SCIENCE DEPARTMENT

The Department's Educational Philosophy

Students will engage in the process of science through scientific inquiry and application of the underlying scientific concepts. Students will use qualitative as well as computational thinking to analyze and interpret data. Students will develop the necessary skills to generate, interpret qualitative and quantitative data, evaluate scientific claims and provide evidence for scientific conclusions. .

Guiding Principles

- Students will engage with the process of science by participating in hands on activities and labs that help students to gain a better understanding of underlying concepts, elucidate concepts and relationships or develop inquiry based experiments.
- Students will apply their computational skills to interpret and represent data.
- Students will be able to evaluate the merits of conceptual models and apply the appropriate models and relationships.
- Students will be able to support scientific claims, provide evidence for those claims and make conclusions based on qualitative and quantitative data.
- Students will work collaboratively.

BIOLOGY AE: COURSE #422

Course Frequency: Full year course

Credits Offered: Five

Prerequisites: By teacher recommendation

Background to the Curriculum

This course is aligned with the MA Frameworks. This course is long-established and has developed over time to align with the Guiding Principles and Educational Philosophy of the ABRHS Science Department.

Core Topics/Questions/Concepts/Skills

- Ecology
- Chemistry of Life
- Cells
- Cells and Energy
- Cell Cycle
- Meiosis
- Heredity
- Molecular Genetics
- Evolution
- Human Systems

Course-End Learning Objectives

Ecology Concepts

A. Science is a way of knowing about the natural world through discovery and hypothesis testing.

1. Explain how a hypothesis differs from a theory.
2. Distinguish between the dependent and independent variables.
3. Distinguish between a controlled variable and a control group.
4. Distinguish between and explain Claim, Evidence, and Reasoning.

B. Species interact with each other and their varied environments.

5. Distinguish between the five levels of ecological organization: *species, population, community, ecosystem, biosphere*. Draw a flow diagram to illustrate these levels.
6. Distinguish between and give examples of biotic and abiotic factors in an ecosystem.
7. Explain the concept of an ecological niche and how it differs from an organism's habitat.
8. Describe how populations can interact within the following relationships:
   - Predation-prey
   - Competition
   - Symbiosis (mutualism, commensalism, parasitism)
9. Explain the competitive exclusion principle (provide an example).

C. Energy flows in one direction through Earth while matter cycles throughout Earth.

10. Compare and contrast the processes of photosynthesis and chemosynthesis.
11. Explain the difference between the following nutritional modes: autotroph, heterotroph, carnivore, herbivore. Provide an example of each.
12. Be able to draw, label, and analyze a food web that illustrates the following trophic levels: producers, various consumer levels, decomposers.
13. Explain the similarities and differences between the pyramids of energy, numbers, and biomass.
14. Describe and explain the 10% rule and contrast it with the process of biomagnification. Draw a diagram to illustrate the difference between these two concepts.

D. Ecosystems are dynamic and ecosystem stability depends on many factors.

15. Distinguish between primary and secondary succession.
16. Describe how ecosystem size correlates with ecosystem stability.
17. Describe why biodiversity is important to ecosystems and to humans within ecosystems.
18. Analyze the effects human activities, such as hunting, habitat fragmentation, and pollution, have on biodiversity and ecosystem health, and be able to provide a solution for reducing human impact.
19. Explain the difference between an introduced species and an invasive species and describe the effects invasive species can have on native species and an ecosystem.
20. Describe the role a keystone species plays in the stability of an ecosystem. Give an example of a keystone species and explain why it is considered a keystone species.

E. Populations grow at different rates and are influenced by multiple factors.

21. Describe the differences between logistic and exponential growth patterns. Also draw 2 graphs to demonstrate these differences.
22. Explain how the following biotic factors affect population growth:
    -- *Birth rate vs. Death rate*
    -- *Immigration vs. Emigration*
23. Explain the concept of carrying capacity. Draw a graph and label where on the graph carrying capacity occurs and explain why.
24. Explain the idea of limiting factors on population growth and how this relates to carrying capacity. Provide two examples of limiting factors and why they would cause the population to decline.
25. Contrast how density-dependent and density-independent limiting factors influence population growth. Give an example of each.

Chemistry of Life Concepts

A. Life depends on the chemical properties of matter.

1. Name the six most common elements in biological molecules.
2. Distinguish between ionic bonds and covalent bonds.
3. Explain the significance of the following properties as they relate to the chemistry of water: *polarity and universal solvent.*
4. Explain why water is necessary for humans (animals) to drink.

