



INTEGRATIVE BIOLOGY 160: EVOLUTION

Table of Contents

Course Description:	Page 2
Course Values:	Page 4
Academic Integrity:	Page 6
Grades:	Page 7
Course Material	Page 8
Contact Information	Page 9
Course Calendar	Page 11

Course Structure

Lecture and Discussion sections are in-person. Attendance is required in both because the course is interactive. **Please wear a k95/n95 masks in class.**

Lectures are based on the primer I have written for you and in-class objects such as fossils, and slides.

Discussion sections are led by three GSIs who are Ph.D. students. They run the sections and handle logistics for both the lecture and discussion (e.g., if you seek an excused absence).

Course Resources

Prof. Noah Whiteman
whiteman@berkeley.edu

<https://bcourses.berkeley.edu/1517308>

Free primer

IB 160 COURSE DESCRIPTION.

The goal of this course is to provide a clear evolutionary context for understanding biology, from the origin of the cell to human intelligence. Evolution is the most fundamental biological concept. As the Ukrainian-American evolutionist Theodosius Dobzhansky wrote, **"Nothing in biology makes sense except in the light of evolution."**

To understand the progression of evolution as a field requires that **we place discoveries in their historical context.** It may seem banal to learn about a long-dead evolutionary biologist, but doing so can help us understand that science is a human endeavor and is a product of its moment in history and of the personalities involved. Placing evolutionary biology in this context reveals how modern biology was built through human economies aided by colonization, subjugation and exploitation, in addition to brilliant insights, everyday discoveries, hard work, privilege, and luck. Instead of focusing on the memorization of facts, **the course is taught through a dialectical lens.** This means that hypotheses and the data to test them are

presented from differing perspectives via major intellectual players in the history of the field as we understand them to be. Please be prepared for me to use the "devil's advocate" and a gentle form of the Socratic method in class.

The process of decolonizing our pedagogy is ongoing, we appreciate feedback and insight from students in these materials, which is a living curriculum, constantly changing and improving. If you see typos or confusing sentences or terms, please email me and let me know (whiteman@berkeley.edu).

You will gain the ability to discern plausible from confused interpretations of evolution. I hope this course will allow you to take a dispassionate view of how life on Earth came to be, but at the same time, that it stokes your passion about the beauty of our biosphere, the great improbable gift of your own individual life, and the wonder of it all.

You will learn how to link microevolutionary processes with macroevolutionary patterns, based on theory, evidence from the geologic record, organic chemistry, biochemistry and cell biology, classical genetics, genome editing experiments, experimental evolution, etc.

You will learn to use tree-thinking as the foundational way of understanding evolution from the origin and spread of a new mutation over time, inferring the tree of life, quantifying the pace of molecular and phenotypic evolution, to tracing the origin and genetic architecture of adaptation.

Just as you will learn the importance of tree-thinking, you will appreciate why Professor Michael Lynch has paraphrased Dobzhansky and said "Nothing in biology makes sense except in the light of population genetics." The same can be said for deep time: "Nothing in biology makes sense except in light of the fossil record."

You will learn to place humans in the context of the evolution of life, and address questions everybody who has ever lived, and will live, wants to know: "Who are we and where did we come from?"

We are so fortunate that human consciousness allows us to be made aware of the nature of the universe, at least in part.

The quest for understanding the evolution of life on Earth is at the heart of the human condition. It is our both our burden and our blessing to grapple with the fact that our

individual lives emerged from the atoms created by the hearts of stars.

Science does not hold all the answers to these fundamental questions, especially of the nature of human values, our purpose, and life's meaning. Science is a way of knowing, and one of the most successful, but my view is that there are other "magisteria" as Stephen Jay Gould put it, and other ways of knowing that are required to understand the human condition. I raise all of this because this course may challenge you in unexpected ways.

The course may change your view of what it means to be human. I hope you agree that this is a good thing in the spirit of our university's motto "Fiat Lux" or "Let there be Light."

