BIO 211-006 – Study Guide for Exam 3

Exam 3 will be in lecture on Thursday, April 10. The exam will include the following types of questions: multiple choice, short answer, problem solving, and short essay.

This study guide is provided for your use and benefit. However, it is not meant to be an exhaustive list of what will (and will not) be on the exam. The study guide will be most useful if you work through the questions and problems well in advance of the exam.

Speciation and macroevolution

- Be able to use the following words and phrases: speciation, species, reproductive isolation, vicariance, allopatric, sympatric, polyploidy, hybrid zone, prezygotic, postzygotic, adaptive radiation, punctuated equilibrium, gradualism, stasis, homeotic genes.
- Discuss the relative merits of the biological, morphological, and phylogenetic species concepts. How does each help identify evolutionarily independent units?
- Propose an experiment or series of experiments to determine whether two populations of organisms are from the same species.
- How does genetic isolation of populations occur during allopatric speciation? during sympatric speciation?
- How can mutation, migration, genetic drift, natural selection, sexual selection, and non-random mating contribute to genetic divergence during speciation?
- Human land use is causing unprecedented fragmentation of habitats. Do you expect this fragmentation to lead to speciation? Why or why not?
- What events can trigger adaptive radiations? Use examples of adaptive radiations within the tree of life to support your answer.
- Does evolutionary change always happen gradually? Defend your answer using what you have learned about the biology of evolutionary change.
- Discuss how mutations in developmental pathways can contribute to evolutionary innovations.
- How can relatively simple genetic changes result in dramatic morphological changes? Explain your answer using an example.
- Propose a hypothesis for the evolutionary diversification of flowering plants. Justify your answer using concepts from macroevolution.

Phylogenies and the tree of life

- Be able to use the following words and phrases: phylogeny, phylogenetic hypothesis, parsimony, common ancestor, sister group, branch, node, monophyletic, paraphyletic, clade, character, character state, character state transition, outgroup, ancestral, derived, informative character, synapomorphy, extant, homology, homoplasy, reversal, convergent evolution
- How does the diversity of life reflect descent with modification? Provide an example to justify your explanation.
- Why are monophyletic groups identified by shared, derived traits?
- Use character states to determine the most parsimonious phylogeny of a small group of related organisms.
- From a phylogeny, identify patterns of evolutionary relatedness and trait evolution.
- Apply parsimony to select among possible phylogenies.
- Compare and contrast homology and homoplasy. Which type of trait is more valuable for inferring phylogenies? Why?
- “Birds should not be regarded as a separate class from reptiles.” Do you agree or disagree with this statement? Explain.
- How is it that eukaryotes can be considered to be more closely related to some prokaryotes (the Archaea) than other prokaryotes (the Bacteria)?
- “The tree of life as a metaphor for the evolutionary history of all organisms should be replaced with the web of life.” Do you agree or disagree with this statement? Explain.

Bacteria and Archaea

- Be able to use the following words and phrases: prokaryote, eukaryote, domain, Precambrian, conjugation, stromatolite, pathogenic, bioremediation, decomposer, extremophile, halophile, thermophile, nitrogen fixation, anaerobe, autotroph, heterotroph, photosynthesis, chemosynthesis, methanogen, lateral gene transfer.
- Be able to discuss the phylogenetic position, phylogenetic status (i.e., monophyletic, paraphyletic, polyphyletic), and defining characteristics of the following groups: Bacteria, Archaea, Eukarya.
- Be able to discuss the ecological roles and importance to humans of the following groups: Bacteria, Archaea, cyanobacteria.
- Discuss the relationship between metabolic diversity and ecological diversity in prokaryotes.
- Discuss the relationship between phylogenetic diversity and metabolic diversity in prokaryotes. Use photosynthesis as an example.
- Would you predict that pathogenic bacteria obtain energy from light, organic molecules, or inorganic molecules? Explain.
- Why are extremophiles important components of biological diversity?
- Why do astrobiologists study prokaryotes?
- If you were to map nitrogen fixation onto a phylogeny of the prokaryotes, what sort of pattern would emerge? Discuss at least two hypotheses that would explain this pattern.
- Discuss the significance of cyanobacteria for the evolution of biodiversity. Include two critical roles that cyanobacteria have played during the history of life.

Protists and the origin of eukaryotes

- Be able to use the following words and phrases: ingestion, absorption, cilia, flagella, endomembrane system, malaria, amoebae, primary producers, plankton, phytoplankton, endosymbiosis, secondary endosymbiosis, multicellularity, colonial, chlorophyll, algae, euglenids, meiosis, alternation of generations.
- Be able to discuss the phylogenetic position, phylogenetic status, and defining characteristics of the following groups: green algae, red algae, brown algae, land plants, choanoflagellates, fungi, animals.
- Be able to discuss the ecological roles and importance to humans of the following groups: green algae, red algae, brown algae, diatoms, dinoflagellates, slime molds.
- Discuss the evolutionary history of “algae”. Why are “algae” so diverse?
- Discuss the evolutionary origin of the following traits: mitochondria, chloroplasts, cell wall, external shell, multicellularity. Which are thought to have evolved once and which more than once? How is this reflected in the phylogeny of Eukarya?
- Outline the steps in the endosymbiosis theory for the origin of mitochondria. What did each partner provide the other, and what did each receive in return? Answer the same questions for the origin of chloroplasts.
- Discuss the significance of each of these evolutionary innovations: organelles, cytoskeleton, multicellularity, meiosis.
- What is the relationship between meiosis and the alternation of generations?