B. Built from a backbone of carbon atoms, macromolecules supply energy and key functions to living things.

5. Explain how the chemistry of carbon makes it fundamental to building organic molecules.
6. Distinguish between monomers and polymers as they relate to organic molecules. Draw a diagram to illustrate this concept.
7. Describe the basic structure and major functions of each of the four major macromolecules: *carbohydrates, lipids, proteins and nucleic acids.* Create a table to organize your answer.
8. Name the building blocks of each of the 4 macromolecules.
9. Provide an example of each of the 4 macromolecules.
10. Distinguish between glucose, glycogen, starch, and cellulose. Be sure to discuss where they are found in living organisms.

C. Chemical reactions are needed for life processes and are facilitated by enzymes.

11. Identify the reactants and products in a chemical reaction.
12. Compare the energy pathway of an energy-absorbing reaction with that of an energy-releasing reaction.
13. Define activation energy and describe its role in chemical reactions.
14. Explain the basic properties of enzymes and their role in chemical reactions.
15. Explain why enzymes are specific to just one type of reaction. Draw and label a diagram to help illustrate why.
16. Describe how temperature and pH affect enzyme activity.
17. Sketch the pH scale and label weak & strong acids, weak & strong bases and the neutral point.
18. Explain the process of 'denaturing' in regards to enzymes and how denaturing affects enzyme activity.

D. The Digestive System is highly specialized to obtain nutrients from food and eliminate solid wastes.

19. Identify the <u>specific</u> nutrients (building blocks of macromolecules) the body needs for growth and survival and which macromolecules are broken down during digestion to release these nutrients.
20. Understand the four main stages of food processing and where each stage takes place along the alimentary canal (digestive tract).
21. Differentiate between mechanical and chemical digestion including what structures are used to accomplish each form of digestion.
22. Identify the various structures that will aid in digesting (break down) each of the four macromolecules into their corresponding building blocks (for example, where are carbohydrates broken down?). Identify the various structures that will absorb each of the four building blocks into the body (for example, where are monosaccharides absorbed?). Create a table to organize your answer.
23. Explain how the small intestine is specifically structured (villi) in order to maximize the absorption of nutrients (building blocks) into the body.
24. List the major structures that food and waste pass through as it moves along the alimentary canal.
25. Understand the role of the accessory organs within the digestive system (liver, gallbladder and pancreas).

<u>Cells Concepts</u>

A. Cells are the basic units of structure in living things.

1. Describe how scientists hypothesize the origins of life.
2. Describe six characteristics that all living things share.
3. Identify and understand the three basic parts of the cell theory.

4. Identify and describe three major differences between prokaryotic cells and eukaryotic cells.
5. Identify and describe the structures that are found in both prokaryotic and eukaryotic cells.
6. Distinguish between unicellular and multicellular life.
7. Describe endosymbiotic theory and the evidence supporting its validity.

B. Cell organelles perform specific functions and build a diversity of cellular products.

8. Describe the function of each of the following cell structures/organelles. (Be sure to include the importance of the organelle to the cell and in which cell types these structures would be found.)
   - cell membrane
   - cell wall
   - chloroplast
   - cytoplasm
   - lysosomes
   - mitochondria
   - nucleus
   - ribosomes
9. Explain the key differences between plant and animal cells, including differences in cell shape and cell structures.
10. Understand how microscopes improved our understanding of living things.

C. The cell membrane is structured to regulate the cells activities.

11. Describe in detail the structure and function of the cell membrane.
12. Explain how the structure of the cell membrane enables it to be selectively permeable.
13. Explain how channel proteins, marker proteins and receptor proteins are positioned within the cell membrane to perform their unique functions.
14. Create a table and distinguish among the following types of cellular transport: simple diffusion, facilitated diffusion, osmosis, active transport by:

    -- *specific substances moved*

    -- *direction of concentration gradient (high----low ; low----high) -- use of channel protein*

    -- *energy requirement*

15. Differentiate between solute, solvent and solution.
16. Contrast the properties of hypotonic, hypertonic, and isotonic solutions. Identify what would happen to a cell if placed in each one of these solutions. Why does this happen?
17. Explain how water balance is maintained in plant and animal cells through osmosis.
18. Explain how active transport is carried out. Why is energy involved? Why might a cell want to move substances against its concentration gradient?