In science, facts are provisional, which is not true for all epistemologies (ways of knowing). Our course is rooted in science as way of understanding the physical universe. Evolution is necessary, but not sufficient for understanding the human condition, however. This is why you need the full breadth of the liberal arts education that Berkeley gives you. Please attend office

hours, ask probing questions and engage with us in discussion.

COURSE VALUES. I (pronouns: he/him/his) am a tenured faculty member at the Full Professor rank in the Department of Integrative Biology (50%) and the Department of Cell and Molecular Biology (50%). I am an affiliate of the Helen Wills Neuroscience Institute, Center for Computational Biology, Museum of Vertebrate Zoology, Essig Museum of Entomology and University and Jepson Herbaria. My research laboratory studies the ancient, ongoing battle between hosts and parasites, and specialize on those ecological interactions between toxic plants and the animals that eat them. I am fascinated by the origin of new adaptation and counter-adaptation in each lineage (co-evolution). You can think of my research program as inspired by the children's book "The Very Hungry Caterpillar." I am a principal investigator of a large NIH-funded lab with two permanent research associates, six Ph.D. students, three postdoctoral scholars, and undergraduates. As a 2020 Guggenheim Fellow, I am writing a book that explores the deep relationship humans and all other land animals have had with toxic plants and other

organisms like fungi—from the plant-animal co-evolution to the Spice Trade, our modern opioid epidemic, and the pharmaceutical potential of psychedelic alkaloids in treating mental health disorders like drug abuse.

I grew up in the wilderness of northeastern Minnesota, graduating with only 15 other people. I am a first-generation college student (and I just paid off my student loans two years ago at age 44) and the first out LGBTQIA+ faculty member in Integrative Biology at UC-Berkeley (as was true in my department at the University of Arizona where I was for 6 years prior to moving here in 2016). I am keen to encourage students from all backgrounds, places, and walks of life to pursue their interests, wherever it takes them, and in changing STEM to be more inclusive, equitable and diverse.

I am your ally, I care about your well-being, and want you to succeed in this class, in pursuit of your degrees and in life.

I know what it is like to struggle financially and personally as a first generation student from a minoritized background. It can be incredibly isolating. It was hard for me to relate to students whose parents were

professionals and at the same time hard to relate my family who seemed to love me back home even if they didn't know how to provide the support I needed while pursuing my education and a life very different from theirs.

But, if I can do it, I know you can do this! You BELONG at Berkeley and rightly earned your spot here.

I know that by being my authentic self, I have been able to both achieve success as a scientist and to feel like I belong in each university where I have worked. This extends from the small college I attended that was run by socially progressive Roman Catholic Benedictine monks on the tallgrass prairie of central Minnesota to the Museum of Comparative Zoology at Harvard University and Department of Molecular Biology at Harvard Medical School, where I did my postdoctoral fellowship, to UC-Berkeley, where I am now. Still, sometimes, it is not easy, even for me as I wonder if I "belong." Let's be there for one another in the ways that we are able.

It is safe to be your authentic selves in IB 160. Please let us know your preferred pronouns and how we can make the course

more welcoming. We want you to be as comfortable as possible. I may slip up when trying to be inclusive and always try to catch myself but I'm not perfect. I know what it is like for assumptions to cause pain, and that's the last thing I want to do.

The unfolding pandemic is deeply challenging to all of us and it is impacting our society unevenly. While we will learn about the evolution of viruses, I decided to steer clear of the evolution of the virus SARS-CoV-2 that causes COVID-19 in this course because it is still too close to home—some of us may have been infected or known somebody who has—and some may have loved ones who have fallen severely ill or even passed away. Importantly, we are still in the early stages of understanding the evolution of this virus. For these two reasons, I will by and large leave the specifics of SARS-CoV-2 out of the course material. On the other hand, my hope is that this course will give you the tools to understand for yourselves, and to be able to explain to others, why there is no compelling evidence that SARS-Cov-2 has been engineered by humans (for example). The molecular evolutionary and phylogenetic

skills you will learn can be applied to this and every other case of evolution.

