Graduate Program in Integrative Biology

Chair: Michael I. Coates
Director of Graduate Studies: Mark Westneat

Professors

- Zeresenay Alemseged
- Michael I. Coates
- Edwin L. Ferguson, Molecular Genetics & Cell Biology
- Melina E. Hale
- Nicholas G. Hatsopoulos
- Robert K. Ho
- David Jablonski, Geophysical Sciences
- Marcus Kronforst, Ecology & Evolution
- Raphael Lee, Surgery
- Zhe-Xi Luo
- Daniel Margoliash
- Nipam Patel, Marine Biological Laboratory
- Victoria E. Prince
- Clifton Ragsdale, Neurobiology
- Russell Reid, Surgery
- Callum F. Ross
- Urs Schmidt-Ott
- Paul Sereno
- Neil H. Shubin
- Mark Westneat

Associate Professors

- Stephanie Palmer
- Graham Slater, Geophysical Sciences

Assistant Professors

- Matthew Kaufman
- Heather Marlow
- Jasmine Nirody
- Zewdi Tsegai

Faculty

- Kenneth Angielczyk, Field Museum
- Andrew Gillis, Marine Biological Laboratory
- Josh Rosenthal, Marine Biological Laboratory

Emeritus Faculty

- Martin Feder
- James A. Hopson
- Michael LaBarbera
- R. Eric Lombard

The graduate program in integrative biology is housed in the Department of Organismal Biology and Anatomy (OBA), which has a long history of training students in integrative organismal biology. During the 1970s, the focus of the (then) Department of Anatomy shifted from the classic purview of anatomy departments in the middle of the 20th century — histology, neurobiology, and cell biology — to more comparative and functionally oriented topics and an explicit focus on evolutionary biology and functional morphology. The neurobiology section of the department expanded first into explicitly comparative areas and later into neuroethology. Over the next twenty years the department evolved into its present configuration with research

and teaching foci which include biomechanics/functional morphology, organismal neurobiology, developmental biology, and evolutionary biology, all unified by a shared reference point in the biological hierarchy — the organism — an entity we see as the natural reference for all of the biological sciences since it is the natural unit of selection. We see the intellectual areas presently housed in OBA as inextricably and naturally connected. To understand the organismal level in biology requires an understanding of both how organisms have been shaped over evolutionary time scales and how they are generated on developmental time scales, the various interacting tissue and organ systems that generate organismal functions, and the mutual feedback among these functional, evolutionary, and developmental processes. The high degree of connectivity among our core disciplines is exemplified by the integrative nature of student dissertation projects in OBA and by the high level of interaction and collaboration among our faculty; both faculty and graduate student research in OBA frequently span several of these areas. In recent years there has been a resurgence of interest in and appreciation for organismal-level biology on the national level, putting molecular, genetic, and computational tools and information to use to understand broader systems-level questions. OBA and its integrative biology program has been actively positioning itself as a leader in research and graduate training in this endeavor.

Research and training in the graduate program focus on the integration of four overlapping areas:

1. Biomechanics: the application of methods from engineering and physics to understanding the design of organisms.
2. Developmental Biology: understanding how information coded into the genome is translated into the patterns seen in organisms. Our developmental biology program has a special emphasis on the interface between evolution and development, an area sometimes called "EvoDevo".
3. Neurobiology: understanding how the nervous system regulates and controls the behavior of animals. Our neurobiology program has a special emphasis on the relationship of the nervous system to behavior (or neuroethology) and the application of quantitative methods to understanding neural function (computational neuroscience).
4. Paleontology: documenting and understanding evolutionary patterns and processes through analyses of the fossil record.

Training in the department places an emphasis on familiarity with a broad range of ideas and skills in organismal biology. Although students can conduct research in any of the areas represented in the department, they are encouraged to develop research programs that capitalize on the talents of two or more faculty members with different perspectives. The department also encourages students to interact with other units on campus (such as the Department of Ecology and Evolution and the Committees on Development, Regeneration and Stem Cell Biology; Evolutionary Biology; Genetics, Genomics and Systems Biology; and Neurobiology) as well as the Field Museum of Natural History, the Brookfield and Lincoln Park zoos, the Shedd Aquarium, and the Marine Biological Lab at Woods Hole. Students earning doctorates through the department will be qualified, following suitable postdoctoral training, for research and teaching careers in biology departments, anatomy departments and museums.

