AMERICAN MUSEUM OF NATURAL HISTORY

RICHARD GUILDER GRADUATE SCHOOL

ELECTIVE COURSES

A minimum of six full and partial elective courses will be offered each year (see representative potential courses, below), providing a combination of lecture, workshop, and laboratory and field segments, as appropriate. Generally elective courses are offered every two years (for more general courses) or every four years (for more specialized topics), but specific annual offerings will be scheduled to coordinate most effectively with the backgrounds and interests of the students enrolled at that time. This schedule will enable students comfortably to satisfy program requirements and to ensure "critical mass" enrollment for course offerings.

Elective courses are meant to be flexible and to assist students in achieving a concentration and a depth of knowledge in an area of individual interest. These courses may not be tied directly to the academic calendar and are not necessarily given onsite. Some may include on- and offsite components on a discontinuous basis (field work separated from lectures, for instance). Elective courses or portions of elective courses (field work, etc.) may be offered anytime; however, attempts will be made for them to commence at dates convenient to other university schedules, particularly when other local institutions are not in session, to permit students outside the AMNH program to take the courses.

Student Evaluation: Evaluation in elective courses will be either by means of traditional class or laboratory examination, structured take-home examination, or research paper, as appropriate to the subject matter. Schedules for these evaluations (if they are research papers or take-home exams) may extend beyond the term of formal instruction. Students will be evaluated on a pass/fail basis, although those enrolled in other universities can petition for a letter grade if required by their university.

ELECTIVE COURSES POTENTIALLY OFFERED ON BIENNIAL ROTATION

Conservation Biology

Conservation Biology

Instructor: Sterling, Amato
1 credit
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.

Earth Sciences

Earth System Science

Instructor: Webster, Ebel
2 credits
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.

Sedimentology, Stratigraphy and Sedimentary Environments

Instructors: Mathez, Flynn
2 credits
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.

Evolution and Biogeography

Biological Diversification

Instructor: Cracraft
2 credits
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.

Genomics

Instructor: DeSalle
3 credits
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 base

manipulation, PERL scripting to mine the burgeoning database, and the incorporation of phylogenetic approaches into studying genomes.

Molecular Evolution

Instructor: DeSalle
2 credits
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 well as 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.

Parasitism

Instructor: Siddall
3 credits
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 co-evolutionary parasitology.

Principles of Biogeography

Instructor: Cracraft
2 credits
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.

Invertebrates

Arthropod Morphology

Instructors: Invertebrate Zoology staff
3 credits
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.

Higher-Level Relationships in the Arthropoda

Instructors: Wheeler *et al.*
1 credit
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.

Insect Diversity

Instructors: Schuh, Carpenter
3 credits
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.

Metazoan Diversity

Instructor: Siddall
3 credits
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.

Molecular, Computational, and Microscopic Techniques

Digital Visualization Techniques

Instructors: Microscopy and Imaging Facility staff
1 credit
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).

Geospatial Tools and Techniques

2 credits: Staff
This course will focus on the practical aspects of remote sensing and geographic information systems (GIS). Species distribution modeling will be used to illustrate how remote sensing products and GIS can be used to predict the location of individual species based on species locality data. The goal of the course is to provide sufficient information that participants will be able to download and display satellite imagery for their area of interest, learn to interpret the imagery by making the connection between abstract image information and the landscape, use this information to support a range of conservation objectives, and manipulate these and other data in a GIS. Participants will work with visual image products, and an overview of the automated land cover classification process will be presented including an assessment of the advantages and

drawbacks of these map products. The course will involve a mix of lecture, computer lab applications, discussions, and field work. The skills learned during this class will be applied on a class project to map species distributions in the area around the Southwest Research Station.

Microscopy

Instructors: Microscopy and Imaging Facility staff
1 credit
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.

Molecular Techniques

Instructors: Wheeler, Perkins
1 credit
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.

Phylogenetic Algorithms

Instructor: Wheeler
1 credit
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 programs.

Systematic Computation

Instructors: Wheeler *et al.*
1 credit
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, CLUSTALW, and POY).

Paleontology and Paleobiology

Bone Histology

Instructor: Norell
1 credit
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.

Fish Paleontology
Instructor: Maisey
2 credits
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.

Invertebrate Paleontology
Instructor: Landman
2 credits
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.

Paleontology Field Methods
Instructors: Paleontology staff
1 credit
This will be a tutorial on how fossils are collected. This course may run concomitant with field expeditions.

Readings in Contemporary Paleobiology
Instructors: Norell, Flynn
1 credit
This course will concentrate on the critical examination of recent studies in paleobiology. Students will be required to lead and participate in focused discussions.

Vertebrates

Herpetology
Instructors: Frost, new Herpetology faculty member
3 credits
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.

Ichthyology
Instructors: Stiassny, Sparks
3 credits
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 of teleostean.

Mammal Section/Vertebrate Morphology

Instructor: Meng
1 credit
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.

Mammalogy

Instructor: Simmons
3 credits
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.

Ornithology

Instructor: Cracraft
3 credits
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.

ELECTIVE COURSES POTENTIALLY OFFERED ON QUADRENNIAL ROTATION

Anthropology

Ethnoscientific Perspectives

Instructor: Whiteley
1 credit
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.

Evolutionary Theory and the Study of Culture Change

Instructor: Spencer
1 credit
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.

Natural Metaphors
Instructor: Whiteley
1 credit
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.

Conservation Biology

Insect Ecology and Conservation
Instructor: Sterling
2 credits
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.

Earth Sciences

Isotope Geochemistry
Instructor: Mathez
2 credits
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.

Nebular Formation
Instructor: Ebel
1 credit
Students will study theory and empirical evidence about the solar nebular and planetary formation.

Techniques in Earth Materials
Instructors: Earth and Planetary Sciences staff
2 credits
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.

Invertebrates

Arachnid Diversity

Instructors: Prendini, Platnick
2 credits
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.

Hemipteran Phylogeny and Biology

Instructor: Schuh
2 credits
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 resources.

Hymenoptera Phylogeny and Biology

Instructor: Carpenter
2 credits
This course will cover the higher-level phylogeny of the entire order, with emphasis on features connected to adaptive radiations, the contribution of the fossil record, and contributions from both morphological and molecular data. Systematics and identification of families will be part of the accompanying lab.

Microbes

Evolution of Eukaryotic Microbes

Instructor: Perkins
3 credits
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.

Microbial Diversity

Instructor: Perkins
3 credits
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, the interaction of microbes within diverse communities and the ways in which phylogenetics and genomics are shaping our understanding of microbial diversity.

Virologenetics
Instructors: Siddall
3 credits
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.

Paleontology and Paleobiology

Molding and Casting
Instructors: Paleontology staff
1 credit
This will be a tutorial on how to construct molds for the replication of fossil materials.

Paleomammalogy
Instructors: Flynn, Meng, Novacek
2 credits
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.

Paleontology in the U.S. Western Interior
Instructor: Landman
2 credits
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.

Reptile and Amphibian Paleontology
Instructors: Norell
2 credits
This course will be a general overview of the systematics and morphology of all non-synapsid 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.

Vertebrates

Actinopterygian Section/Vertebrate Morphology

Instructors: Stiassny, Sparks
1 credit
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.

Fish Bioluminescence

Instructor: Sparks
1 credit
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.

Reptile and Amphibian Section/Vertebrate Morphology

Instructors: Norell, new Herpetology faculty member, Cracraft
2 credits
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.

Vertebrate Biogeography of Madagascar

Instructors: Raxworthy, Flynn, Sparks
1 credit
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.