GSIs and PhD candidates **Sylvia Durkin, Jenn Wagner and Lexi Black** represent the best of our graduate trainees and have expertise in evolutionary biology. Sylvia studies the evolution of mammalian tails, Jenn studies the evolution of plants as revealed by the fossil record, and Lexi studies the physiology and behavior of small mammals.

Your success in this class is important to me and the GSIs. Each of us learns differently and we are here to accommodate these differences as best as we can. If there are aspects of this course that prevent you from learning or you feel may exclude you, let us know. Together, we'll develop strategies to meet your needs and requirements of the course.

Please visit the Disabled Students' Program (<https://dsp.berkeley.edu>) to determine how you could improve your learning. If you need official accommodations (DSP), you have a right to have these needs met. It is important that you inform the DSP office as soon as possible

to arrange for these accommodations. We take privacy and FERPA regulations seriously.

ACADEMIC INTEGRITY. You are a member of an academic community at one of the world's most lauded public research universities. Universities like UC-Berkeley create knowledge with a lasting impact in the world. Such knowledge creation can be sparked by a comment from an undergraduate or from an internationally known professor.

Please adhere to the Berkeley Honor code: "As a member of the UC Berkeley Community, I act with honesty, integrity and respect for others."

One of the most important values of an academic community, is the balance between the free flow of ideas and the respect for the intellectual property of others. Researchers don't use another's without permission, scholars and students always strive to use proper citations in papers, professors may not circulate or publish student papers without the writer's permission, and students may not circulate or post materials (handouts, primes, slides, exams, quizzes, photographs, screen captures, videos, audio recordings, syllabi--any class materials) from

their classes **without the written permission of the instructor.**

Any test, paper or report submitted by you and that bears your name is presumed to be your own original work that **has not previously been submitted** for credit in another course. In all of your assignments, including your homework or drafts of papers, you may use words or ideas written by other individuals in publications, web sites, or other sources, but only with proper attribution (direct quotes must always be bounded by parentheses or indented and set apart from your text). If you are not clear about the expectations for completing an assignment or taking a test or examination, **be sure to seek clarification from us beforehand.**

Finally, you should keep in mind that as a member of the campus community, you are expected to demonstrate the highest integrity in all of your academic endeavors and will be evaluated on your own merits. **The consequences of cheating and academic dishonesty**—including a formal discipline file, possible loss of future internship, scholarship, or employment opportunities, and denial of admission to graduate school—**are simply not worth it.** Anyone caught cheating on a quiz, exam or

paper will receive a failing grade and be reported to the University Office of Student Conduct.

In order to ensure that you are not suspected of cheating, please keep your eyes on your own materials and do not converse (in person or electronically) with others during the quizzes and exams. It is not permissible under any circumstances to use any material, electronically obtained or otherwise, to aid in exams or quizzes while taking them. If you have a question during a quiz or exam, please raise your hand and we will make this available to you and we will address it. We appreciate your attention to these important matters.

GRADES. There are two midterms and a comprehensive final (but note that the final exam will emphasize the last 10 lectures of the course). Each exam is worth 25% of the course grade ($3 \times 25\% = 75\%$). Study questions will be made available about one week before each exam and are given to help you study; there is no guarantee that they will be on the exam or that other material won't be on the exam that isn't on the study sheet. A review session will be held in class before each exam. ****Questions related to the course materials will not be**

answered (either in person or electronically) by us after the review session prior to each exam.** This requires that you prepare accordingly. The discussion section as a whole, including a research paper (10%), weekly discussion questions and worksheets (10%), and quality of participation during discussion (4%) count for 24% of the course grade. The syllabus for discussion section will be provided to you by your GSIs and you should direct questions about the discussion section to them. The final 1% of the grade is determined by your level of participation in lecture, which I measure in lecture time through your electronic responses to the in-class quiz (please bring a laptop or cell phone to class with WiFi or cell capability). It should be easy to get the full 1% of these participation points since all that is required is your in-person participation. You are not allowed to submit quizzes if you are not physically present in class nor can another student do so on your behalf. If you have an excused absence, we will note this and give you a point for missing that day so it doesn't count against you.

