Richard Gilder Graduate School
AT THE AMERICAN MUSEUM OF NATURAL HISTORY

Course Catalog

CORE COURSES

Core courses give students a broad overview of the conceptual basis for studying life and to provide them with a common language and essential set of tools and methods for research. The annual organization, content, and flow of each core course will be developed by the course director (in consultation with the AMNH Comparative Biology Ph.D. Program Committee), who will oversee the implementation of the course throughout the semester. Course directors and faculty may vary, but teaching of all core courses will be done by faculty representing the broad spectrum of research disciplines of the AMNH.

RGGS501 Systematics and Biogeography

Credits: 3

This one-semester class will explore the principles of systematics, the science of classifying organic diversity, contemporary systematic methods, and biogeography.

- **Section 1**—Introduction and background: history of systematics and classification, applications of systematics, schools of thought, and philosophical underpinnings of systematics.
- **Section 2**—Systematic data: homology, types of data, characters, weighting, and molecular data.
- **Section 3**—Analytical methods: alignment of nucleotide characters, inferring trees, distance algorithms, parsimony algorithms, likelihood, measures of support, consensus methods, optimization, and missing data.
- **Section 4**—History of biogeographic inquiry: dispersalist and vicariance perspectives, analytical methods in biogeography, and relation to conservation biology.
- **Section 5**—History and importance of classification; phylogenetic classification,applications of classifications, DNA “bar-coding,” and Assembling the Tree of Life initiatives.

RGGS501L Systematics and Biogeography Lab

Credits: 1

Lab component for Systematics and Biogeography course.

RGGS502 Grantsmanship, Ethics, and Communication

Credits: 3

This course will be offered in a workshop format and focused on how scientists operate within the broader range of society.

- **Section 1**—Grantsmanship: preparing grants, identifying granting agencies, developing and maintaining grant budgets, and practical development of a grant application (e.g., Predoctoral Fellowship or Doctoral Dissertation Improvement Grant).
- **Section 2**—Ethical issues in science, including scientific misconduct, interpersonal responsibilities, institutional responsibilities, mentoring, peer review of papers and grants, serving on panels and boards, and use of animals in research.
- **Section 3**—Communication: writing quality papers, targeting papers to particular journals, crafting press releases, dealing with the media, and giving high-quality presentations.

RGGS503 Evolution

Credits: 3

This one-semester course will include historical and critical reviews of evolutionary theory and will cover the basic principles of contemporary evolutionary biology.

- **Section 1**—Evidence of evolution: the historical development of evolutionary biology; evolution in modern biology; evolution outside of biology
- **Section** 2—Basic principles of evolutionary biology: e.g., population and species concepts), fitness, adaptation, selection, species, clade, phylogeny, hierarchy, homology, and constraint.
- **Section 3**—Evolution of genes: population genetics; quantitative genetics; molecular evolution; molecular tools in evolutionary analyses.
- **Section 4**—Microevolution: fitness, natural selection, sexual selection, analysis of adaptation; nonadaptive causes of pattern, coevolution, complex adaptations.
- **Section 5**—Evolution of Development: molecular, cellular, and anatomical origin and transformation of form and function; developmental genetics, expression patterns, lineage analysis, and developmental analysis.
- **Section 6**—Macroevolution and major transitions in the history of life: speciation, cospeciation, tempo and mode in evolution, phyletic evolution in lineages, kin selection, clade dynamics, evolution of cells, and evolution of sex.
- **Section 7**—History of Life and the Earth: paleobiology, phylogenetic radiations, extinction, Earth history, tectonics, climate and environmental change, and interaction of biological and physical processes.

RGGS503L Evolution Lab

Credits: 1

The lab component for Evolution course.

ELECTIVE COURSES

RGGS601 Phylogenetics Applications

Credits: 3

This readings course will delve into the myriad ways in which phylogenetic methods are applied across the diversity of biological disciplines including their use for studying disease, ecology, conservation, population biology, genomics, anthropology, biogeography, and even astrobiology.

