**BSC2005 Exam #3 Study Guide**

In general, material from the book (and other readings), material from the lecture videos and other videos, and material from the assignments (especially those which reinforce a concept from the reading and/or lectures) is all fair game for the exam.

This is not an exhaustive list of everything you may need to know, and not every single thing from this list will necessarily be asked about on the exam, but this study guide is meant to help you focus in your studying effort on the most important concepts from the modules covered by this exam.

**Module 9: Evidence for Evolution**

* How can we tell the difference between a rock and a fossil? Why do we care about fossils in the first place?
  + Specialists learn to recognize the structures and patterns of anatomical features
  + Fossils give info about the kinds of organisms that lived, what they looked like and where and how they lived
* How do fossils form? How does this affect what organisms (or what parts of organisms) are more or less likely to become fossils?
  + Remains must avoid being trampled, scavenged, or decomposed
  + Remains must be buried rapidly in dry or anoxic (no oxygen) environment
  + Harder/larger parts are more likely to fossilize
  + Once remains are buried, minerals in the dirt around it soak into the bone/shell
  + Alternatively, soft tissues may leave an imprint
  + Fossil must be exposed to the surface and found before it erodes
* What are the three main types of rock? Which one is most likely to have fossils in it, and why?
  + Igneous: new rock, from lava
  + Sedimentary: hardened layers of sediment/dirt (sandstone)
  + Metamorphic: igneous or sedimentary rock with have been transformed by extreme pressure and/or heat
  + Fossils are found in sedimentary rock
* What is the principle of superposition? What is the principle of faunal succession? How can we use these to determine the age of a given fossil?
  + Superposition: in a sequence of sedimentary rocks, the oldest layer is at the bottom and the newest layers are at the top (layers are called strata)
  + Faunal succession: fossils appear in the same order in rock layers (older species appear first)
* What is radiometric dating? What kind of rocks does it work on? How can we use these to determine the age of a given fossil?
  + Absolute dating. Uses rate of decay of radioactive isotopes to determine age
* Relative dating:
  + Based on position. Older fossils are buried below younger fossils
* What is a half-life? Be able to go from # of half-lives to expected % of parent isotope remaining (or expected ratio of parent:daughter isotopes), and vice-versa.
  + Time it take for half of the original isotopes to decay
  + 1 / 2^num\_half\_lives = fraction remaining (1/16 after 4 half-lives)
  + Long time duration dating is done by dating surrounding layers of igneous rocks
* What are transitional fossils? What are some examples of transitional fossils (or transitional series) in the fossil record, and why are they considered transitional?
  + Fossils that show the evolution of a species
  + Horses, archaeopteryx (early bird), primitive whales, Tiktaalik
  + Horse ancestors got taller over time, and the number of toes dropped from 4 to 3 to 1
* Be able to define and recognize homologous traits.
  + Traits that were present in and inherited from a common ancestor
* What are vestigial structures and what do they tell us about the history of life?
  + Structures that have lost their use through evolution
  + They provide evidence for evolution because they suggest that an organism changed from using the structure to not using the structure, or using it for a different purpose
* How old is the Earth? How long has life existed on Earth? What was the earliest life on Earth like? When did eukaryotes evolve? Multicellular eukaryotes?
  + Earth is ~4.5 billion years old
  + Life has existed ~3.5 billion years
  + Earliest life was prokaryotes
  + Photosynthetic prokaryotes arose 2.5 billion years ago
  + Eukaryotes evolved around 1.5 billion years ago
  + Multicellular eukaryotes evolved around 1.2 billion years ago
  + Land plants appeared 400 MYA
  + Firs land vertebrates appeared 380 MYA
* What is the structure of the geologic time scale? (\_\_\_ subdivided into \_\_\_\_) How did we determine the boundaries between these divisions?
  + Eras are subdivided into periods
  + Each period is characterized by specific animals, plants, climates, and positions of the continents
  + Boundaries between periods are marked by extinction events
  + Really big extinctions mark the boundary between eras
* What event marked the beginning of the Paleozoic? The end of the Paleozoic and the start of the Mesozoic? The end of the Mesozoic and the start of the Cenozoic?
  + Paleozoic: start=Cambrian explosion, end=the great dying
  + End of Mesozoic=K/T boundary, dinosaur killing asteroid
* Approximately when were the two biggest mass extinction events in the history of life on Earth? Which one was bigger? What are believed to be the causes of each?
  + End-Ordovician: 444 MYA, 86% species lost, glacial activity
  + Late-Devonian: 360 MYA, 75% species lost, land plants created severe global cooling
  + End-Permian: 250 MYA, The great dying, the biggest, volcanic activity
  + End Triassic: 200 MYA, 80% lost, underwater volcanic activity
  + End-Cretaceous: 65 MYA, 76% lost, Yucatan asteroid

