

BIO101-01 Winter 04  
Exam III Study Guide

The format of Exam III will be like that of Exam I, a mixture of application/concept and factual recall questions. For this unit, the topics covered in Chapters 13-14 and 18-19 are more conceptual. The material covered in Chapters 15-17 is a lot of taxonomy and description of the features that distinguish groups of microbes (Ch. 15), plants/fungi (Ch. 16), or animals (Ch. 17).

Chapters 13-14

- **DARWIN.** “On the Origin of Species” changed the face of biology forever. Understand the two principles put forth by this work: (1) **descent with modification**, the idea that populations evolve over generations, and (2) **natural selection**, the idea that *nature* (or the environment) selects for those organisms that are most likely to succeed (i.e. ‘survival of the fittest’).
- Natural Selection: how does it work? Darwin made two very important observations in his travels that led to this idea of natural selection: (1) **overproduction** (which leads to competition) and (2) **individual variation** within a population (i.e. individual organisms in a population are NOT genetically identical and therefore, will have some phenotypes or traits that vary). These two observations are essential to understanding how natural selection works. A ‘universal feature’ of life is replication/reproduction—all individuals of all species in a community or an ecosystem have the capacity (and in most cases, desire) to reproduce. However, resources are limiting in many ecosystems, so when a population is too prolific, only those individuals that have the competitive edge will survive. Those individuals bearing the traits that are most suitable to the environment will live longer and reproduce more than those individuals less suitable to the environment. So, the result is **differential reproductive success**. This means that the most ‘fit’ organisms reproduce more and the following generations will have a higher frequency of the traits responsible for that fitness. Natural selection is an editing process, *not* a creative one (meaning that the selective pressure from an environmental condition favors those individuals that *already exist* in a population with a particular trait).
- What is the result of natural selection? Evolutionary **adaptation**. Adaptation occurs as a result of differential reproductive success over many generations. An adaptation is a ‘derived’ trait, one that is not found in the original, or primitive, population. Think about Darwin’s finches from the Galapagos Islands. Each species has a different kind of beak, shaped for particular uses. These are adaptations, each an independent derivation from the original beak shape of the finch population on the coast of South America. The different adaptations allow each species to have a different **niche** in the community (some feed on insects in the trees while others feed on seeds on the ground, for example) and prevents direct competition amongst the different species for resources. Another important point about natural selection is that it relates to a particular **place and time**. So, selection occurs because of very specific environmental conditions (weather, resources, competition, etc) at a particular time and location in the biosphere. That’s why you have a diverse community of marsupials in Australia but not other parts of the world, for example.

