Augustana College

Reconstructing the Tree of Life

BIOL410 (Special Topics)

(Code name: Evolutionary Trees)
3 credits
Spring term 2018

Class time
MWF 8:30-9:45am at Olin 302

Instructor
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Site: http://rafamedina.com
Pronouns: he/him/his
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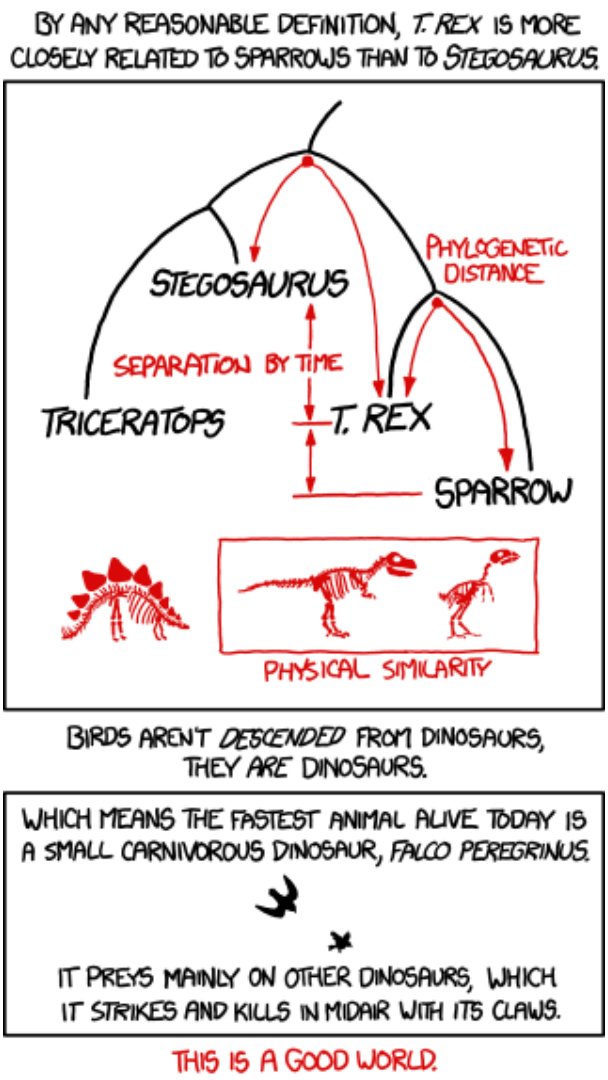
Office hours:
Mondays 2:30 to 4:00; Thursdays 9:00 to 10:30; and by appointment at your request.

Email policy: Under ordinary circumstances, I reply all emails within a 24h period (M-F), 8-6



Course Description and Goals
This course is an Introduction to Phylogenetics, the biological discipline responsible of disentangling the evolutionary history and relationships among all living organisms. Since "*Nothing in biology makes sense except in the light of evolution*", we will be spending the next weeks **making sense out of biology** by learning how to see organisms in evolutionary perspective and turn phenomena into stories.

In particular, after taking this course you will be able to: 1) Understand and discuss how evolutionary history is reconstructed and why it matters; 2) Create your own phylogenetic trees using molecular data freely available and applying different bioinformatic methods; and 3) Improve your skills reading and discussing critically current scientific literature.

These three objectives are connected to all the campus-wide learning outcomes of related to Intellectual Sophistication: Understand, Analyze, and Interpret. They are also reflected in the IDEA objectives of gaining a basic understanding of a subject; developing specific skills needed by professionals in the field; and learning appropriate methods for collecting, analyzing, and interpreting information.

Requirements
This course has no required textbook, although you have a suggested bibliography later in this document. Required reading materials (including the papers for discussion) and other relevant documents will be shared via Moodle. You are required to bring a laptop to class on a regular basis (you can borrow one from ITS if needed), and the following software should be installed and fully functional before class. If you have problems installing the software I can help you, but it is essential that you ask for help in advance. Many of these programs work on Java, so make sure that the Java of your system is updated.