**Module 10: Life on Earth**

* Approximately how many species are there on Earth right now? Approximately what percent are animals vs. plants vs. fungi vs. unicellular organisms? How would that change if we looked at estimated species vs. described species?
  + 1.8 million named species
  + Animals are most diverse
  + 8.7 million estimated eukaryotes
  + Animals: ~60%
  + Plants: ~15%
  + Fungi: ~3%
  + Protists: ~1.5%
  + Bacteria: ~0.75%
  + Archaea: ~0%
* Define biodiversity. Why is it important?
  + The totality of life
  + All species are connected ecologically
  + Provides ecosystem services (fresh water, erosion control)
* Define biogeography. What can the movement of the continents tell us about the evolution of life? Explain some examples.
  + The study of how organisms are distributed in geographical space
  + Some species live in a particular place because that’s where their ancestors lived
  + Diversity is affected by competition and selective pressures
* What is an adaptive radiation? Why/how does it occur?
  + A species or group of species adapts and diversifies to fill open niches
  + Produces many daughter species
  + Rapid diversification
  + May be due to extinction of an unoccupied niche
* What’s the difference between gradualism vs. punctuated equilibrium?
  + Both are patterns in the fossil record
  + Gradualism: traditional viewpoint, evolution takes place in small incremental steps
  + Punctuated equilibrium: long periods of stasis with no changes, followed by large rapid changes (adaptive radiation)
* Taxonomy:
  + Science of identifying organisms, naming them, and classifying them into groups
* What is binomial nomenclature, and why is it important?
  + The system of nomenclature in which two terms are used to denote a species of living organism, the first one indicating the genus and the second the specific epithet.
  + Previously, organisms could have several different names depending on the system
  + Allows scientists to ensure that they’re talking about the same species
* What are the levels of Linnean taxonomy, from most inclusive to least inclusive?
  + Domain, kingdom, phylum, class, order, family, genus, species
  + Each organism gets a name with two words, the genus (always capitalized), and specific epithet
  + The species name is both words combined
  + Always in italics and in latin
* What is a phylogenetic tree, and how is it similar to / different from Linnean taxonomy?
  + Phylogeny is used to show the patterns of relatedness among species
  + Taxonomy + phylogeny = systematics, which reflects relatedness and evolutionary history of species
* Given a phylogenetic tree (drawn in a variety of ways), be able to identify:
  + the common ancestor/root and the tips of the tree. What does this imply about how time is depicted using a tree?: past on the bottom
  + the most recent common ancestor of any two organisms on that tree: intersection/node that connects them
  + the closest relative of any organism on a tree: shortest distance to shared node
  + the clades that that tree contains: ancestral node and all its descendants (triangle with a point at a node)
  + identical trees with rotated branches: compare closest relatives
* What are nodes on phylogenetic trees? What event in the evolutionary history of a group of organisms do they represent?
  + Traits
  + New species being formed
* What types of traits can be used to reconstruct phylogenetic trees? What are some of their pros/cons? Which types of organisms can they be used for vs. not used for?
  + Traits shared by some members
* What is the principle of parsimony, and how does it apply to phylogenies? Given a simple set of traits, be able to identify the most parsimonious phylogeny.
  + The preferred explanation for an observed set of data is the simplest explanation
  + Traits likely didn’t evolve independently in a tree
* Be able to identify synapomorphies, symplesiomorphies, and analogous/convergent traits. Which one is the same as homologous traits?
  + Synapomorphies: shared characteristics are inherited from the most recent common ancestor (away from the common ancestor, traits shared going up the tree)
  + Symplesiomorphies: traits that evolved very early on and is shared by all taxa within the group, not informative about relationships (everyone has it)
  + Homologies: similar structures in different lineages inherited from a common ancestor
  + Analogous structures look and perform the same function, but did not come from a common ancestor and evolved independently