Homeostasis and Organism Transport Concepts

A. The human body is organized in distinct levels and maintains homeostasis.

1. List the levels of body organization from cell to system, giving an example of each.
2. Explain what is meant by *homeostasis* and its importance to the human body.
3. Explain the various ways the body's individual cells and organ systems interact to maintain homeostasis.

B. The endocrine system regulates homeostasis, growth, and development.

4. Explain what glands and hormones are and how glands and hormones function in the endocrine system.
5. Explain how hormones affect their target cells. Be sure to discuss receptor proteins.
6. Distinguish between the action of a steroid (lipid) hormone and a non-steroid (protein) hormone. Be sure to include cell membrane structure.
7. Explain how the endocrine system uses negative feedback to maintain optimal levels of substances/conditions within the human body, maintaining homeostasis (e.g., regulation of blood glucose).
8. Explain how the endocrine system uses positive feedback in certain instances to restore homeostasis.

C. The circulatory system transports materials throughout the body.

9. Identify the organs and blood vessels that make up the circulatory system.
10. Identify the major substances transported by the circulatory system.
11. Explain how arteries, veins, and capillaries are structured to perform their functions.
12. Explain how the circulatory system transports nutrients and oxygen to cells and removes cell wastes in order to maintain homeostasis.
13. Describe how oxygen and carbon dioxide are exchanged between the capillaries and the body's cells. Explain how capillaries are structured to maximize this process.

14. Distinguish between pulmonary and systemic circulation.
15. Describe the anatomy of the heart including chambers and valves.
16. Diagram the flow of blood from the body, through each of the heart's chambers, to the lungs, back to the heart, and to the body.

D. The nervous system maintains homeostasis by linking sensation to response.

17. Explain the complete pathway of nervous system processing from stimulus to response and how this helps to maintain homeostasis in the body.
18. Distinguish between the five types of sensory receptors and the stimuli they receive.
19. Identify the parts of a neuron and show the direction that a nerve impulse travels along a neuron.
20. Contrast a resting potential with an action potential. Explain how active transport is used to maintain the resting potential of a neuron.
21. Explain, in detail, the transmission of a nerve impulse along a neuron. Be sure to discuss facilitated diffusion, active transport, protein channels and pumps.
22. Describe how nerve impulses travel across a synapse, including the role of neurotransmitters and receptor proteins.
23. Explain how drugs, such as stimulants and depressants, alter the normal functioning of synapses.

E. The excretory system regulates body fluid levels and removes waste products.

24. Describe the excretory function of each of the following structures: *kidney, ureter, urinary bladder, urethra.*
25. Describe the structure and function of a nephron (including the *glomerulus, bowman's capsule, capillaries, nephron tubule, and collecting duct*) and how it functions to maintain homeostasis.
26. Explain the four stages of urine formation that occur in the nephron. Be sure to explain the types of cell transport that are occurring.
27. Explain how negative feedback and hormones regulate water balance in the human body.
28. Explain how the liver and the skin serve as excretory organs and remove waste from the body.

<u>Science Skills</u>

- Perform a dissection of a sheep heart and trace the flow of blood through each of the chambers and valves.
- Analyze models to explain the organization of the endocrine, circulatory, nervous, and excretory systems.
- Develop models to explain the action of nerve impulse transmission.
- Model the process of negative inhibition and construct a negative feedback loop given specific parameters.

Cell Processes Concepts

A. ATP is the source of chemical energy used for most cellular work.

1. Describe the structure of ATP and how it stores energy.
2. Give examples of the types of cellular work that ATP performs.
3. Summarize the ATP cycle.

B. Energy can be obtained from sunlight (photosynthesis).

4. State the overall equation for photosynthesis and create a table to illustrate where each of the reactants comes from, what processes they go through, and what products result.
5. Describe the structure of a chloroplast (grana, stroma, thylakoids, chlorophyll).
6. Explain what the light dependent reactions are, where they occur, and what the reactants and products of this process are.
7. Explain what the Calvin Cycle is, where it occurs, and what the reactants and products of this process are.
8. Describe the possible fates of the 3 carbon half sugars that exit the Calvin cycle.

C. Energy can be obtained from food (cellular respiration and fermentation).

Cellular Respiration (Glycolysis, Krebs Cycle and the Electron Transport Chain)

9. State the overall equation for cellular respiration and create a table to illustrate where each of the reactants comes from, what processes they go through, and what products result.
10. Explain why mitochondria are considered the "Powerhouse of the Cell"; which type of cells would require more mitochondria?
11. Explain what glycolysis is, where it occurs, and what the reactants and products of this process are.
12. Explain what the Krebs cycle is and where it occurs; clarify what enters this cycle and what leaves it.
13. Explain what an electron transport chain is, where this process occurs, and what its role is in the production of ATP.

