genotype-phenotype map, dynamical sufficiency.
   **Questions/Objectives**
   How do we use empirical observations to construct a theory? How can a theory shape how we interpret empirical observations?
   **Reading**
   Selections from Lewontin, RC. 1974. *The genetic basis of evolutionary change*. Chapter 1

6. **Topic**
   Natural kinds and the importance of process.
   **Questions/Objectives**
   What are biological units?
   **Reading**
7. Topic
Populational/Variational vs. Typological thinking. Introduction to quantitative genetics.
Questions/Objectives
Variation is a key property in evolutionary investigations.
Reading

8. Topic
Components of a model of evolution. I. Sequences. Probabilities of change
Questions/Objectives
Understanding likelihood models of sequence evolution and particularly the role the transition matrix plays.
Reading
Chapter 11 in *Molecular Systematics*

9. Topic
Components of a model of evolution. II. Phenotypes.
Questions/Objectives
Can we construct a likelihood model for phenotypic evolution? Introduction to the concepts of accessibility, configuration spaces, and mutational variance.
Reading

10. Topic
*Natura non facit saltum*
Questions/Objectives
Introduction to the idea of landscapes. Are they rugged? Does nature jump? Early ideas.
Reading

11. Topic
Discontinuity, punctuated equilibria, and punctuated anagenesis
Questions/Objectives
What is punctuation? What does it have to do (if anything) with development?

**Reading**


**12. Topic**

Developmental trajectories. I. Allometry

**Questions/Objectives**

Introduction to correlations between parts

**Reading**


**13. Topic**

Developmental trajectories. II. Morphometrics.

**Questions/Objectives**

Understand morphometric approaches to studying phenotypes. How can morphological measurements give insight into the underlying developmental processes?

**Reading**


**14. Topic**

Developmental trajectories. III. Heterochrony.

**Questions/Objectives**

Timing is a crucial part of integrating parts in a developing organism. How can development be represented?

**Reading**


**15. Topic**

Development constrains evolution.

**Questions/Objectives**

Introduction to the idea of developmental constraints and various aspects of the concept of constraint.
Reading

16.
Topic
Results from modeling genetic networks.
Questions/Objectives
How can we quantify robustness and modularity? Examples from genetic network simulations.
Reading

17.
Topic
Developmental genetics of modules.
Questions/Objectives
What are the biological properties of developmental modules?
Reading

18.
Topic
Which comes first, the phenotype or the mutation?
Questions/Objectives
Introduction to the idea of genetic assimilation. Illustrate how reaction norms make Waddington's idea more intuitive. Does this square with the molecular genetics?
Reading

19.
Topic
Molecular perspectives on which came first, the phenotype or the mutation.
Questions/Objectives
Where is the cause of a phenotypic evolutionary change? What is selected? How do genetic systems work? For which biological questions does it make sense to focus on the genes, for which the phenotypes?

Reading
Shubin, N, C Tabin, and SB Carrol. 1997. Fossils, genes and the evolution of animal limbs

20.
Topic.
Characters. I. Quasi-independence
Questions/Objectives
Introduce notion of quasi-independence and character identity. What do we mean by independent characters?
Reading
Wagner, GP and JA Gauthier. 1999. 1,2,3=2,3,4: A solution to the problem of the homology of the digits in the avian hand. PNAS. 96:5111-5116.

21.
Topic
Characters. II. Geometric approach to character identification.
Questions/Objectives
How can we identify independent characters?
Reading

22.
Topic
Characters III. Sketches for a theory of phenotypic evolution.
Questions/Objectives
How do homology, independence, characters, configuration spaces, and units of selection relate?
Reading

23.
Topic
Summing up
Questions/Objectives
Some nice examples. What is generalizable in biology?
Reading
Guralnick, RP and DR Lindberg. 1999. Integrating developmental evolutionary patterns and mechanisms: a