Degrees

Master of Science

Students are not admitted to the program for the sole purpose of obtaining a Master of Science degree, but this degree is awarded to students from other academic units who require a Master of Science degree as one requirement for the doctorate.

Doctor of Philosophy

The requirements for the Doctor of Philosophy are as follows:

- Course requirements are individualized and are defined for students early in their stay in the program, based on the student's background and interests. Students will complete a course distribution requirement by the end of their second year. Students must fulfill the divisional requirement of serving as a teaching assistant in two courses and completing ethics training.
- The preliminary examination, consisting of a written segment which covers a range of topics in organismal biology, as well as both the oral and written presentation of a directed research project or dissertation research proposal.
- The completion of a research project and the presentation of a dissertation satisfactory to the department faculty.
- The passing of a final oral examination.

Admission

We strongly advise students considering application to the graduate program to begin preparation of their application early in the autumn quarter, so that all materials will arrive by the annual deadline (https://biosciences.uchicago.edu/admissions/how-to-apply/). International applicants whose first language is not English also must submit TOEFL test scores with their application materials. Further information also may be obtained from the department's home page at http://integbio.uchicago.edu (http://pondside.uchicago.edu/).

Courses

Didactic and seminar courses are offered in each of the departmental research foci. The specific courses presented vary from year to year. A list of current courses can be obtained by contacting the graduate program administrator. Students are encouraged to take courses related to their interests in other academic units on campus.

Organismal Biology and Anatomy Courses

ORGB 30001. The Human Body. 125 Units.
The Human Body course is the first component of the Scientific Foundations of Medicine curriculum in Year 1. The Human Body course will provide you with a foundation in the structural organization of the body. You will learn gross anatomy of the back, thorax, abdomen, pelvis, head and neck, and upper and lower limbs through large and small group teaching sessions, as well as cadaver dissection. Correlations with Radiology and Surgery are an integral part of the course and provide real world clinical context for the anatomic material.
Instructor(s): C. Ross Terms Offered: Autumn
Note(s): For Pritzker students only, unless by instructor consent

ORGB 30002. PE: The Human Body. 300.00 Units.

ORGB 30250. Chordates: Evolution and Comparative Anatomy. 100 Units.
Chordate biology emphasizes the diversity and evolution of modern vertebrate life, drawing on a range of sources (from comparative anatomy and embryology to paleontology, biomechanics, and developmental genetics). Much of the work is lab-based, with ample opportunity to gain firsthand experience of the repeated themes of vertebrate body plans, as well as some of the extraordinary specializations manifest in living forms. The instructors, who are both actively engaged in vertebrate-centered research, take this course beyond the boundaries of standard textbook content.
Instructor(s): M. Coates Terms Offered: Winter. L.
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence, including BIOS 20187 or BIOS 20235
Note(s): Offered Winter during even years. E.
Equivalent Course(s): BIOS 22250, EVOL 30200

ORGB 30260. Chordate Evolutionary Biology. 100 Units.
TBD
Equivalent Course(s): BIOS 20260

ORGB 30400. Primate Evolution. 100 Units.
This course explores the diverse primate radiation throughout 65 million years of their evolutionary history. This includes a focus on primate origins and adaptive changes across different primate groups, as well as an emphasis on the biomechanics of the locomotor and feeding systems. Through a combination of lectures and readings, students will gain opportunities to deepen their understanding of key topics in primate evolution. A field trip to the Lincoln Park Zoo is also required.