RGGS602 GIS Methods and Applications

Credits: 2

This course will focus on the application of Geographic Information Systems (GIS) to address questions relating to evolution and conservation. Students will gain hands-on experience with multiple GIS software packages, and will learn the fundamentals of species distribution modeling and remote sensing. The course will combine lectures and computer lab exercises, and each student will undertake an individual project.

RGGS603 Marine Zoological Biodiversity Surveys & Inventory

Credits: 3

This course will familiarize students with the nature of the DEB-BSI granting panel priorities at the National Science Foundation with a focus on the broad zoological diversity in marine and associated environments. Passamaquoddy Bay, at the mouth of the Bay of Fundy, exhibits a tidal range of 30 feet. From low water to high water takes about 6.2 hours and in that time, up to 2-1/4 billion tons of water swill into assamaquoddy Bay through the passages. Few places on this planet have such a huge tidal variation and, consequently, few offer as great a diversity of marine organisms and habitats. Lectures will cover basic principals of physical oceanography, biological oceanography, marine taphonomy, phylum-by-phylum marine metazoan diversity (from sponges to mammals), marine protozoology, and parasitology. Field work will focus on survey-based marine sampling strategies from I-meter plots, to transects and trawling effort across a range of habitats that includes benthic, pelagic, inshore, meiofaunal, intertidal, salt marshes and rocky shores.

RGGS604 Understanding Biological Disparity

Credits: 3

Disparity analyses attempt to characterize and explain extreme differences in morphology and diversity in closely related groups of organisms. Through group discussion of a series of contemporary readings covering both the fossil record and modern organisms, students will explore the basic concepts of biological disparity and learn how to apply these in their own research.

RGGS605 Conservation Biology

Credits: 1

This course, the first semester of a two-semester course, will serve as an introduction to the applied science of maintaining the Earth's biological diversity, landscapes, and wilderness. The course will focus on the biological principles relevant to the conservation of biodiversity at the genetic, population, community and landscape levels. Due to the cross-disciplinary nature of Conservation Biology, some of the social, philosophical, and economic dimensions of biological conservation will also be addressed. Major themes to be covered include what biodiversity is, why it is important, and what threatens it. In the second half, the class will concentrate on different strategies for addressing the biodiversity crisis. The focus will be on applications and problem solving in conservation biology, drawing from international and national examples. The course is intended to link perspectives gained in other courses offered in the AMNH graduate program under the common theme of how biological principles can be applied to the conservation of biological resources.

RGGS606 Earth System Science

Credits: 2

This course will survey Earth's dynamic systems and show how they have interacted through time to give the planet its present character. It will cover plate tectonics, the ocean/atmosphere system, and the global carbon and sulfur cycles. It will explore how Earth, particularly conditions on its surface, has changed through time, the emergence of life and evolution of metabolic pathways, and the feedbacks between the biological and physical world that determined planetary evolution, and it will seek to provide insight into terrestrial evolution by comparing Earth with Venus and Mars.

RGGS607 Sedimentology, Stratigraphy and Sedimentary Environments

Credits: 2

This course will describe the types of sediments distributed in modern environments of the Earth's surface and the physical and/or chemical processes that lead to their deposition. Earth's depositional environments will be presented in a plate tectonic context. The course will also illustrate how sediments and sedimentary rock sequences record events in Earth's history, and it will address burial and fossilization processes.

RGGS608 Biological Diversification

Credits: 2

This course will examine the patterns and processes of the diversification of life. Topics include species and speciation analysis, the rate-controls of speciation and extinction, understanding how biotas evolve, and explaining patterns of diversity through space and time. Prerequisites: a course in evolution,

systematics, and ecology.

RGGS609 Genomics

Credits: 3

The techniques and analytical approaches to examining the genomes of organisms will be the focus of this course. This course will begin with detailed examination of the high throughput approaches used to analyze and collect information on genomes. Such approaches include estimating genome size, obtaining genome level maps, estimating gene content in genomes, sequence alignment, and genome level shotgun sequencing approaches. This course will then proceed to annotation of genomes and discovery of ortholog/paraolog relationships. It will conclude with detailed examination of data basemanipulation, PERL scripting to mine the burgeoning database, and the incorporation of phylogenetic approaches into studying genomes.