**Module 11: Prokaryotes**

* Review from Exam 1: What are the differences between prokaryotes and eukaryotes?
  + Prokaryotes lack the organelles of eukaryotes. Also have circular DNA
  + Single-celled
  + Divide by binary fission
* What are the three domains of life? Be able to draw/interpret their phylogeny (how are the three related to each other?).
  + Bacteria:
  + Archaea:
  + Eukarya: Animals, plants, fungi, and protists. More closely related to archaea than bacteria
* Where do we find prokaryotes? What is the microbiome?
  + Literally everywhere
  + 40 million in one gram of soil
  + More prokaryotic cells in and on your body than human cells
  + The microbiome is the collection of all microbes, such as bacteria, fungi, viruses, and their genes, that naturally live on our bodies and inside us.
* Differentiate between obligate anaerobes, obligate aerobes, and facultative anaerobes. Can you relate this back to what you learned about cell respiration & metabolism back in Module 4?
  + Obligate anaerobes: cannot survive in O2
  + Aerotolerant anaerobes: don’t use, but can survive in O2
  + Obligate aerobes: cannot survive without O2
  + Facultative anaerobes: can swap back and forth to metabolic pathways that use or don’t use O2
* Differentiate between autotrophic and heterotrophic prokaryotes. What are some of the ways each type can get their nutrients?
  + Autotrophic: make own food, some with photosynthesis, some with chemosythesis (with H2, S, or NH4)
  + Heterotrophic: most bacteria and archaea, must obtain energy from other organisms. Typically secrete enzymes that break down food and then absorb the digested material
    - Saprotrophic: decomposers
    - Parasites: live in or on host
    - Mutualistic: symbiotic
* What are the three main shapes of bacteria? How does shape affect their lifestyle?
  + Coccus (round)
  + Bacillus (rod)
  + Spirella (spiral/helical)
  + Shape affects how they gain energy, how they attach to their surroundings, and how they move
* What’s unique about the bacterial cell wall? What’s the difference between gram positive and gram negative bacteria?
  + Made up of peptidoglycan (sugar/protein polymer)
  + A diagram of a cell membrane

    Description automatically generatedGram negative cells have an additional membrane on either side of the peptidoglycan
* How do bacteria move around vs. stay in one place?
  + Flagella: whip-like rotor
  + Helical bacteria can move via a corkscrew motion
  + Other can glide or roll, or move up/down by adjusting gas levels (buoyancy)
  + Attach via fimbriae (hair-like structures) or secreting sticky capsules
* How do bacteria reproduce? How does this differ from the process of mitosis that you learned about in Module 5?
  + Binary fission: duplicated DNA, then splits in half
* What is conjugation? How is this similar to sexual reproduction? How does it differ?
  + Gene exchange via a pilus from one cell to another
  + Exchange is one way, and only a few genes
* What are endospores? In what conditions might they be formed?
  + Tough cell wall and are resistant to heat, freezing, pressure, desiccation
  + Formed when conditions are bad
  + Can remain inert for millions of years
* What are biofilms? Where are they found?
  + Dense groups of bacteria/archaea that form on solid surfaces
* How do Archaea differ from Bacteria?
  + Archaea lack peptidoglycan in cell walls (have other lipids in their membranes)
  + Many are extremophiles
* What does it mean to be an extremophile? Which domain has the most diverse extremophiles? What kind of environments can they be found in?
  + Can live in extreme environments
  + Archaea have the most
  + Halophiles: salt lovers, live in salty, alkaline environments (pH up to 11.5). Many have like absorbing molecules called bacteriorhodopsin which makes them essentially photosynthetic
  + Thermophilic: loves heat
  + Acidophilic: loves acidic environments
  + Methanogens: produce methane as a metabolic by-product
  + Chemosynthetic: metabolize H2 and CO2 into CH4
* Are most prokaryotes beneficial, harmful, or neutral in their effect on humans?
  + Vast majority are neutral or beneficial
* Why are cyanobacteria so important to the history of life on Earth?
  + Changed composition of atmosphere by generating O2
* What are some of the main jobs that prokaryotes do that benefit humans (directly or indirectly)?
  + Photosynthesis
  + Decomposers
  + Break down pollutants (bio-remediation)
  + Nitrogen fixation
* What is nitrogen fixation and why is it so important? What role do prokaryotes play?
  + Converts atmospheric N2 into a form that plants can use (N2-NH4->NO2->NO3)
* What is symbiosis? What does it mean if a symbiotic relationship is parasitic? Mutualistic? Commensalistic? Be able to give examples of each.
  + Symbiosis: long-term close interaction between two organisms
  + Mutualism: beneficial to both
  + Commensal: neutral
  + Parasitic: one benefits, the other doesn’t