FigTree v1.4.3. (http://tree.bio.ed.ac.uk/software/figtree/)

Notepad++ (Windows) https://notepad-plus-plus.org/
-OR-
TextWrangler (iOS) https://itunes.apple.com/us/app/textwrangler/id404010395?mt=12

PhyDE (http://www.phyde.de/download.html)

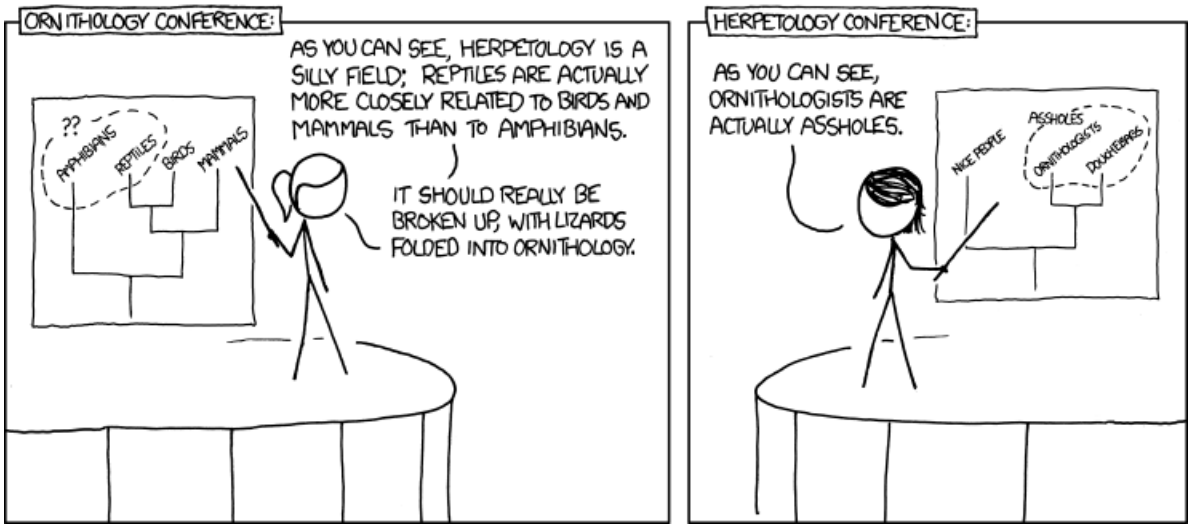
MEGA 6 (GUI) (We will use version 6 since version 7 does not run on 32-bit systems anymore)
http://www.megasoftware.net/older_versions

MrBayes v. 3.2.6. (http://mrbayes.sourceforge.net/download.php)

Tracer v1.6 (http://tree.bio.ed.ac.uk/software/tracer/)

BEAST (http://beast.community/installing)

Academic Accommodations
All students enrolled in this class who have a documented disability have the right to reasonable accommodations under the American with Disabilities Act. Students requesting accommodations are required to provide documentation of their disability to the Coordinator of Student Success Services. Please present the Accommodation Letter to me after class or during office hours in the first week of the term. Students who have or think they may have a disability are invited to contact the Coordinator of Student Success services for a confidential discussion.



Inclusive and respectful learning environment
Your successful learning in this class will depend on enjoying a professional, collaborative and friendly environment open to exchange and discussion of ideas. Be punctual to every class session, do not leave the class (unless in case of emergency), and keep a civil and respectful environment towards the other students and the instructor.

I am committed to make time in lectures a positive environment for learning irrespective of gender, sexual, racial, religious, or other identities. Students are invited to optionally share their preferred names and pronouns with the instructor and classmates. Honesty and courtesy are essential at all times. Any kind of discrimination based on race, class, gender, sexual orientation, national origin, etc. will not be tolerated. Students creating disturbance during class that interferes with the ability of other students to learn or distracts the instructor will be asked to leave.

Since we will be using laptops on a regular basis, you will be allowed to take notes with them if you prefer it. Using the laptops (or any other device) for non-class related purposes will be considered academic misconduct with effects on all the assignments of that particular class.

Academic Integrity
I expect you to maintain the highest ethical standards at all times. Evidence of dishonesty (including cheating, plagiarism or fabrication) during quizzes, research projects, and other evaluations will earn a zero (0) for that assignment. Additional penalties may also apply and the Honor Council will be notified. Please refer to the Honor Code website for more information.

Expectations
This is a 400-level class, meaning that you are expected to show a high independence and intellectual maturity. Although the focus of the class is phylogenetics, we will be discussing a number of diverse biology-related topics and you are expected to be ready to contribute, even if you need to find information by yourself. Working with computers may also be frustrating at times, but I expect you to be active and engaged even if you need to troubleshoot. Active participation is required on a regular basis, we will discuss as a group which system makes you feel more comfortable. This course is worth 3 credits, which means that you are expected to work 8-10 hours per week outside class.