RGGS610 Molecular Evolution

Credits: 2

This course will focus on current paradigms of molecular evolution. These include the evolution of the genetic code, molecular clocks, and the measurement of selection and adaptation at the molecular level. The evolution of the genetic code will introduce the student to the dynamics of the coding regions of the genome and introduce basic concepts such as synonymous and non-synonymous substitutions,as wellas codon bias selection. The molecular clock section of the course will focus on the utility and vagaries of molecular clocks and the final section on selection will focus on the use of synonymous and non-synonymous measurements (Dn/Ds; Ka/Ks) to detect selection. Examples from a wide array of organisms will be used to demonstrate the utility of these three major subjects in modern molecular evolution.

RGGS611 Parasitism

Credits: 3

Parasitism is the most successful life history strategy on Earth. There are more and more varied species of parasites than there are free-living species hosting them. Students will discover a full range of eukaryotic parasites ranging from the protistan causative agents of malaria, sleeping sickness, Chagas disease, and leishmania to the metazoan tapeworms, flukes, nematodes, and arthropod parasites. Subject matter will include comparative anatomy, life cycles, pathology, phylogenetic relationships, and coevolutionary parasitology.

RGGS612 Principles of Biogeography

Credits: 2

This course will present an overview of the history of biogeography, current biogeographic principles and methods, and a survey of biogeographic patterns within continental and marine biotas. Additional topics will include the application of biogeographic pattern analysis to biotic evolution and the study of diversity through time.

RGGS613 Arthropod Morphology

Credits: 3

Students will investigate basic structural characteristics and theories of homology through selected readings in the literature and intensive laboratory work on exemplar organisms. Participation of multiple staff members will assist in the examination of a broad range of lineages within the Arthropoda.

RGGS614 Higher-Level Relationships in the Arthropoda

Credits: 1

This course will deal with the diversity and relationships of the Arthropoda. Units will cover living taxa in the Onychophora, Tardigrada, Chelicerata, Crustacea, Myriapoda, and Hexapoda. The extensive fossil record of arthropods will also be explored with special reference to Trilobita, Anomalocarida, and Orsten Crustacea. Information will be drawn from anatomy, physiology, and developmental and molecular data.

RGGS615 Insect Diversity

Credits: 3

As the most diverse lineage of living organisms, the Insecta will be examined down to the family-group level. Field, laboratory, and lecture components will allow for students to master skills in taxon recognition and understand the basis for existing classificatory schemes.

RGGS616 Metazoan Diversity

Credits: 3

Taking a phylogenetic approach to the origins and diversification of animals, this course will cover the full scope of animal life from the origins of multicellularity through the major synapomorphies that unite and define the Tree of Life. This course will cover more than 30 non-vertebrate phyla in the context of the most up-to-date hypotheses of their relationships to each other and the evolution of morphological diversity within each group. This course will consist of lectures and examination of museum and fresh collections.

RGGS617 Digital Visualization Techniques

Credits: 1

This course will be a hands-on course, under the direction of the MIF staff. Students will gain practical knowledge and experience using laser surface scanner and image processing software for volumetric data (MRI, CT, laser surface, confocal).

RGGS618 Microscopy

Credits: 1

This course will be a hands-on course, under the direction of the MIF staff, where students will gain practical knowledge and experience using the confocal and electron microscopes. Topics will include sample preparation, use of equipment, image capture, and processing.

RGGS619 Molecular Techniques

Credits: 1

This laboratory course will expose students to the basic techniques of evolutionary molecular analysis, including DNA extraction, primer design, PCR amplification, cloning, and sequencing. Basic sequence analysis will also be covered.

