PhyloMeth: Syllabus

Brian O'Meara

Phylogenetic Methods (PhyloMeth). Spring 2021

UT students may sign up at EEB 587.

Syllabus version: 09:52 AM, 02 March, 2021

Instructor: **Brian O'Meara** (bomeara@utk.edu)

Course website: http://phylometh.info

Office hours by appointment (and routinely available over slack as well)

Anonymous feedback   https://www.brianomeara.info/feedback.html

What you will learn   This is a modern class in phylogenetic methods. You will learn how to get data, build a tree, use comparative methods, and how to make new methods. More importantly, you will learn **why** to do all this. You will also learn some best practices – these will be annoying at first, but worth it overall.

Requirements

- A laptop on which you can install software (have root / admin access)
    - It'll be easiest if this is a Mac; less easy is Linux; Windows will be hard
- A question and some data to answer it
- GitHub account
- Slack
- R
- And other software we'll learn about during the course

I am revising a textbook as part of the course * HTML version * PDF

It will be updated as we go, so check back frequently.

Evaluation   Grading will be based on effort and performance. Some of the things will be harder for some students than others just given differences in what they've been exposed to so far, and I don't want to penalize students who are less skilled at R, for example. But I do require that you put in work on this class: work through the exercises, think about the papers, etc. Much of the homework is chewy, so it will take some thought to get through, and you might not be able to do all of this. That's ok. *But ask for help!*

These projects should be able to serve as the core for a dissertation chapter or published paper: still requiring more work and writing, but a solid idea with preliminary results.

Teaching   The class is generally flipped: rather than me droning at the front of the room, I'll be releasing videos online for you to watch. They will be linked to from this syllabus. In class, talk about what was not clear from the videos about methods, and we'll dig into that. We can also work on problematic parts of the exercises (you should do most of them before class) and talk about papers.

Connecting The class discussion board is public on Slack; you will need the [Slack invite code]https://join.slack.com/t/phylometh/shared_invite/enQtOTAwMDQwMTMyODMyLTM2N2I1YmRjNzhkM2Zh YWVhMzlhMjU1YzExZTQ2MGRlYTQyMzA3YzBjYWQyYzhmNGMxYzgzOTJhZTAwYTA2NzI) to join.

Online option There is a no-credit online option, as well.

Schedule

- Week 1
  - Topic: Getting ready
  - Items: R, github, unit testing
  - Instructions & exercise: Getting Started
- Week 2
  - Topic: Gathering data
  - Reading: Chapter 3 of the textbook.
  - Videos: See videos in this playlist
  - Items: Sequences, trees, name resolution, alignment
  - Exercise: Getting trees, but often easier to get the raw file instead.
  - In class: Discussion of what kinds of data you need for your questions, what kind of trees you need.
- Week 3
  - Topic: Building trees
  - Videos: Terminology, Tree space, Likelihood vs Bayes
  - Reading
    * Felsenstein 1978
    * Felsenstein 1985
    * Lewis 2001
    * Drummond & Rambaut 2007
  - Items: Likelihood; Bayes; Parsimony
  - Potential exercises (choose your own)
    * RAxML tutorial: Fast maximum likelihood tree inference program.
    * BEAST tutorials: Bayesian tree inference program, especially used for getting chronograms.
    * Cyverse discovery environment: Free service (thanks, NSF!) for running phylogenetic (and other) software
- Week 4
  - Topic: Building trees
  - Items: Gene tree species tree; Network
  - Reading
    * Maddison 1997: Gene trees in species trees
    * Heled & Drummond 2009: A method for inferring species trees given gene trees inside them
    * Degnan & Rosenberg 2000: Cases where the most frequent gene tree does not match the species tree
    * Solís-Lemus & Cécile Ané, 2016: Phylogenetic networks. A bit mathy for many students in this class, but worth introducing quartets, reticulation, and an existing method.
    * Hahn & Nakhleh 2016: Irrational exuberance for resolved species trees. Mind-blowing (to me) paper on why to understand trait evolution we may care about the gene trees, not the species tree.
  - Class exercise: Gene tree species tree
- Week 5
  - Topic: Dating trees
  - Items: Beast, r8s
  - Reading
    * Sanderson, 2002: Penalized likelihood.
    * Drummond et al. 2006: Bayesian dating. And good paper title.
    * Drummond and Rambaut, 2007: BEAST description.