ORGB 30415. Evolution Before Darwin. 100 Units.
This course will explore the emergence and development of evolutionary thought prior to Charles Darwin's On the Origin of Species (1859). We will pay particular attention to the way in which transformism was a feature of nineteenth-century thought more generally, connecting natural history to astronomy, theology, and the study of humanity. Natural philosophers and later scientists who wished to make arguments concerning nature's deep past and hidden or obscured processes (such as the long-term transformations of stars, strata, and organic species) faced an essential problem: the power of observation and experiment was limited. Our class will interrogate this problem, and examine the way in which the development of evolutionary thought prior to Darwin was intimately connected to contentious debates regarding speculation and scientific method. We will conclude by contemplating the ways in which the ideas and challenges raised by transformism and evolution influenced the reception of Darwin's work, and the way in which these ideas and challenges remain embedded within seemingly disparate fields of study today.
Instructor(s): J. Daly Terms Offered: Winter
Equivalent Course(s): KNOW 21415, HIST 25316, HIPS 21415, ECEV 30415

ORGB 30510. Evolution and the Nervous System. 100 Units.
Evolutionary neuroscience has traditionally focused on the neural bases of animal behavior (neuroethology) and employed the methods of comparative anatomy, cellular neurophysiology and behavioral neuropsychology. This course will approach neuroethology from a modern evolutionary perspective, one that integrates findings from genomics, molecular developmental biology and paleontology with insights from neuroethology. Our exploration will include the controversies over the evolutionary origin of neurons and centralized brains, the independent solutions across taxa to processing ecologically important sensory information, and recent insights into the evolution of the neocortex.
Instructor(s): C. Ragsdale Terms Offered: Winter
Prerequisite(s): NSCI 20101 and NSCI 20130, or consent of instructor
Equivalent Course(s): NSCI 20510

ORGB 31201. Mammalian Evolutionary Biology. 100 Units.
This course examines mammalian evolution-the rise of living mammals from ancient fossil ancestors stretching back over 300 million years. Lectures focus on the evolutionary diversification of mammals, including anatomical structure, evolutionary adaptations, life history, and developmental patterns. Labs involve detailed comparative study of mammalian skeletons, dissection of muscular and other systems, trips to the Field Museum to study fossil collections, and studies of human anatomy at the Pritzker School of Medicine. Students will learn mammalian evolution, functional morphology, and development, and will gain hands-on experience in dissection. Taught by instructors who are active in scientific research on mammalian evolution, the course is aimed to convey new insights and the latest progress in mammalian paleontology, functional morphology, and evolution. Prerequisite(s): Second-year standing and completion of a Biological Sciences Fundamentals sequence; or GEOS 13100-13200 or GEOS 22300, or consent of instructors.
Instructor(s): Z. Luo, K. Angielczyk Terms Offered: Autumn. L.
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals Sequence or consent of instructors.
Note(s): E.
Equivalent Course(s): EVOL 31201, BIOS 23262

ORGB 31300. Key Issues in Early Vertebrate Evolution. 100 Units.
Equivalent Course(s): EVOL 30300

ORGB 32233. Comparative Vertebrate Anatomy. 100 Units.
This course covers the structure and function of major anatomical systems of vertebrates. Lectures focus on vertebrate diversity, biomechanics, and behavior (from swimming and feeding to running, flying, seeing, and hearing). Labs involve detailed dissection of animals (muscles, organs, brains) and a focus on skull bones in a broad comparative context from fishes to frogs, turtles, alligators, mammals, birds, and humans. Field trip to Field Museum and visit to medical school lab for human dissection required.
Instructor(s): M. Westneat. L. Terms Offered: Winter
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals Sequence.
Note(s): Offered Winter during odd years. E.
Equivalent Course(s): BIOS 22233

ORGB 32245. Biomechanics: How Life Works. 100 Units.
This course will explore form and function in a diversity of organisms, using the principles of physics and evolutionary theory to understand why living things are shaped as they are and behave in such a diversity of ways. Biomechanics is at the interface of biology, physics, art, and engineering. We will study the impact of size on biological systems, address the implications of solid and fluid mechanics for organismal design, learn fundamental principles of animal locomotion, and survey biomechanical approaches. Understanding the mechanics of biological organisms can help us gain insight into their behavior, ecology and evolution.
Instructor(s): M. Westneat Terms Offered: Spring. L. Spring.
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence. Physics useful.
Note(s): This course will include a lab and will alternate years with BIOS 22233. E.
Equivalent Course(s): BIOS 22245, EVOL 32245