RGGS620 Phylogenetic Algorithms

Credits: 1

This course will cover the fundamental procedures and algorithms of systematic analysis. Tree construction (Wagner), refinement (SPR, TBR), simulated annealing, genetical algorithm, and character-optimization techniques will be examined in depth through analysis and use of open-source

RGGS621 Systematic Computation

Credits: 1

This course will cover basic techniques in the use of computers in systematic analysis. It will be an introduction to operating systems, especially LINUX, scripting languages, and use of parallel computers. Several phylogenetic computer software packages will be examined (e.g. PAUP,

RGGS622 Bone Histology

Credits: 1

This course will provide an introduction to both mechanical and interpretive aspects of analyzing fossil bone. It will introduce the identification of tissue types and their interpretation relative to specific hypotheses of growth, longevity, and life history. Part of the class will include practical preparation of specimens. A general review and discussion of several contemporary studies will also be included.

RGGS623 Fish Paleontology

Credits: 2

This course will examine the origins and early radiations among primitive vertebrates ("fish"), especially the major gnathostome groups (chondrichthyans, osteichthyans, placoderms, and acanthodians). Aspects of modern vertebrate morphology, the fossil record (including collections-based study), classical embryology, and modern evolutionary-developmental investigations will all be included. The course will therefore provide an integrated perspective of past, current, and future directions in research on early vertebrate evolution.

RGGS624 Invertebrate Paleontology

Credits: 2

This course will concentrate on one or more fossil invertebrate groups, emphasizing their morphology, evolutionary history, biostratigraphy, and systematics. Study of actual specimens, drawing on the AMNH collections, will be an important part of the course. Work will feed into broader issues of functional morphology, biodiversity over time, crises in the history of life, and geologic events.

RGGS625 Paleontology Field Methods

Credits: 1

This will be a tutorial on how fossils are collected. This course may run concomitant with field

RGGS626 Readings in Contemporary Paleobiology

Credits: 1

This course will concentrate on the critical examination of recent studies in paleobiology. Students will be required to lead and participate in focused discussions.

RGGS627 Herpetology

Credits: 3

This course will address the anatomical, ecological, and life history diversity of reptiles and amphibians. It will be structured around the evolutionary history of living and relevant fossil groups with special attention to scientific evidence.

RGGS628 Ichthyology

Credits: 3

This course will be a taxonomic survey and introduction to the science of ichthyology. It will focus on the systematic relationships among the major clades of fishes, and will also include discussions focusing on ecology, biogeography, and the natural history of fishes. This course will consist of lectures, readings from the primary literature, and laboratory sections focusing on a taxonomic review

RGGS629 Mammal Section/Vertebrate Morphology

Credits: 1

Framed within an explicitly phylogenetic context, this course will provide students with an overview of mammalian musculoskeletal anatomy. Anatomical variation will be investigated utilizing a suite of exemplar taxa spanning the morphological diversity of the group.

RGGS630 Mammalogy

Credits: 3

This course will survey the structural, ecological, and behavioral diversity of extant mammals from an evolutionary perspective. Students will be expected to gain familiarity with all of the mammalian orders and the specializations associated with different functional complexes and lifestyles. These and other patterns of mammalian diversity will be investigated in a phylogenetic context.

RGGS631 Ornithology

Credits: 3

This course will present an overview of avian history and evolution. Topics to be considered include origin of birds; avian phylogenetics, speciation, and biogeography; structural and functional evolution; general ecology; and behavior. Field trips will be required.

RGGS632 Ethnoscientific Perspectives

Credits: 1

Although their forms vary, classification and explanation of the natural world are human universals. "Ethnoscience" examines the epistemological bases and concrete applications of analytical procedures in non-Western cultures. Focusing on small-scale, "traditional" societies, this course will introduce key anthropological inquiries into principles of natural classification and explanation, both comparatively and in specific cases.

RGGS633 Evolutionary Theory and Study of Culture Change

Credits: 1

A number of anthropologists and archaeologists have used principles from evolutionary biology in their efforts to understand patterns of major culture change, such as the transition from hunting-gathering to agriculture, the emergence of social inequality, and the rise of the state. Such efforts will be critically examined, both in terms of their theoretical rationale and their consistency with the empirical record.
The course will consist of lectures, readings, discussions, and a final project.