Land plants

- Be able to use the following words and phrases: deforestation, desertification, bioprospecting, gametangia, embryo, bryophyte, moss, pores, vascular tissue, lignin, sporopollenin, fern, ovary, ovules, pollination, seed, cone, gametophyte, sporophyte, spore, zygote.
- Be able to discuss the phylogenetic position, phylogenetic status, and defining characteristics of the following groups: green algae, non-vascular plants, seedless vascular plants, gymnosperms, angiosperms.
- Draw a simplified phylogeny of land plants and map the origin of the following traits: spores, seeds, tracheids, vessels, cuticle, stomata, pollen, flowers, fruits.
- Describe three ways that the presence of land plants affects the abiotic environment.
- What challenges are associated with life on land for plants? Discuss the evolutionary innovations within plants that are important for living and reproducing on land. Be able to map these traits onto a phylogeny of the green plants.
- Some members of the Charales synthesize sporopollenin and lignin. What is the significance of this observation for the evolution of land plants?
- Discuss the evolutionary radiation of angiosperms. Why are angiosperms so diverse?

- "Pollination has been the most significant mutualism for the evolution of biodiversity on Earth." Do you agree or disagree with this statement? Explain.

Fungi

- Be able to use the following words and phrases: mycorrhizae, saprophyte, yeast, hyphae, mycelium, heterokaryotic, zygosporangium, basidium, ascus, ascocarp, chitin, endophyte, extracellular digestion, lignin peroxidase, cellulase, spore, plasmogamy, karyogamy, sporangium
- Be able to show the phylogenetic position and discuss the defining characteristics of the following groups: chytrids, basidiomycetes, ascomycetes.
- Be able to discuss the ecological roles and importance to humans of the following groups: ectomycorrhizal fungi, arbuscular mycorrhizal fungi, lichens, endophytes, yeasts, chytrids.
- Describe two different ways that fungi increase the productivity of terrestrial ecosystems.
- Discuss the adaptations for decomposition found within the fungi.
- Compare and contrast reproduction in ascomycetes and basidiomycetes.
- Describe the niche of the chytrid *Batrachochytrium dendrobatidis*, as described in the article by Pounds et al. How does the life cycle of this fungus affect its niche? How might an understanding of the life cycle of chytrids help biologists prevent the spread of this pathogen?
- A great diversity of life cycles can be observed within the multicellular eukaryotes. Which of the following groups include species with alternation of generations: protists, land plants, animals, fungi? Draw a generalized life cycle with alternation of generations and label the following events or structures: sporophyte, gametophyte, meiosis, zygote, fertilization, syngamy, spores, gametes. How is this basic plan altered to result in the life cycles of the following organisms: bryophytes, angiosperms, basidiomycetes, animals?
- Compare and contrast the roles of plants and fungi in the carbon cycle with the roles of bacteria in the nitrogen cycle.
- Discuss two distinct ways that the surface area:volume problem has been solved within the tree of life.

Animals

- Be able to use the following words and phrases: Cambrian explosion, body plan, diploblast, triploblast, tissue, ectoderm, endoderm, mesoderm, asymmetry, radial symmetry, bilateral symmetry, cephalization, pentaradial symmetry, coelom, pseudocoelom, hydrostatic skeleton, spiral cleavage, radial cleavage, gastrulation, sessile, exoskeleton, endoskeleton, internal fertilization, external fertilization, metamorphosis, water vascular system, pharyngeal gill slits, notochord, dorsal hollow nerve cord.
- Be able to discuss the phylogenetic position, phylogenetic status, and defining characteristics of the following groups: Porifera, Cnidaria, protostomes, deuterostomes, Annelida, Nematoda, Arthropoda, Platyhelminthes, Mollusca, Echinodermata, Chordata, vertebrates, invertebrates, fishes, amphibians, reptiles, birds, mammals.
- Draw a simplified phylogeny of animals (including at least six major phyla) and map the origin of the following traits: symmetry, tissue layers, coelom, segmentation, protostome development, deuterostome development.
- Draw a phylogeny of major vertebrate groups and map the origin of the following traits: cartilaginous skeleton, bony skeleton, jaw, lungs, limbs, amnion, endothermy.
- Discuss the importance of the following evolutionary innovations: mesoderm, bilateral symmetry, metamorphosis, desiccation-resistant eggs, jointed appendages.
- What challenges are associated with life on land for animals? Discuss the evolutionary innovations within the vertebrates that are important for living and reproducing on land, and be able to map these traits onto a phylogeny of the vertebrates. Compare and contrast the adaptations for life on land within the vertebrates with similar adaptations within the arthropods and mollusks.
- Compare and contrast the role of metamorphosis in the life cycle of sedentary animals and in the life cycle of mobile animals.
- Brachiopoda is a phylum within the Protostomes. Even though they are not closer relatives of the mollusks, brachiopods look and act like clams or mussels. They attach to hard surfaces, suspension feed, and live inside two calcium carbonate shells that sometimes hinge together. How is it possible for brachiopods and bivalves to be so similar if they did not share a recent common ancestor?
- Give several distinct examples of animals using different feeding modes.
- Discuss the evolutionary radiation of arthropods. Why are arthropods so diverse?
- Use the evolution of vertebrate limbs and jaws to discuss the evolution of novel traits.

- Compare and contrast adaptations involved in the diversification of the three most species-rich animal lineages: arthropods, mollusks, and vertebrates.
- Compare and contrast adaptations for life on land within the plants and the vertebrates.
- Discuss at least three examples of major adaptive radiations within the evolution of animals. Describe the key events that triggered these radiations.
- Your textbook states that human populations within Africa are more genetically diverse than all human populations outside of Africa. How can this be? How does this statement relate to the Y-chromosome phylogeny developed by Ke et al.?
- How are patterns of past isolation and gene flow revealed by a phylogeny? Use the study described by Ke et al. as an example.