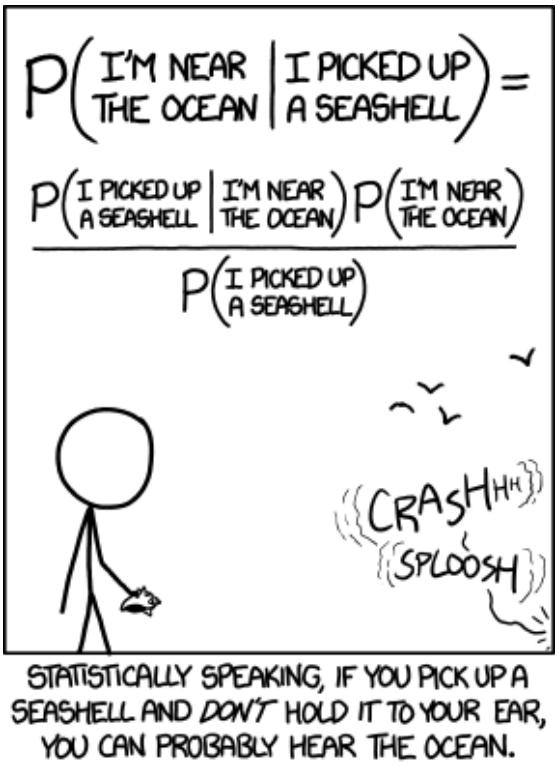
You are responsible to be well rested and prepared for class and keep track of the assignments and deadlines. This includes all the required readings, project progress, software, files, etc. Missing a class is not an excuse to be unprepared for the next one. Email me an evolution-themed meme before the third class and you will get five points. Punctual attendance is expected in all classes. Every student is allowed two unexcused absences. I *reserve the right* to reduce your class participation/assignments grade by 5% for every extra unexcused class absence (including arriving too late or leaving too early).

Absences may be excused, providing the appropriate documentation, due to illness or professional development (but not travel plans or sports). Absences due to family emergencies need to be approved by the Dean of Students. Late work is not acceptable on a regular basis, but it might be accepted exceptionally and at my discretion with a 5% penalty if turned in the 12 hours following the original deadline with a 10% incremental penalty for each day after.

Assessment and grading

Your grade will be based on a 500 point system:

Daily clicker quizzes	30%	150 pts
Paper discussion	20%	100 pts
Class participation	20%	100 pts
Project (paper)	20%	100 pts
Project (presentation)	10%	50 pts



Clicker quizzes. We will begin every class with a low-stake quiz worth up to 10 points implemented via clickers. There will be a total of 20 quizzes and I will drop your 5 lowest grades. The quizzes will evaluate understanding of phylogenetic theory and interpretation of trees (from the previous papers or others). These quizzes cannot be retaken.

Paper discussion. We will discuss 16 primary literature papers on phylogenetics (see schedule and references). The responsibility to lead and summarize this information will be shared. You are required to sign up once to perform either of these roles. You will find on Moodle specific instructions on this assignment. I do not expect you to understand 100% of the paper, but you are required to grasp its significance and to interpret correctly the phylogenetic results, even if this involves independent documentation.

Class participation. Since you are required to be engaged and take an active role in your learning as mature biologists, participation in class will be essential. During the first class meetings we will agree a system to count your active participation in a way that fits the majority of the students.

Project. Students will pair up to develop an original project in which they will use DNA sequences available at GenBank and perform phylogenetic analyses on a group of organisms of their choice. The project will be delivered as a paper and presented to the whole class during weeks 9 and 10. Specific instructions and requirements on this assignment are available on Moodle.

Grades will be determined on a point basis (not percentages) and they will not be curved. Extra credit opportunities may be offered at my discretion and will be available for the whole class.