RGGS634 Natural Metaphors

Credits: 1

In the words of Claude Levi-Strauss, natural species and elements are "good to think," providing a primary analogical scheme for human self-conceptions. What does it mean for the Bororo of Central Brazil to say, "We are red macaws," or for the Hopi of Arizona

to identify themselves as sparrow hawks, rain, or rattlesnakes? This course will address how and why conceptions of the biological world suffuse thinking about humanity-and vice versa.

RGGS635 Insect Ecology and Conservation

Credits: 2

This course will present an overview of the ecology and conservation of the Earth's most diverse group of organisms-insects. The first part of this course will cover ecological concepts as they apply to insects. How these concepts are applied to the conservation of this important taxon will be the focus of the second part. Students will emerge from the course with an understanding of the unique problems and solutions that insects have evolved and how these solutions can be applied to their conservation.

RGGS636 Isotope Geochemistry

Credits: 2

This course will present the fundamentals of radiogenic and stable isotope systems. It will focus on those systems that most closely bear on global biogeochemical cycles, including the uranium-thorium-lead decay series, rubidium-strontium, carbon-14, and the stable isotope systems for carbon, sulfur, and oxygen. It will use examples to illustrate the utility of isotopes in deducing changing conditions on Earth's surface at present and during the past 600 million years.

RGGS637 Nebular Formation

Credits: 1

Students will study theory and empirical evidence about the solar nebular and planetary formation.

RGGS638 Techniques in Earth Materials

Credits: 2

This course will deal with minerals and organic compounds and how they are identified/analyzed to extract useful physical and chemical information. Applications include research on biomaterials, sediments, and sedimentary rocks. Analytical methodologies of interest include: basic petrography, SEM, electron microprobe, ion microprobe, ICPMS and LA-ICPMS, X-ray diffraction, and (potentially) other techniques.

RGGS639 Arachnid Diversity

Credits: 2

Arachnid Diversity will provide an overview of the orders of arachnids, including their interrelationships, natural history, systematics, and biogeography. Lectures and labs will

enable students to become familiar with the most commonly encountered families and their diversity.

RGGS640 Hemipteran Phylogeny and Biology

Credits: 2

This course will examine the classification and relationships of the Hemiptera down to the family-group level. Morphological, molecular, and biological data will be examined as a way of comprehending diversity and relationships. The extensive collections of the AMNH will be used to augment literature

RGGS641 Evolution of Eukaryotic Microbes

Credits: 3

Although they may consist of just single cells, the eukaryotic microbes present fascinating studies in the evolution of life. This course will include discussions on the origins of organelles in eukaryotes, adaptations for motility, and phylogenetic relationships among eukaryotic microbes based on genetic and genomic data. There will also be a focus on several groups of parasitic protists such as malaria parasites (Plasmodium), trypanosomes, and Trichomonas and their unusual evolutionary genetic adaptations to the pathogenic lifestyle.

RGGS642 Microbial Diversity

Credits: 3

This course will explore the diversity of microbial life, focusing on bacteria and archaea. Major groups of microbes will be covered along with the conceptual issues pertinent to how microbial diversity is studied. This course will include lectures and discussions of the major evolutionary transitions in the microbial world and how these are thought to have come about, the patterns of evolutionary change, theinteraction of microbes within diverse communities and the ways in which phylogenetics and genomics are shaping our understanding of microbial diversity.

RGGS643 Virologenetics

Credits: 3

The specifics of the placement of viruses in the Tree of Life remain enigmatic, and their monophyly is doubted by most. Following an introductory period focusing on traditional modes of viral classification
(strandedness, morphology, and pathology), this course will engage in an in-depth investigation into the evolutionary relationships of viral species and larger taxonomic groups.

RGGS644 Molding and Casting

Credits: 1

This will be a tutorial on how to construct molds for the replication of fossil materials.