This course is not graded on a curve—we use standard grading. Course point

totals are converted to %, which corresponds to a letter grade:

<i>%</i>	<i>Grade</i>
≥ 97.5	A+
≥ 92.5	A
≥ 90.0	A-
≥ 87.5	B+
≥ 82.5	B
≥ 80.0	B-
≥ 77.5	C+
≥ 72.5	C
≥ 70.0	C-
≥ 67.5	D+
≥ 62.5	D
≥ 60.0	D-
< 60.0	F

These grade boundaries are absolute and **strictly adhered to** in order to keep grading policy transparent and fair. I do not round up before converting your course percentage to a letter grade because to do so changes all of the cutoffs (a ripple effect), and the entire table would need to be re-set accordingly. Please respect that these cutoffs are not negotiable—if you earned 89.9 you will get a B+, if you earned 90.0 you will get an A-, etc. It is important that you fully understand this framework at the outset.

COURSE MATERIALS. To reduce the costs associated with this class, there is no required textbook. Instead, I have written a primer just for you. A pdf of this primer will

be uploaded to bCourses by the end of the day on Friday and will cover the next week's lecture material. It is a work in progress so if you see typos, unclear sentences, etc. please write me and let me know and I will correct or clarify as needed.

PARTICIPATION. Participating in Lecture and Discussion sections is mandatory. There will be graded exercises during each lecture, so please be sure to attend. Because some of you may fall ill, have a family member pass away, or have a personal crisis, I videotape the lectures so you can watch them after class. Discussion sections will only work well if you attend each one. You are all adults—life happens, and an occasional absence is fine and excusable by telling your GSI ahead of time if at all possible, unless it is truly an emergency or crisis. We respect your privacy and don't need to know the details of why you had to miss class. Please do not email me (Professor Whiteman) about absences or other logistical issues. Your GSIs will handle the Lecture and Discussion course logistics and have and

have delegated authority to excuse absences in both Lecture and Discussion.

If you are really into evolution and plan to study it in more depth, I recommend purchasing Douglas Futuyma's textbook "Evolution." It is excellent and co-written with Mark Kirkpatrick now.

CONTACT INFORMATION. We are happy to take questions during discussion sections and office hours. **The best way to communicate with us is during office hours, not over email (except in urgent situations to your GSIs).**

Professor Noah Whiteman's office hours:
11:15-noon on Mondays, VLSB 2063
Email: whiteman@berkeley.edu

GSI Sylvia Durkin's office hours:
3:10pm on Thursdays, VLSB 3007
Email: sdurkin@berkeley.edu

GSI Jenn Wagner's office hours:
9:10 am on Fridays, VLSB 3007
Email: jenn_wagner@berkeley.edu

GSI Lexi Black's office hours:
11:10 am on Wednesdays, VLSB 3007
Email: ablack17@berkeley.edu

Should a campus emergency arise (e.g., unforeseen closure due to wildfires, terrorism, pandemic), I will alert you about the status of our lecture those days as soon as I am able, via an announcement on bCourses and will adjust the syllabus accordingly. It is likely we will simply switch to asynchronous lectures uploaded to bCourses since they are already being recorded and synchronous Discussion sections. Please familiarize yourself with earthquake and other life safety situations that we must, unfortunately, consider and, particularly, the location of all exits in our rooms and all those in VLSB. Office hours and exam review sessions are a great time to discuss concepts more deeply, and to clarify lecture.