- What are the different scientific disciplines that contribute evidence for evolution? Geology, geography, paleontology (study of fossils), comparative anatomy, comparative embryology, molecular biology and so on.
- How can you think about Darwin's ideas of evolution and natural selection from a genetic or molecular biology perspective? Population genetics. A **population** is a group of individual organisms of the same species living in a particular location at the same time. A population is the smallest biological unit (or 'level of life' as we have said in class) that can evolve. An individual within a population CANNOT evolve within its lifetime! This is because any 'traits' that are acquired during the lifetime of an individual are somatic and not 'germline' (For example, highlighting my hair would give *me* blonder hair but it doesn't mean my children will have blond hair because it doesn't change my particular alleles for haircolor. Another example would be if I have the *BRCA1* mutation that is associated with breast cancer and I decide to have a mastectomy so that I don't have to worry about getting breast cancer).
- Only the genetic causes of variation in a population play a role in evolution of that population. Traits that vary from individual to individual within a population are called **polymorphic** (eye color, for example). The variation that we see (the phenotype) is caused by variation at the gene level (the genotype). So, different alleles of the same gene contain polymorphisms (slight variations in the DNA sequence of the gene) that result in a different phenotype. Genetic variation in a population can be the result of **mutations** (which can be beneficial, harmful, or have no effect on viability) and the result of sexual reproduction (the **recombination**, or crossing over, that occurs during meiosis).
- The '**gene pool**' is all of the alleles represented in a population of individuals. If the trait follows Mendelian principles of genetics, the dominant allele in the gene pool will occur at a certain frequency (designated by the letter "**p**"), the recessive allele will occur at a certain frequency ("**q**"), and the sum or total of those frequencies should be 1 (or 100%). You can use the **allele frequencies (p and q)** to calculate the **genotype frequencies** for a given trait in a diploid population in which the alleles are in equilibrium (not evolving). So, value of  $p^2$  represents individuals with the homozygous dominant genotype,  $q^2$  represents individuals with the homozygous recessive genotype, and  $2pq$  represents individuals who are heterozygous. If you know the allele frequencies (p and q) for a given trait in a population, you can calculate the genotype frequencies using the Hardy-Weinberg formula  $p^2 + 2pq + q^2 = 1$ .
- **Evolution can be observed** when there is a change in the allele frequencies within a population from generation to generation (this is called **microevolution**). Antibiotic resistance in bacteria and drug resistance in viruses such as HIV are modern examples of microevolution that has occurred in the last several decades.
- Understand the **mechanisms of microevolution**: genetic drift (examples are the bottleneck effect and the founder effect), gene flow, mutations, and natural selection (three possible outcomes are directional selection, diversifying selection, and stabilizing selection).
- Understand what 'Darwinian Fitness' means—that the 'success' of an individual in a population depends on what contribution that individual has made to the gene pool of the next generation (compared to others in the population)... i.e. the more offspring you have, the more 'fit' you are.

- **Macroevolution, the biological species concept and speciation.** Macroevolution involves the branching out of different species. A species is defined by the ability (mechanically, geographically, etc) to interbreed according to the biological species concept.
- What are the barriers that define a species? Know the different kinds of pre-zygotic and post-zygotic barriers.
- How does speciation occur? Know the mechanisms of speciation (allopatric and sympatric) and also the models that describe the ‘tempo’ of speciation (gradualistic vs. punctuated equilibrium).
- Understand how novel structures and/or functions might evolve. **Exaptation**, for example, is the term used to describe the evolution of a structure that has evolved in one environment and been adapted for use in another environment. Know what **paedomorphosis** means and be able to give examples of it.
- Understand the kinds of events that can promote evolution/adaptation/diversification of life. Mass extinctions, geographic isolation (continental drift, for example), etc.
- **Know how organisms are classified (taxonomy).** The scientific or latin name of an organism is **binomial** (genus and species). The modern hierarchy that taxonomists use for **classification** has eight levels and they are (starting with the broadest category): domain, kingdom, phylum, class, order, family, genus, and species.
- Understand the concept of **convergent evolution**. This occurs when distantly related organisms evolve structures that have similar functions (analogous but not homologous). An example of this is the wings of a bat (which is a mammal). They function like the wings of a bird, but have a completely different origin.
- Know what **cladistic analysis** is... searching for branches of organisms consisting of an ancestral species and all of those species derived from it. Clades or branches are identified based on homology of structures or genes and are often represented by the phylogenetic tree diagrams we have seen throughout the textbook. Cladistic analysis always involves comparison of the related organisms to a distantly related organism (called the ‘outgroup’). If you are doing a cladistic analysis on mammals, you could use a reptile or bird as the outgroup (so, something that is a vertebrate but not a mammal).

### Chapters 15-17

- Know what the phylogenetic tree of life looks like (i.e. how living organisms are generally related to one another and the timing of the major diversification events in evolutionary history).
- Origin of life: understand the difference between spontaneous generation and biogenesis. Spend some time thinking about how life came into being from non-living things and the four steps that are predicted in the evolution of life.
- Two domains of prokaryotes: **archaea and bacteria**. Prokaryotes come in different **shapes** (including cocci, bacilli, and spirochetes) and reproduce (divide) through a process called **binary fission**. Know about endospores.
- Understand how different prokaryotes have different nutritional and energetic requirements (i.e. autotroph vs. heterotroph, and phototroph vs. chemotroph).
- Microbes in the ecosystem: pathogenic bacteria cause disease (endotoxins and exotoxins), other bacteria are useful in waste recycling and bioremediation.