RGGS645 Paleomammalogy

Credits: 2

An introduction to the major features of mammalian evolution, this course will survey major groups of mammals, focusing on fossil taxa as well as the broader context of their relationships to living groups. We will focus on phylogeny, morphology, biogeography, and patterns of diversification and extinction, using illustrations from the AMNH's world-class collections.

RGGS646 Paleontology in the U.S. Western Interior

Credits: 2

This intensive two-week field course/collecting expedition will travel to paleontological sites in the U.S. Northern Great Plains (Colorado, South Dakota, Wyoming, and Montana). Emphasis is on marine deposits containing invertebrate and vertebrate fossils deposited in the Epicontinental Sea that once covered this area. Themes will include changes in biodiversity, paleoceanographic reconstructions, modes of fossil preservation, and anoxic events.

RGGS647 Reptile and Amphibian Paleontology

Credits: 2

This course will be a general overview of the systematics and morphology of all nonsynapsid tetrapods. Special attention will be placed on the origins of extant groups. The course will consist of a detailed review of systematic patterns in these groups and will include the examination of specimens in the museum collections.

RGGS648 Actinopterygian Section/Vertebrate

Credits: 1

Framed within an explicitly phylogenetic context, this course will provide students with an overview of actinopterygian musculoskeletal anatomy. Anatomical variation will be investigated utilizing a suite of exemplar taxa spanning the morphological diversity of the group.

RGGS649 Fish Bioluminescence

Credits: 1

Bioluminescence is a complex relationship between host fishes and luminescent bacteria. Recent work has shown that the phylogeny of bacteria and host are not necessarily congruent. Furthermore, methods of transmission are poorly understood. This course will review current work in this area.

RGGS650 Reptile & Amphibian Section/Vertebrate Morphology

Credits: 2

Framed within an explicitly phylogenetic context, this course will provide students with an overview of amphibian and reptile musculoskeletal anatomy. Anatomical variation will be investigated utilizing a suite of exemplar taxa spanning the morphological diversity of the group.

RGGS651 Vertebrate Biogeography of Madagascar

Credits: 1

The unique vertebrate fauna of Madagascar is of great interest. This course will examine the origin of major groups of vertebrates of the island including taxa known only from the fossil record.

TEACHING ASSISTANTSHIPS

The experience of teaching is an integral part of graduate training, especially in preparation for a career including academic service and teaching. After the first year, each student must complete mentored teaching assistantships in two courses or other educational programs. A particular strength of the
AMNH graduate program is the opportunity for a student to participate in AMNH pre-college, teacher training, life-long learning, and public outreach programs with the goal of enhancing the public understanding of science.

RGGS701 Teaching Assistantship I

Credits: 3

RGGS702 Teaching Assistantship II

Credits: 3

MUSEUM SEMINAR SERIES

Throughout the academic year, the AMNH will present the weekly Museum Seminar Series at which presentations on a variety of scientific topics will be given by leading scientists, educators and AMNH curators. During the first year, students will be required to attend each program in the Series and will meet prior to each program for a discussion of the pertinent literature, which they will be expected to have read prior to the lecture, for a total of two hours each week. First year students will earn one credit per semester for a total of two credits.

RGGS703 Museum Seminar Series I

Credits: 1

RGGS704 Museum Seminar Series II

Credits: 1

STUDENT SYMPOSIUM

First-year students will organize and be required to attend a day-long Annual Symposium that will feature their research interests and the Graduate School curriculum. This informal retreat-like gathering, to which the faculty and the entire AMNH student community will be invited, is intended to give new students access to faculty and other students, to share information about labs and research programs and activities, and to strengthen the Richard Gilder Graduate School community.

RGGS705 Student Symposium

Credits: 1

DIRECTED RESEARCH

RGGS801 Directed Research

Credits: 1

1 credit directed research.

RGGS802 Directed Research

Credits: 2

2 credits directed research.

RGGS803 Directed Research

Credits: 3

3 credits directed research.