Finally, it is fine to come to office hours to listen to the questions of other students and get to know the instructional staff better, as long **as you come with at least one question of your own.** It could be about the material or even my journey in science, etc. Questions on problem sets should be covered with GSIs during the discussion section. In office hours, we are happy to discuss career options in biology and what it is like to be a scientist. We will use bCourses extensively, including the announcements and discussion features. All reading material for the course, including all this syllabus, slides, primer, problem sets and papers for discussion section will be uploaded as PDFs to bCourses.

IB 160 LECTURE SCHEDULE, 2022, MWF 10-11am, VLSB 2060 IN PERSON

(D) = Discussion sections meet on these Fridays. Syllabus is subject to change, updates given in class.

Lecture #	Day	Date	Lecture Topic
1	W	8/24	(1) Course structure and introduction and (2) History of evolutionary biology
2	F	8/26	Evolution by artificial and natural selection: corn, dogs, flies, mice, pigeons & finches
3	M	8/29	Phylogeny 1: Darwin's tree to the tree of life
4	W	8/31	Phylogeny 2: tree thinking & trait evolution
5	F	9/2 (D1)	Phylogeny 3: reconstructing evolutionary trees
NO CLASS	M	9/5	Labor Day
6	W	9/7	Mutation: the ultimate source of heritable variation
7	F	9/9 (D2)	Evolution at a single locus 1: genetic drift
8	M	9/12	Evolution at a single locus 2: natural selection
9	W	9/14	Evolution at a single locus 3: migration and mutation
10	F	9/16(D3)	Evolution at multiple loci 1: linkage, linkage disequilibrium and recombination
11	M	9/19	Evolution at multiple loci 2: quantitative trait evolution, QTL and GWAS mapping
12	W	9/21	Evolution at multiple loci 3: heritability & the breeder's equation
REVIEW 1	F	9/23 (D4)	Midterm 1 review in class
EXAM 1	M	9/26	Midterm 1 in class
13	W	9/28	Adaptation 1: definitions, experiments, observations & "spandrels"
14	F	9/30(D5)	Adaptation 2: geometric model & abiotic/biotic agents of selection
15	M	10/3	Adaptation 3: sexual selection
16	W	10/5	Adaptation 4: cooperation and conflict
17	F	10/7 (D6)	Adaptation 5: co-evolution
18	M	10/10	Molecular evolution 1: neutral theory of molecular evolution
19	W	10/12	Molecular evolution 2: natural selection and the molecular basis of adaptation
20	F	10/14 (D7)	Genome evolution 1: mutational hazard hypothesis
21	M	10/17	Genome evolution 2: gene duplication & horizontal transfer
22	W	10/19	A case study in adaptation: toxin resistance in the monarch butterfly
23	F	10/21 (D8)	Origin of species 1: types of speciation
24	M	10/24	Origin of species 2: isolating mechanisms
25	W	10/26	Origin of species 3: speciation with gene flow & hybridization
REVIEW 2	F	10/28 (D9)	Midterm 2 review in class
EXAM 2	M	10/31	Midterm 2 in class
26	W	11/2	Origin of the Earth, continents, oceans, seasons & glacial cycles
27	F	11/4 (D10)	Origin of Life 1: RNA world, origin & diversification of prokaryotes & viruses
28	M	11/7	Origin of Life 2: origin & diversification of eukaryotes & multicellularity
NO CLASS	W	11/9	Veterans Day (thank you Veterans)
29	F	11/11 (D11)	The fossil record: Origination and extinction, & mass extinction
30	M	11/14	The fossil record: Punctuated vs. gradual patterns of morphological change
31	W	11/16	Major lineages 1: Origin & diversification of plants
32	F	11/18 (D12)	Major lineages 2: Origin & diversification of arthropods
33	M	11/21	Major lineages 3: Origin & diversification of vertebrates
NO CLASS	W	11/23	No class – Thanksgiving Break
NO CLASS	F	11/25 (D13)	No class – Thanksgiving Break
34	M	11/28	The evolution of development (evo-devo)
REVIEW 3	W	11/30	Final exam review in class
EXAM 3	M	12/12	Final exam, 8-11am, LOCATION TDB