BIO 43: The Evolution of Plant Diversity

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Course Overview

This course has several, interrelated objectives. First, it serves as an introduction to the science of phylogenetics, providing an overview of both the theory and methodology involved in constructing phylogenetic trees, and how to use trees to study character and organismal evolution. For our second objective, we will to put this new framework to immediate use by using phylogeny to explore and illustrate 400 million years of land plant evolution. The course will examine major trends in plant evolution from functional, ecological, and biogeographical perspectives. Students will leave the class with a basic understanding of 1) phylogenetic theory and methods of studying character evolution, 2) plant anatomy and morphology, 3) evolutionary relationships among the major land plant clades (with emphasis on the flowering plants), and 4) major evolutionary trends that have significantly shaped the diversity of plant life that we see today. The third and most important objective is to instill in students the ability to look at any biological problem through the lens of "phylogeny-colored glasses"- a powerful way to examine the complexity of life that surrounds (and includes) us.

Lectures will be primarily chalkboard talks with supplemental slideshows- students should be expected to attend class and take good notes. There is a nearly weekly lab that will include varied activities, including two field trips to see local flora, anatomical dissections at the greenhouse, and phylogenetic software training. Your final grade will be determined with the following components:

First midterm: 15%
Second midterm: 15%
Lab participation: 10%
Lab practical exam: 5%
Response papers: 10%
Take home final exam: 20%
Term paper/short animation: 25%

The term paper: this is a very important exercise, and is weighted accordingly (25% of total grade). The term paper should present a phylogenetic analysis of character evolution in a monophyletic group of plants. That is the one essential requirement. It is up to you to decide on the scale. You can write in great detail about a group of 10 very closely related species, or you can tackle questions about the major lineages of land plants. You also have complete flexibility in what sort of traits you focus your research on, though the trait/traits must exhibit variation in your focal clade. The paper should be 10-12 pages of text and fully referenced. Figures, especially a phylogeny of the clade, are strongly encouraged. The goal of this assignment is for you to immerse yourself in the details of a lineage- you will become the resident Brown University expert of that lineage!- and you might uncover key remaining questions that could inspire a future research project.

Short animation: As an alternative to the term paper, you may produce a short animated film that tells a cool evolutionary story about plants, in the style of a 'CreatureCast' episode (www.creaturecast.org). We are collaborating with the Dunn lab on contributing to the creaturecast site with a 'Branching Out' series that focuses on the wonderful world of plants (plants, as you will discover, are far more fabulous than animals, though most people don't realize this). There has been only one 'Branching Out' episode thus far (visit the website and watch 'Hollow Trees'). The animation is extraordinary, but I will expect more scientific content from you in your assignment. Stellar animations will go live on the creaturecast blog!! **NOTE: this option is fun and creative but is much harder than it looks!**

A final note on writing: This is a designated 'W' course, and as such there will be a fair amount of high-quality writing expected from you. In addition to the (optional) term paper, the take-home final exam will consist of several essays on various aspects of plant evolution, and you will also have a series of short response papers due over the course of the semester. I will be critiquing your writing style as well as the content of your response papers, and hope that your final response paper will be short, pithy, and clean. The ability to write clearly is essential for most careers, scientific or otherwise, and this class serves as an opportunity for you to develop your writing abilities. There will be a window of

time before the final due date of the term paper when you may submit a draft for me and/or the TA to look over and get back to you with comments. I also strongly encourage you to make use of the Writing Center.

Lab supplies:
You will need a sketchbook and a pencil (some students have really enjoyed colored pencils- good but not essential). A hand lens is nice for field trips, but also is not essential (we can share).

Text:
Plant Systematics: a phylogenetic approach 3rd edition **(required)**
Supplemental book chapters/journal articles to be selected by instructor, which can be downloaded from the mycourses website.

Some decent field identification books and floras for New England that might be of interest to you (but not requirements for the course):
Flora of the Northeast, by Magee and Ahles, 1999
Newcomb's Wildflower Guide
Peterson's Guide to Trees

Grand finale: in the long tradition of Bio 43 we will finish the semester with a plant diversity potluck. The goal is to prepare a smorgasbord of delicious food that maximizes phylogenetic diversity.