Grading scheme:

490-500 = A+	440-449 = B+	390-399 = C+	300-349 = D
460-489 = A	410-439 = B	360-389 = C	<300 = F
450-459 = A-	400-409 = B-	350-359 = C-	

Important deadlines

- Paper summaries must be uploaded to Moodle in a 24-hr period (before the next day at 8:30 am)
- A project plan must be approved by me (even verbally) before the end of week 3 (Friday, 6 pm)
- A draft of your alignment must be submitted before the end of week 5 (Friday, 6 pm)
- Your final project (paper) must be turned before up to 11:59 pm of Symposium day

Tentative class schedule

Week	Date	Main topic	Bioinformatics	Paper discussion
1	03/05	Basic principles of phylogenetics and cladistics. Elements of a tree	Tree manipulation	
	03/07			Fitch & Margoliash (1967)
	03/09			Woese et al. (1990)
2	03/12	Basics of molecular phylogenetics. Alignment. Support	File formats GenBank Alignments (1)	Aguinaldo et al. (1997)
	03/14			
	03/16			Medina et al. (2012)
3	03/19	Molecular markers Distance methods	Alignments (2) Distance trees	Lagomarsino et al. (2017)
	03/21			
	03/23			Mitchell et al. (2014)
4	03/26	Parsimony. Long Branch Attraction, saturation	Parsimony trees	Lewis et al. (2017)
	03/28			
	03/30	**Easter recess**		
5	04/03	(**Muesday**). Paper discussion and work on alignments		Worobey et al. (2016)
		No lecture. Your alignment draft is due Friday at 6 pm		
6	04/09	Substitution models. Maximum Likelihood. Partitions	Model testing. ML trees	Filliol et al. (2006)
	04/11			
	04/13			Holden & Mace (1997)
7	04/16	Bayesian Inference. Divergence time estimates. Reconstruction of characters	Bayesian Inference trees	Poux et al. (2005)
	04/18			
	04/20			Boutellis et al. (2014)
8	04/23	Conflict among trees Coalescence Theory	Divergence Time Estimates	Fehrer et al. (2007)
	04/25			
	04/27			Cahill et al. (2013)
9	04/30	Phylogenomics	Work on projects	Morris et al. (2018)
	05/02	**Symposium day. Projects must be turned before 11:59 pm**		
	05/04	Wrap up. Project presentations		Prum et al. (2015)
10	05/07	Project presentations		
	05/09			
	05/11			

Reference books

Felsenstein, J. 2004. Inferring Phylogenies. Sinauer Associates, Inc. Sunderland, MA

Hall, B.G. 2017. Phylogenetic Trees Made Easy. 5th Ed. Oxford University Press. Oxford

Hamilton, A. (Ed.). 2014. The Evolution of Phylogenetic Systematics. University of California Press. Berkeley and Los Angeles

Lemey, P., Salemi, M., Vandamme, A.M. (Eds.) 2009. The Phylogenetic Handbook. A Practical Approach to Phylogenetic Analysis and Hypothesis Testing.2nd Ed. Cambidge University Press. Cambridge

Page, R.D., Holmes, E.C. 1998. Molecular Evolution: A Phylogenetic Approach. Wiley-Blackwell. London

Comic credits: xkcd.com. (Once you understand the three of them, you probably deserve an A)

Papers for class discussion (available for download in Moodle)

Week 1

Fitch, W.M., Margoliash, E., 1967. Construction of Phylogenetic Trees. Science 155, 279-284. doi:10.2307/1720651

Woese, C.R., Kandler, O., Wheelis, M.L., 1990. Towards a natural system of organisms: proposal for the domains Archaea, Bacteria, and Eucarya. Proc. Natl. Acad. Sci. U. S. A. 87, 4576–4579. doi:10.1073/PNAS.87.12.4576

Week 2

Aguinaldo, A.M.A., Turbeville, J.M., Linford, L.S., Rivera, M.C., Garey, J.R., Raff, R.A., Lake, J.A., 1997. Evidence for a clade of nematodes, arthropods and other moulting animals. Nature 387, 489–493. doi:10.1038/387489a0

Medina, R., Lara, F., Goffinet, B., Garilleti, R., Mazimpaka, V., 2012. Integrative taxonomy successfully resolves the pseudo-cryptic complex of the disjunct epiphytic moss *Orthotrichum consimile* s.l.(Orthotrichaceae). Taxon 61, 1180–1198.

