**Phylogenetic Theory**

**Fall 2014**

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| Course Title/Number | Phylogenetic Theory BSC482/583 |
| Semester/Year | Fall 2014 |
| Days/Time | Tuesday and Thursday; 2pm – 3:15 pm |
| Location | Science Building, Room 166 (computer lab on the ‘Geology’ floor) |
| Instructor | Dr. Emily Gillespie |
| Office | Science Building, Room 364 |
| Phone | (304) 696-6467 |
| E-Mail | [gillespieE@marshall.edu](mailto:gillespieE@marshall.edu) (email is the best way to contact me—allow 24 hrs to respond, please. Also, |
| Office/Hours | 1-2 pm Tuesdays and Thursdays, and/or by other appointment—24 hrs notice, please |
| University Policies | By enrolling in this course, you agree to the University Policies listed below. Please  read the full text of each policy be going to [www.marshall.edu/academic-affairs](http://www.marshall.edu/academic-affairs) and clicking on “Marshall University Policies.” Or, you can access the policies directly by going to <http://www.marshall.edu/academic-affairs/?page_id=802>  Academic Dishonesty/ Excused Absence Policy for Undergraduates/ Computing Services Acceptable Use/ Inclement Weather/ Dead Week/ Students with Disabilities/ Academic Forgiveness/ Academic Probation and Suspension/ Academic Rights and Responsibilities of Students/ Affirmative Action/ Sexual Harassment |

**Course Description**

This course introduces students to the field of phylogenetics, in theory and in practice. Students will learn how phylogenetic biology fits into the broader field of biology (and beyond), and how biologists and others can think phylogenetically in their professional activities. Students will learn to critically evaluate the information contained in phylogenies, and to carry out all steps involved in constructing a phylogeny from data collection to phylogenetic analysis. Students will ultimately choose a project based on their interests, gather data, construct one or more valid phylogenies, and present the interpretation of their original research to the class.

**Course Goals**

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| **Learning Outcomes: Be able to…** | **Practiced by…** | **Assessed by….** |
| Recognize the applications of phylogenies and ‘tree thinking’ across all areas of biology and beyond | Identifying phylogenies in the primary literature used in different disciplines (e.g., evolutionary biology, human health, ecology, linguistics) and exploring what information they contain. | Demonstrating the ability to locate phylogenies in the literature and describe how the phylogeny was used.  Describing the similarities and differences of how different disciplines employ ‘tree thinking’  Explaining the evolutionary context associated with any published tree |
| Interpret and summarize the information contained in a phylogeny in a scientifically accurate way | Locating and exploring phylogenetic trees and characterizing and evaluating the various kinds of information contained therein and the strength of statistical support for the tree | Summarizing and/or explaining the use of trees in the literature, characterizing the extent to which any particular tree is valid or useful using established criteria, critiquing how others use trees, critiquing the technical validity of trees |
| Analyze data by executing modern phylogenetic analyses | Downloading data from public databases, constructing alignments using different methodologies, selecting appropriate models of evolution, applying different phylogenetic analytical frameworks to datasets, and presenting dynamic trees to an audience | Summarizing the availability of relevant databases, evaluating and choosing the most appropriate alignment and the most appropriate phylogenetic strategy, implementing valid statistical tests for trees |

**Required Texts, Additional Reading, and Other Materials**

1. Tree Thinking: An Introduction to Phylogenetic Biology (2013—1st edition) by David Baum & Stacey Smith.
2. Phylogenetic Trees Made Easy: A How-To Manual (2011—4th edition) by Barry Hall
3. Papers from primary literature, provided via Blackboard
4. Supplemental lecture materials/notes, provided via Blackboard

**Course Requirements / Tentative Due Dates for major assignments/assessments**

If extenuating circumstances occur, we may shift these dates. You will have at least two weeks’ notice of the change.

1. Exam 1—October 7
2. Project approval—October 14
3. Draft Project paper—November 11
4. Final Project paper—December 2
5. Final Project presentation—December 2 and 4
6. Final Exam—Thursday, December 11 from 12:45pm – 2:45 pm.