ORGB 32500. Survey of Systems Neuroscience. 100 Units.
This lab-centered course teaches students the fundamental principles of vertebrate nervous system organization. Students learn the major structures and the basic circuitry of the brain, spinal cord and peripheral nervous system. Somatic, visual, auditory, vestibular and olfactory sensory systems are presented in particular depth. A highlight of this course is that students become practiced at recognizing the nuclear organization and cellular architecture of many regions of brain in rodents, cats and primates.
Instructor(s): Oswald, A. M. Terms Offered: Autumn
Prerequisite(s): NSCI 20100, NSCI 20111, NSCI 20130.
Note(s): Undergrads by consent only
Equivalent Course(s): NURB 31600, CPNS 30116, NSCI 23500

ORGB 33265. Human Origins: Milestones in Human Evolution and the Fossil Record. 100 Units.
This course aims at exploring the fundamentals of human origins by tracking the major events during the course of human evolution. Starting with a laboratory based general introduction to human osteology and muscle function, the latest on morphological and behavioral evidence for what makes Homo sapiens and their fossil ancestors unique among primates will be presented. Our knowledge of the last common ancestor will be explored using the late Miocene fossil record followed by a series of lectures on comparative and functional morphology, adaptation and biogeography of fossil human species. With focus on the human fossil record, the emergence of bipedalism, advent of stone tool use and making, abandonment of arboreality, advent of endurance walking and running, dawn of encephalization and associated novel life histories, language and symbolism will be explored. While taxonomic identities and phylogenetic relationships will be briefly presented, the focus will be on investigating major adaptive transitions and how that understanding helps us to unravel the ecological selective factors that ultimately led to the emergence of our species. The course will be supported by fresh data coming from active field research conducted by Prof. Alemseged and state of the art visualization methods that help explore internal structures. By tracing the path followed by our ancestors over time, this course is directly relevant to reconnoitering the human condition today and our place in nature.
Instructor(s): Z. Alemseged. L. Terms Offered: Autumn. Will be offered Autumn 2025. Offered every other year.

Prerequisite(s): Three quarters of a Biological Sciences Fundamentals Sequence, or consent of Instructor.
Note(s): E.
Equivalent Course(s): BIOS 22265, ANTH 28110

ORGB 33600. Vertebrate Development. 100 Units.
This advanced-level course combines lectures, student presentations, and discussion sessions. It covers major topics on the developmental biology of embryos (e.g. formation of the germ line, gastrulation, segmentation, nervous system development, limb pattering, organogenesis). We make extensive use of the primary literature and emphasize experimental approaches including embryology, genetics, and molecular genetics.
Instructor(s): V. Prince, P. Kratsios. Terms Offered: Winter
Prerequisite(s): For Biological Sciences majors: Three quarters of a Biological Sciences Fundamentals Sequence including BIOS 20189 or BIOS 20235
Equivalent Course(s): DVBI 35600, BIOS 21356, MGCB 35600

ORGB 33850. Evolution and Development. 100 Units.
The course will provide a developmental perspective on animal body plans in phylogenetic context. The course will start with a few lectures, accompanied by reading assignments. Students will be required to present a selected research topic that fits the broader goal of the course and will be asked to submit a referenced written version of it after their oral presentation. Grading will be based on their presentation (oral and written) as well as their contributions to class discussions. Prerequisite(s): Advanced undergraduates may enroll with the consent of the instructor.
Instructor(s): U. Schmidt-Ott Terms Offered: Spring
Prerequisite(s): Advanced undergraduates may enroll with the consent of the instructor.
Note(s): E.
Equivalent Course(s): BIOS 22306, DVBI 33850, EVOL 33850

ORGB 36400. Molecular Phylogenetics. 100 Units.
While evolution by natural selection is an elegantly simple phenomenon, modern research in evolutionary biology contains a variety of controversial, and sometimes confusing, topics. In this course, we will explore, as a group, a select list of controversial or confusing topics in evolutionary biology through a mix of student-led presentations and discussion of the primary literature. Each student will also write a review paper about his or her selected topic.
Instructor(s): J. Thornton, A. Drummond Terms Offered: TBD. offered in alternate years
Note(s): not offered in 2018-19
Equivalent Course(s): HGEN 36400, ECEV 36400

ORGB 40000. Intro to Integrative Organismal Biology. 100 Units.
A graduate seminar to introduce students to research of faculty in the Department of Organismal Biology and Anatomy. Prerequisite(s): Required for first and second year graduate students in Integrative Biology.
Instructor(s): M. Westneat Terms Offered: Autumn
Prerequisite(s): Required for first and second year graduate students in Integrative Biology.

