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, with emphasis on the diversity of flowering plants. 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 weekly lab that will include varied activities, including two field trips to see local flora, anatomical dissections at the greenhouse, and the development of your own pressed plant collection. 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 lineage 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 essential. 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 (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. Stellar animations will go live on the creaturecast blog!! **NOTE: this option is fun and creative but is much harder than it looks.** For detailed information and advice about making a creaturecast, please go to http://creaturecast.org/making-a-creaturecast-episode.

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. Morgan and 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 scientific 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, preferably without lines, 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:

REQUIRED: *Plant Systematics, 1st edition, by Michael G. Simpson (2006)*
This is not available at the bookstore, but it is a bargain on Amazon; because there is a 2nd edition out you can by a used copy for as little as $16.99!! Order one immediately!!

HIGHLY RECOMMENDED: *Tree Thinking: An introduction to phylogenetic biology, by David Baum and Stacey Smith (2012).*

I will be assigning certain chapters to go along with two early lectures, and these will be available as scanned PDFs. However, this is just a great book to have and to read from cover to cover, and I recommend it.

Supplemental book chapters/journal articles to be selected by instructor, which will be available 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 2015

Lectures: Tuesday, Thursday 9-10:20, Smith-Bounanno Hall G01

Lab: Tuesday 1-4, Greenhouse teaching classroom, BERT

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10 Sept. Introduction to the course

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

Reading: Simpson chap 9: 347-403

(15 Sept) lab: basic plant morphology: leaves, stems, flowers

17 Sept. Introducing phylogeny: Linnean classification, the birth of phylogenetic systematics, tree-thinking, tree-building

Reading: Baum and Smith chap 3; chap 7 pp 173-194 (scanned and available on canvas)

22 Sept. Phylogeny part two: continuation of tree-building; using trees to understand character evolution

Reading: Baum and Smith chap 8 pp 217-247 (scanned and available on canvas)

Donoghue 1989; ***response paper due (please respond to Donoghue 1989 only)***

(22 Sept) field trip: Caratunk Wildlife Refuge

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

Reading: Judd et al chap 7: pp 153-165 (scanned and available on canvas)

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

Reading: Judd et al chap 7: pp. 165-180 (scanned and available on canvas)
Simpson pp. 78-87; 107-118

(29 Sept) 'get yourself there' field trip: the conifers of Swan Point Cemetery

1 Oct. The origin of angiosperms – unpacking that node in both directions

Reading: Feild et al. 2004; Doyle 2012; ***response paper due***

6 Oct. eudicots and genetic model of flower development;
(covering basal angiosperms; eumagnoliids)

Reading: Soltis et al. 2007; Simpson pp. 138-153

(6 Oct.) field trip: The Great Swamp

8 Oct. MIDTERM (covering 15 Sept- 6 Oct)

13 Oct. an overview of monocot phylogeny

Reading: Simpson pp. 153-219

(13 Oct.) lab: basal angiosperms and magnoliids

15 Oct. some eudicot phylogeny: ranunculales, proteales, caryophyllales

Reading: Simpson pp. 228-249

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

Reading: Edwards and Ogburn 2012

(20 Oct.) lab: monocots

22 Oct. An overview of rosid phylogeny

Reading: Simpson pp 250-289

27 Oct. An overview of asterid phylogeny
Reading: Simpson pp 289-335

(27 Oct.) lab: basal eudicots, caryophyllales

IMPORTANT DEADLINE: TERM PAPER/CREATURE CAST TOPIC MUST BE OK'ED BY PROF EDWARDS BY 27 OCTOBER

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

Reading: Bolmgren et al. 2005; ***response paper due***

3 Nov. morphological and functional diversity of flowers: fusion of parts, convergence of flower 'types'; evolution of novel structures

Reading: Glover et al. 2015; ***response paper due***

(3 Nov.) lab: rosids

5 Nov. the evolution of growth form

Reading: Speck and Rowe 2005; Westwood et al. 2010

10 Nov. MIDTERM (9 Oct- 5 Nov)

(10 Nov.) lab: asterids

12 Nov. the evolution of plant breeding systems

Reading: Barrett 2002

17 Nov. symbioses and plant-organism interactions across the tree of life

Reading: Bronstein et al. 2006; Edger et al. 2015; ***response paper due***

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

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

Reading: Donoghue and Sanderson 2015;

24 Nov. THANKSGIVING

26 Nov. THANKSGIVING

1 Dec. Feedbacks between plant evolution and global climate

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

1 DECEMBER: TERM PAPER/CREATURE CASTS DUE!

(1 Dec) lab: plant diversity potluck!

3 Dec. a phylogenetic perspective on biome assembly and niche evolution

Reading: Donoghue and Edwards 2014; ***response paper due***

On 3 December I will email you the final essay exam questions

8 Dec. Last class: CreatureCast presentations!

11 Dec. **TAKE-HOME ESSAYS DUE, 5PM**