Week 3

Lagomarsino, L.P., Forrestel, E.J., Muchhala, N., Davis, C.C., 2017. Repeated evolution of vertebrate pollination syndromes in a recently diverged Andean plant clade. Evolution (N. Y). 71, 1970–1985. doi:10.1111/evo.13297

Mitchell, K.J., Llamas, B., Soubrier, J., Rawlence, N.J., Worthy, T.H., Wood, J., Lee, M.S.Y., Cooper, A., 2014. Ancient DNA reveals elephant birds and kiwi are sister taxa and clarifies ratite bird evolution. Science 344, 898–900. doi:10.1126/science.1251981

Week 4

Lewis, L.R., Biersma, E.M., Carey, S.B., Holsinger, K., McDaniel, S.F., Rozzi, R., Goffinet, B., 2017. Resolving the northern hemisphere source region for the long-distance dispersal event that gave rise to the South American endemic dung moss *Tetraplodon fuegianus*. Am. J. Bot. 104, 1651–1659. doi:10.3732/ajb.1700144

Week 5

Worobey, M., Watts, T.D., McKay, R.A., Suchard, M.A., Granade, T., Teuwen, D.E., Koblin, B.A., Heneine, W., Lemey, P., Jaffe, H.W., 2016. 1970s and "Patient 0" HIV-1 genomes illuminate early HIV/AIDS history in North America. Nature 539, 98–101. doi:10.1038/nature19827

Week 6

Filliol, I., Motiwala, A.S., Cavatore, M., Qi, W., Hazbon, M.H., Bobadilla del Valle, M., Fyfe, J., Garcia-Garcia, L., Rastogi, N., Sola, C., Zozio, T., Guerrero, M.I., Leon, C.I., Crabtree, J., Angiuoli, S., Eisenach, K.D., Durmaz, R., Joloba, M.L., Rendon, A., Sifuentes-Osornio, J., Ponce de Leon, A., Cave, M.D., Fleischmann, R., Whittam, T.S., Alland, D., 2006. Global Phylogeny of Mycobacterium tuberculosis Based on Single Nucleotide Polymorphism (SNP) Analysis: Insights into Tuberculosis Evolution, Phylogenetic Accuracy of Other DNA Fingerprinting Systems, and Recommendations for a Minimal Standard SNP Set. J. Bacteriol. 188, 759–772. doi:10.1128/JB.188.2.759-772.2006

Holden, C., Mace, R., 1997. Phylogenetic analysis of the evolution of lactose digestion in adults. Hum. Biol. 69, 605–28.

Week 7

Boutellis, A., Abi-Rached, L., Raoult, D., 2014. The origin and distribution of human lice in the world. Infect. Genet. Evol. 23, 209–217. doi:10.1016/j.meegid.2014.01.017

Poux, C., Madsen, O., Marquard, E., Vieites, D.R., de Jong, W.W., Vences, M., 2005. Asynchronous Colonization of Madagascar by the Four Endemic Clades of Primates, Tenrecs, Carnivores, and Rodents as Inferred from Nuclear Genes. Syst. Biol. 54, 719–730. doi:10.1080/10635150500234534

Week 8

Cahill, J.A., Green, R.E., Fulton, T.L., Stiller, M., Jay, F., Ovsyanikov, N., Salamzade, R., St. John, J., Stirling, I., Slatkin, M., Shapiro, B., 2013. Genomic Evidence for Island Population Conversion Resolves Conflicting Theories of Polar Bear Evolution. PLoS Genet. 9, e1003345. doi:10.1371/journal.pgen.1003345

Fehrer, J., Gemeinholzer, B., Chrtek, J., Bräutigam, S., 2007. Incongruent plastid and nuclear DNA phylogenies reveal ancient intergeneric hybridization in *Pilosella* hawkweeds (*Hieracium*, Cichorieae, Asteraceae). Mol. Phylogenet. Evol. 42, 347–361. doi:10.1016/j.ympev.2006.07.004

Week 9

Morris, J.L., Puttick, M.N., Clark, J.W., Edwards, D., Kenrick, P., Pressel, S., Wellman, C.H., Yang, Z., Schneider, H., Donoghue, P.C.J., 2018. The timescale of early land plant evolution. Proc. Natl. Acad. Sci. U. S. A. 201719588. doi:10.1073/pnas.1719588115

Prum, R.O., Berv, J.S., Dornburg, A., Field, D.J., Townsend, J.P., Lemmon, E.M., Lemmon, A.R., 2015. A comprehensive phylogeny of birds (Aves) using targeted next-generation DNA sequencing. Nature. doi:10.1038/nature15697