**Grading Policy**

Your final course grade will be calculated as follows: quizzes (15%), homeworks (15%), exams (30%), project (30%) and participation (10%).

Quizzes, homeworks and exams will be some mixture of problems, critiques, essays and short answer questions, and objective questions. The final exam is cumulative, but generally, any assignment/assessment may include information from any past assignment/assessment.

Project topics must be approved well in advance to ensure their viability and quality, but the area of focus is essentially unlimited and can/should reflect student interests. The project will include a paper and Powerpoint presentation, both of which will be peer-reviewed as part of the assessment. Graduate students should choose a project that is substantial, original research and that enhance one’s thesis research. More detailed information about the project assignment will be provided early in the semester.

Participation points will be earned each week (3 points per meeting, or 6 points per week = 84 points in 14 weeks). Participation points cannot be made up after absences, whether excused or unexcused. Repeated tardy arrivals will diminish your participation points (see below, Attendance Policy) proportionately, depending on severity and frequency. In this course, ‘participation’ means demonstrating during class discussions and activities that you are well-prepared for that day’s meeting through meaningful contribution. Failure to follow through on peer-review assignments or other assignments impacting other students will diminish your participation score.

**Attendance Policy**

Good attendance will make any course much easier on you and much more rewarding. It tends to be very difficult to get caught up on your own. Further, your questions are extremely important to your classmates and professor (and vice versa!) Any assignment missed without a University-approved excuse will earn a zero, regardless of the grade-importance of the assignment (i.e., including exams and projects). Any exam missed with a University excuse must be made up within one week of your return to school. You may be given an alternative assessment as a makeup. If your final project is impacted by a University-approved absence, you may lose the opportunity to present your project to your classmates and your grade will be based solely on my evaluation (as opposed to partial peer evaluation).

It is important to arrive to class on time so that 1) you do not miss any important announcements or the beginning/introduction to the day’s activities, and 2) other students who may rely on you are not negatively impacted. Arriving tardy with any regularity will diminish your participation score.

**Tentative schedule.** You should prepare the readings for the week indicated. The yellow highlighting indicates the Baum & Smith (Tree Thinking) text. The blue highlighting indicates the Hall (Phylogenetic Trees Made Easy) text. These are the textbook readings only; be prepared to have supplemental readings occasionally added during any week.