ORGB 40001. Topics: Integrative Organismal Biology. 100 Units.
Instructor(s): U. Schmidt-Ott, S. Palmer Terms Offered: Winter
Prerequisite(s): Required for first and second year graduate students in Integrative Biology.

ORGB 40100. Anatomical Research. 100 Units.
TBD
Terms Offered: Autumn
Note(s): Only open to first year graduate students in the Darwinian Sciences Cluster

ORGB 40101. Grants, Publications, and Professional Issues. 100 Units.
Covers professional topics in evolutionary biology, primarily strategies in grant writing and review. Each student will work towards the submission of an application of their choice. The course meets weekly and involves extensive writing and discussion.
Instructor(s): S. Allesina, R. Ho, T. Wootton Terms Offered: TBD
Note(s): Open to first and second year graduate students in the Darwinian Sciences Cluster
Equivalent Course(s): EVOL 40100, ECEV 40100

ORGB 40200. Advanced Topics in Ethics for the Darwinian Sciences. 100 Units.
This course covers advanced topics in ethics relevant to senior Ph.D. candidates in the Darwinian Sciences. CEB students are required to successfully complete this course before being awarded the Ph.D.
Instructor(s): M. Coates, S. Hackett Terms Offered: Winter. offered in alternate years (even)
Prerequisite(s): Open to Ph.D. candidates in the Darwinian Sciences
Equivalent Course(s): EVOL 40200, ECEV 40200

ORGB 42600. Theoretical Neuroscience: Statistics and Information Theory. 100 Units.
This course begins with an introduction to inference and statistical methods in data analysis. We then cover the two main sections of the course: I) Encoding and II) Decoding in single neurons and neural populations. The encoding section will cover receptive field analysis (STA, STC and non-linear methods such as maximally informative dimensions) and will explore linear-nonlinear-Poisson models of neural encoding as well as

generalized linear models alongside newer population coding models. The decoding section will cover basic methods for inferring stimuli or behaviors from spike train data, including both linear and correlational approaches to population decoding. The course will use examples from real data (where appropriate) in the problem sets which students will solve using MATLAB.
Instructor(s): S. Palmer Terms Offered: Spring
Prerequisite(s): Prior exposure to basic calculus and probability theory, CPNS 35500 or instructor consent.
Equivalent Course(s): STAT 42600, CPNS 35600

ORGB 49401. Approaches to Teaching in The Darwinian Sciences. 100 Units.
This course will introduce different teaching philosophies and methods that address how to be an effective teacher in the Darwinian Sciences. Specifically, the course will address what skills and knowledge undergraduates need to acquire and which assignments best teach these skills. Students will prepare course syllabi, discuss different approaches to teaching, and draft a philosophy of teaching statement. The overall goal for the course is that the students think critically about the art of teaching and formulate their own thoughts on the matter to better prepare them for their own careers in teaching.
Equivalent Course(s): ECEV 49401, EVOL 49401

ORGB 49500. Lab Teaching/Teaching: Organismal Biology/Anatomy. 100 Units.
For graduate students to build their teaching skills by assisting with the instruction of a course in a core area of Integrative Biology. Students should register for the section under the faculty member who is their teaching mentor for the quarter.

ORGB 49700. Rdgs: Organismal Biology/Anatomy. 300.00 Units.

ORGB 49800. Rsch: ORGB-Off Campus. 300.00 Units.
For graduate students conducting dissertation research at an off-campus lab or field location. Students should register for the section under their adviser only when using pro forma status for the quarter.

ORGB 49900. Rsch: ORGB-On Campus. 300.00 Units.
For graduate students conducting dissertation research wholly or partly on campus for the quarter. Students should register for the section under their adviser and time spent should directly advance their dissertation in Integrative Biology.

ORGB 70000. Advanced Study: Organismal Biology & Anatomy. 300.00 Units.
Advanced Study: Organismal Biology & Anatomy