Bio 43 Course Schedule 2009

Lectures: Tuesday, Thursday 9:00-10:20, Salomon 202

Lab: Tuesday 1-4, Brown University Greenhouse, 91 Waterman St.

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8 Sept. Introduction to the course

13 Sept. What is a plant? The world of the autotroph; basic plant anatomy, alternation of generations

Reading: Sadava chapter 34

(13 Sept) lab: basic plant anatomy

15 Sept. Introducing phylogeny: Linnean classification, the birth of phylogenetic systematics, DNA sequencing, model-based tree building

Reading: chapters 2,3,5; Holder and Lewis 2003 (pp. 275-280)

20 Sept. How to use a phylogeny: dating divergence times, diversification, character evolution; phylogenetic nomenclature

Reading: chapter 2, Donoghue 1989; ***response paper due***

(20 Sept) field trip: Caratunk Wildlife Refuge

22 Sept. guest lecture: PhD student Matt Ogburn presents cool things you can do with a phylogeny

27 Sept. An overview of green plant phylogeny and the transition to land: reduction of the gametophyte, plant hydraulic design, evolution of leaves

Reading: pp 153-165

(27 Sept) field trip: The Great Swamp

29 Sept. an overview of monilophyte and acrogymnosperm phylogeny, considering the evolution of the seed and a bifacial cambium

Reading: pp. 165-180;
Reference: pp. 191-221

4 Oct. Introduction to the angiosperms and their early ecological evolution

(covering basal angiosperms; eumagnoliids)

Reading: Feild et al. 2009; ***response paper due***
Reference: chapter 9, 225-249

(4 Oct.) 'get yourself there' field trip: the conifers of Swan Point Cemetery

6 Oct. eudicots and ABC model of flower development; constraints and opportunities afforded by plant modularity

Reading: Soltis et al. 2007

11 Oct. MIDTERM (covering 13 Sept- 6 Oct)

(11 Oct.) lab: basal angiosperms and magnoliids; mesquite tutorial

13 Oct. an overview of monocot phylogeny

Reference: chapter 9, 249-306

18 Oct. some eudicot phylogeny: ranunculales, proteales, caryophyllales
Reference: chapter 9, 307-338

(18 Oct.) lab: monocots

20 Oct. ecology and evolution of CAM and C4 photosynthesis, with examples from the monocots and caryophyllales

Reading: Keeley and Rundel 2003

25 Oct. An overview of rosid phylogeny

Reference: chapter 9, 346-441

(25 Oct.) lab: basal eudicots, caryophyllales

IMPORTANT DEADLINE: PAPER TOPIC MUST BE OK'ED BY PROF EDWARDS BY 25 OCTOBER

27 Oct. An overview of asterid phylogeny

Reference: chapter 9, 441-515

1 Nov. morphological and functional diversity of flowers: fusion of parts, convergence of flower 'types'; evolution of novel structures. Case studies from asterids and rosids

Reading: Endress 2011; ***response paper due***

3 Nov. morphological and functional diversity of fruits: types, dispersal 'syndromes', fruits we eat, etc. Case studies from asterids and rosids

Reading: Valido et al. 2011; ***response paper due***

(1 Nov.) lab: rosids

8 Nov. the evolution of growth form

Reading: Rowe and Speck 2005

(8 Nov.) lab: asterids

10 Nov. symbioses: the origin of plant photosynthesis; the loss of plant photosynthesis; co-evolution of plants and animals

Reading: Futuyma and Agrawal 2009

15 Nov. MIDTERM (6 Oct- 10 Nov)

(15 Nov.) lab: practical examination; turn in lab notebooks

17 Nov. processes of diversification; mechanisms of speciation; polyploidy

Reading: chapter 6

17 NOVEMBER: TERM PAPER/CREATURE CASTS DUE

22 Nov. THANKSGIVING

24 Nov. THANKSGIVING

29 Nov. Feedbacks between plant evolution and global climate

Reading: Beerling 2005, Boyce et al. 2010; ***response paper due***

(29 Nov) lab: plant diversity potluck!

On 29 Nov I will email you the final essay exam questions

1 Dec. a phylogenetic perspective on plant communities and biogeography

Reading: Donoghue 2008; ***response paper due***

6 Dec. Last class: CreatureCast presentations!

8 Dec. Reading period. **TAKE-HOME ESSAYS DUE, 5PM**