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| **Week #** | **Week of** | **Topic(s)** | **Chapter & text** | **Comments** |
| 1 | Aug 25 | Pre-course phylogenetics assessment  Course Introduction  Importance of phylogenetic trees  Introductory ‘quick’ tutorial | N/A  N/A  Preface (Baum) pxv-xvii (3 pp.)  Ch. 1 (Baum) p1-8 (8 pp.)  Ch. 1 (Hall) p1-10 (10 pp.)  **Total reading: 21 pp.** | Via Blackboard  Syllabus, student introductions, etc…  Angle of the text  Broad overview/intro  Quick introduction to using the Hall text |
|  |  | **Interpreting phylogenetic trees** |  |  |
| 2 | Sept 1 | Tree-thinking and evolutionary thought  What a phylogenetic tree represents | Ch. 2 (Baum) p9-30 (22 pp.)  Ch. 3 (Baum) p35-67 (32 pp.)  **Total reading: 54 pp.** | Explores the connection between ‘tree thinking’ and ‘evolutionary thinking’  The basic ‘mechanics’ of understanding trees |
| 3 | Sept 8 | Trait evolution  Estimating phylogenetic trees | Ch. 4 (Baum) p77-99 (22 pp.)  Ch. 2 (Hall) p11-27 (17 pp.)  **Total reading: 39 pp.** | Using trees to understand how traits evolve; concept of homology  Overview tutorial: downloading homologous sequences, aligning them and building a tree |
| 4 | Sept 15 | Relatedness and Taxonomy  Acquiring sequences  Aligning sequences | Ch. 5 (Baum) p107-133 (26 pp.)  Ch. 3 (Hall) p29-46 (18 pp.)  Ch. 4 (Hall) p47-60 (14 pp.)  **Total reading: 58 pp.** | How phylogenies inform taxonomy and when they don’t ‘match up’  A more detailed tutorial on acquiring sequences; advanced use of BLAST  Advanced topics in alignment  See Hall ch. 12 for even more advanced topics (optional) |
| 5 | Sept 22 | Gene Trees and Species Trees  Major phylogenetic methods | Ch. 6 (Baum) p139-166 (28 pp.)  Ch. 5 (Hall) p61-68 (8 pp.)  Ch. 7 (Hall) p 91-109 (19 pp.)  **Total reading: 55 pp.** | Differences in what a single gene reveal about evolution; ‘non-branching’ evolution  Theoretical overview of major approaches to phylogeny reconstruction (preparatory to next week)  Presenting phylogenetic trees |
|  |  | **Inferring Trees** |  |  |
| 6 | Sept 29 | Parsimony | Ch. 7 (Baum) p173-207 (35 pp.)  Ch. 8 (Hall) p111-122 (12 pp.)  Handout—Dendrogrammaceae  Handout—command line PAUP\*  **Total reading: 47 pp.** | Basics of the Maximum Parsimony strategy  Parsimony analysis in MEGA  Constructing a tree using morphological data and parsimony  Parsimony analysis in PAUP\* |
| 7 | Oct 6 | Exam 1  Distance Methods | Ch. 8 (Baum) p217-237 (20 pp.)  Ch. 6 (Hall) p69-90 (22 pp.)  **Total reading: 42 pp.** | Covers through ‘Parsimony’  Basics of the Distance strategy  Distance analysis using MEGA |
| 8 | Oct 13 | Maximum Likelihood Methods | Ch. 8 (Baum) p238-247 (9 pp.)  Ch. 9 (Hall) p123-136 (13 pp.)  **Total reading: 22 pp.** | Basics of the Likelihood strategy  Maximum Likelihood analysis using MEGA |
| 9 | Oct 20 | Bayesian Methods | Ch. 8 (Baum) p247-258 (12 pp.)  Ch. 10 (Hall) p139-160 (21 pp.)  Handout  **Total reading: 33 pp.** | Basics of the Bayesian strategy  Bayesian analysis using MrBayes  Bayesian analysis using BEAST |
| 10 | Oct 27 | Statistical tests of phylogenetic hypotheses | Ch. 9 (Baum) p265-297 (33 pp.)  **Total reading: 33 pp.** | Deciding how ‘strong’ a phylogeny is |
|  |  | **Using phylogenetic Trees** |  |  |
| 11 | Nov 3 | Using trees to study character evolution  Reconstructing ancestral sequences | Ch. 10 (Baum) p305-340 (36 pp.)  Ch. 13 (Hall) p191-201 (10 pp.)  **Total reading: 46 pp.** | Using phylogenies to understand how characteristics/traits evolve within lineages  Using MEGA to estimate the DNA sequence of an extinct ancestor |
| 12 | Nov 10 | Using Trees to study Space, Time & Evolutionary Diversification  Detecting adaptive evolution | Ch. 11 (Baum) p349-381 (32 pp.)    Ch. 14 (Hall) p203-218 (16 pp.)  **Total reading: 48 pp.** | Using phylogenies to study biogeography, ecology and coevolution  Detecting evolutionary adaptation using MEGA |
| 13 | Nov 17 | Phylogenetic networks  Catch-up, review, troubleshooting, etc… | Ch. 15 (Hall) p219-248 (20 pp.)  **Total reading: 20 pp.** | Dealing with reticulate (non-branching) relationships using SplitsTree |
| 14 | Nov 24 | Thanksgiving break—No classes |  |  |
| 15 | Dec 1 | Class project presentations  Final/finished project papers due! |  | Tuesday and Thursday  Due Tuesday |
| 16 | Dec 8 | Finals week |  | Thur, Dec 11 @ 12:45pm |