**Module 12: Eukaryotes**

* Review from Exam 1: What are eukaryotes? What features do they all share that distinguish them from prokaryotes?
* What is endosymbiont theory? What does it suggest about how eukaryotes evolved? Which organelles are involved? What is the evidence that supports this theory?
  + One prokaryote ate another and formed a symbiotic relationship
  + Mitochondria, chloroplasts
  + Mitochondria and chloroplasts are similar size to prokaryotes, divide in a similar way, have their own circular DNA, and the DNA is similar to prokaryotic DNA
* What are the four main groups/types of Eukaryotes? Which of these are clades (Module 10) and which is not?
  + Protists
  + Plants
  + Animals
  + Fungi
* What are protists? How do they get their food? Where can we find them? Are they always unicellular? Give some examples.
  + Catch all group, some with animal like properties, some with plant-like properties, and some with fungi-like properties
  + Can be uni or multicellular
  + Found in diverse habitats, mostly water, soil and as parasites
  + Kelps are the largest
  + Diatoms form glass shells and are responsible for nearly half the photosynthesis in the oceans
* What features distinguish plants from other eukaryotes?
  + Multicellular autotrophic eukaryotes
  + Cell walls contain cellulose
* When did land plants first evolve? What major challenges of living on land did they have to face?
  + ~500 MYA
  + Cuticle (covering on surface of leaf to hold in water), stomata (valves to let in air), vascular tissue, wood
* Also, what is the importance of the following traits? In the evolution of land plants, which groups have which traits? Which of these traits evolved earliest vs. latest?
  + Vascular tissue (xylem & phloem): phloem: transports sugars and other items, xylem: transports water and minerals. Transports things around the plant. Separates Bryophytes
  + True leaves: separates Lycophytes
  + Seeds:
  + Flowers & Fruits: protects seeds in angiosperms
  + Cones: protects seeds in Gymnosperms
* A diagram of a plant life cycle

  Description automatically generatedWho are the members of each of the following groups? What unique features do they have?
  + Bryophytes: non-vascular, small, damp environments, non-flowering, no seeds, dust-like spores which require the presence of water, mosses, liverworts, hornworts
  + Lycophytes: vascular, no true leaves, only about 1K species, coal is mostly fossilized lycophytes
  + Ferns: vascular, true-leaves, non-flowering, no seeds, reproduction still relies on water (floating spores)
  + Gymnosperms: vascular, no longer require water for reproduction, have pollen and seeds, seeds are exposed
  + Angiosperms: vascular, flowers, seeds contained in fruit, dominant plant type
* What features distinguish animals from other eukaryotes?
  + Movement
* Define asymmetrical, radially symmetrical, and bilaterally symmetrical body plans. Give examples of animals that have each type.
  + Asymmetrical: no symmetry, sponges
  + Radial: circularly symmetry, jellyfish
  + Bilateral: left and right haves, people, dogs
* Who are the members of each of the following groups? What unique features do they have?
  + Sponges: asymmetric, lack defined tissues or organs, no specific shape
  + Cnidarians: radial symmetry, jellyfish, stinging cells (cnidocytes)
  + Flatworms: simplest animal with bilateral symmetry
  + Mollusks: soft body, hard outer shell, clam
  + Annelids: segmented body, earthworm
  + Nematodes: long, unsegmented body, roundworm
  + Arthropods: exoskeleton, flies
  + Echinoderms: endoskeleton, leathery outer skin, sea cucumber
  + Chordates: vertebrates, dogs
* What’s the difference between each of these comparisons, and who belongs to each group? For each, which one are you?
  + Invertebrates and vertebrates? Spinal cord, most have jaws, nervous system with n enlarged brain
  + Protostomes and deuterostomes?
    - Protostome: mouth end of digestive track develops first
    - Deuterostome: mouth end develops second
  + Fish vs. Tetrapods?
    - Fish: Bony and cartilaginous, most diverse vertebrates, many different reproductive modes and adaptations, gills
    - Tatrapods: Tiktaalik, four feet, fins evolved to fingers and toes
  + Amphibians vs. Amniotes?
    - Amphibians: Grogs, toads, salamanders, newts, caecilians. Must stay near water, gas exchange via skin or lings. Larval state when young
    - Amniotes: Amniotic egg (outer shell), can reproduce on land, skin, feathers, scales prevent water loss
  + Monotremes, Marsupials, and Placental Mammals?
    - Monotremes: lay eggs
    - Marsupials: pouched mammals
    - Placental: carry young in uterus until birth
  + Endotherms vs. Ectotherms?
    - Endotherms: warm-blooded, high metabolism
    - Ectotherms: cold-blooded, lower-metabolism, use heat from environment
* How are fungi similar to plants? How are they similar to animals? Which one are they more closely related to, phylogenetically?
  + Modern fungi evolved from unicellular protists, have chitinous cell wall
  + Plants: Don’t move, reproduce via spores, have a cell wall
  + Protists: Can be uni or multicellular
  + Animals: heterotrophs, fungi diverged from animals
* What are hyphae? Mycelium?
  + Hyphae: thin filaments which secrete digestive enzymes onto food sources and absorb nutrients
  + Mycelium: whole body make of hyphae
* What are some other types of fungi in addition to mushrooms?
  + Yeasts, molds, mushrooms
* Lichens are a symbiosis of fungi, algae or cyanobacteria, and yeast
* How do fungi get their nutrients?
  + Decomposers, nutrient uptake via osmotrophy in hyphae