- Protists are mostly unicellular eukaryotes. The early protists were the first eukaryotic organisms, thought to have evolved through several steps of endocytosis to generate the membrane-bound organelles. In the case of organelles like the mitochondrion and chloroplast, this process is called endosymbiosis because it involves the endocytosis of another organism.
- Know the general features and be able to give examples of the four groups of protists, which include protozoans, slime molds, unicellular algae, and seaweed.
- Understand the main differences between plants and whole alga with respect to the transition from water to land. Know the structural and reproductive adaptations of plants compared to algae.
- Know the major steps in plant evolution and be able to give examples of organisms representing each stage, starting with (1) the origin of terrestrial plants, (2) the evolution of a vascular system, (3) the evolution of the seed, and (4) the emergence of flowering plants.
- Understand the life cycle of plants, the **alteration of generations**, between the **sporophyte** and **gametophyte** and know what kinds of plants represent each of those generations.
- Study the anatomy of an angiosperm: what are the male and female reproductive organs?
- Study the anatomy of fungi (hyphae, mycelium, etc) and how they reproduce (spores).
- Know the different roles that fungi play in our ecosystems (decomposers, parasites, antibiotic-producers, and sometimes food)
- Understand what **symbiosis** means and be able to give some examples (**mycorrhizae**—the fungus that grows on the roots of plants, **lichens**—the symbiotic combination of fungi and algae, etc.)
- What is the major difference between the multicellular, heterotrophic eukaryotes that are fungi and the multicellular, heterotrophic eukaryotes that are animals? Fungi obtain food and nutrients through **absorption** (by digesting things around them) while animals obtain food and nutrients through **ingestion**.
- Know the life cycle of an animal (i.e. the **development** from fertilization to blastula to gastrula, etc) and the stages of **metamorphosis** (from embryo to larva to pupa to adult).
- Review the ideas proposed for the evolution of multicellularity and from there, the origin of the first animals (multicellular organisms that could ingest food).
- Be familiar with the 9 major animal phyla that we have discussed in the animal kingdom (Porifera, Cnidaria, Platyhelminthes, Nematoda, Mollusca, Annelida, Arthropoda, Echinodermata, and Chordata) and the four significant evolutionary steps in the evolution of animals (evolution of true tissues, bilateral symmetry, body cavity, and then the diversification of the true coelom). You should be able to look at each phylum, describe its features with respect to the four categories above and give examples of organisms represented in that phylum.
- Know the differences between invertebrates and vertebrates (and where they fall in the phylogenetic tree of animals), the four general features of chordates, and the general features of the different classes of vertebrates we discussed (fishes, amphibians, reptiles, birds, and mammals).
- Consider what adaptations animals had to have in order to transition from water to land and compare that with what you know about the same move for plants.

## Chapter 18

- Know what 'ecology' means (the study of interactions between organisms and their environments) and be able to identify the **biotic** and **abiotic** components of an **ecosystem**.
- Understand the hierarchy of interactions, or different levels at which you can examine ecology (organismal, population, community and ecosystem).
- Consider the connections between ecology and environmentalism AND ecology and evolution.
- Organismal ecology focuses on the interaction of specific organisms and their environments. There are three types of evolutionary adaptations that allow organisms to adjust to, or **acclimate**, to changes in the local environment. These include **anatomical, physiological, and behavior responses**. Think of examples of each of these.
- Population ecology focuses mainly on population density and population growth (be able to define 'population'). Know the different patterns of dispersion and also the different models for population growth. Understand how density-dependent and density independent factors can affect population growth.
- Be familiar with population cycles (like boom-and-bust), how birth rate, death rate, and age structure all determine population growth, and how life history (opportunistic or equilibrial) affects a survivorship curve.