- ∗ Beaulieu et al., 2015: One possible caveat to Bayesian dating.
- ∗ Heath et al. 2015: Using fossils as tips.
- ∗ Course book
- Week 6
  - Topic: Discrete character models
  - Items: corHMM, geiger
  - Video: PhyloMeth discrete characters
  - Reading (all three for Tues)
    - ∗ Pagel, 1999: Ancestral state reconstruction
    - ∗ Lewis, 2001: MKV model
    - ∗ O'Meara, 2012: Review of models
  - Exercise (for Thurs): Discrete data
- Week 7
  - Topic: Continuous character models
  - Items: Surface, OUwie, geiger
  - Videos: OU, BM, etc
  - Reading:
    - ∗ Hansen and Martins, 2006: Linking micro and macroevolutionary models. TL;DR: Table 1 shows that many microevolutionary models reduce to Brownian motion.
    - ∗ Felsenstein 1988: Biology behind the model.
    - ∗ O'Meara, 2012: Not nearly as important as the ones above, but an intro to models that shows how I think.
    - ∗ Course Book
      - · Exercise (for Thurs): Continuous data
- Week 8
  - Topic: Correlating characters
  - Items: independent contrasts, Pagel 1994, Hansen OU
  - Reading
    - ∗ Felsenstein, 1985: Independent contrasts
    - ∗ Pagel, 1994: Pagel 94 correlation
    - ∗ Maddison & FitzJohn, 2015: A big problem with correlation (and other issues)
  - Exercise (for Thurs): Correlations
- Week 9
  - Topic: Biogeography and optimization
  - Reading
    - ∗ Ronquist and Sanmartin, 2011
    - ∗ Ree and Smith, 2008
  - Exercise: None this week, but continue working on past ones.
- Week 10
  - Topic: Diversification and SSE models
  - Items: diversitree, hisse
    - ∗ Magallon and Sanderson, 2001: As an empirical paper of ages, later work has improved on this, but it has extremely clear explanations of the math behind these methods.
    - ∗ Maddison, FitzJohn, and Otto, 2007: The BiSSE paper. Download it as a PDF: the equations do not render in the HTML.
    - ∗ Maddison & FitzJohn, 2015: Already read it, but reread for this week.
    - ∗ Beaulieu & O'Meara, 2016: A hidden state version of the BiSSE model.
  - Exercise: Diversification
- Week 11
  - Catching up
- Week 12
  - Topic: Simulating data
  - Items: TreeSim, geiger
  - Topic: Building a new comparative method

- Week 13
  - Topic: Testing a new comparative method
- Week 14
  - Topic: Student choice
  - Exercise: make an R package based on the NSF API.
- Week 11
  - Topic: Student choice
  - Exercise: Mixed data types. https://github.com/bomeara/phylometh_mixed.

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My goal is to have you learn. If you are having trouble with something in the course, or if there is a topic you just have to learn more about, let me know (email, office hours, online forum, etc.). Faculty often use evaluations at the end of the semester to get info from students so we can improve before the next class, but this does not help you directly. To allow the class to improve while you are taking it, I have created a site for anonymous feedback at https://www.brianomeara.info/feedback.html (and yes, it is really anonymous). Let me know things that are going well or poorly — both are important. I might not implement all your suggestions, but they will all be read and considered, generally the same day you submit them.

Any student who feels s/he may need an accommodation based on the impact of a disability should contact me privately to discuss specific needs. Please contact the Office of Disability Services at 865-974-6087 in Dunford Hall to coordinate reasonable accommodations for students with documented disabilities.

All relevant University policies (including, but not limited to, policies on academic integrity, attendance, etc.) apply to this course. In the case of any conflict between the policies in this syllabus and University policy, University policy applies. The instructor reserves the right to revise, alter, and/or amend this syllabus as necessary. Students will be notified by email of any such revisions, alterations, and/or amendments.