Anaerobic pathways (Lactic Acid Fermentation and Alcoholic Fermentation)

14. Name the types of organisms that use these pathways.
15. Name the reactants and products associated with lactic acid fermentation.
16. Explain why lactic acid fermentation needs to happen when our muscle cells run low on oxygen.
17. Name the reactants and products associated with alcoholic fermentation.
18. Give examples of several commercial products that are produced by alcoholic fermentation.

D. The respiratory system is organized to exchange gases between the blood and the air.

19. Understand the basic anatomy and function of the respiratory system. (Trace the pathway of air from the nose to the alveoli.)
20. Explain the physical mechanics of breathing and how breathing is regulated by the nervous system.
21. Explain how oxygen and carbon dioxide are exchanged between the alveoli and the circulatory system.
22. Explain why oxygen is needed by the human body. In which step of cellular respiration is oxygen required?
23. Explain what will happen if cells do not get enough oxygen; what process will we need to perform?

Cell Cycle Concepts

A. The structure of DNA is essential to its function.

1. Name the building blocks of DNA.
2. Diagram the chemical structure of a nucleotide. Label the 3 major parts.
3. Identify the 4 nitrogenous bases in DNA.
4. Distinguish between *purines* and *pyrimidines*.
5. Make a diagram of a DNA double helix. Label the nitrogen bases, sugar-phosphate backbone, and location of covalent and hydrogen bonds.
6. Describe Chargaff's rules and explain their importance to the structure and replication of DNA.

B. DNA replication is the molecular mechanism of inheritance.

7. Describe the steps involved in DNA replication; include specific enzymes and their functions.
8. Distinguish between a template strand and a complementary strand of DNA.
9. Explain why DNA replication is considered semiconservative.
10. If the bases on one strand of a DNA double helix are **ATA GGC CGA TTA**, what would be the bases on the complementary strand?
11. Explain what replication bubbles are and how they facilitate the replication process.
12. Describe when (generally) and where DNA replication takes place.

C. Cell reproduction contributes to repair and growth.

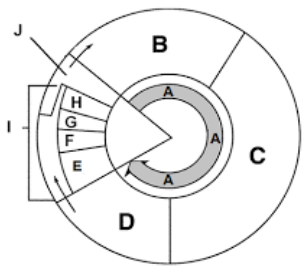
13. Describe the relationship between cell size, surface area, and volume. How does each variable/ratio change as cell size increases? Be able to calculate volume, SA, and make claims regarding their relationship.
14. Describe two problems cells encounter as they grow larger and how cell division solves this problem.

D. All cells come from preexisting cells.

15. "Cell reproduction contributes to growth, maintenance and repair." Explain what this statement means in terms of your own body.
16. Contrast the two main ways that organisms reproduce (sexual vs. asexual).
17. Explain the difference between binary fission, mitosis, and meiosis. (In what types of cells do they occur? Is each a sexual or asexual process?)

E. The cell cycle multiplies cells.

18. Diagram an unduplicated and a duplicated chromosome. Label the sister chromatids (duplicated chromosome) and the centromere (both).
19. Explain the difference between chromatin, chromatids, and chromosomes.
20. Identify and provide a brief description of each of the lettered stages of the Cell Cycle, as shown in the diagram below.



21. Explain how cytokinesis differs in plant and animal cells.

F. Cancer cells are cells that are dividing out of control.

22. Explain how a disruption of the cell cycle leads to cancer.
23. Contrast benign and malignant tumors.
24. Describe the three different ways that cancer is commonly treated (surgery, radiation, and chemotherapy).

Meiosis and Reproduction Concepts

A. Meiosis functions in sexual reproduction

1. Define the purpose and products of meiosis.
2. Explain the difference between a haploid and a diploid cell.
3. Explain what homologous chromosomes are and describe their role in meiosis.
4. Compare and contrast the starting material and the end products of meiosis I and meiosis II (number of cells, haploid or diploid, etc.).
5. Describe the events that occur in interphase I and in each phase of meiosis. (prophase I, metaphase I, anaphase I, telophase I, prophase II, metaphase II, anaphase II, and telophase II).
6. Be able to draw and label the phases of meiosis for a cell with a given number of chromosomes (for example, 2N=6).
7. Explain how the chromosome number in cells undergoing meiosis is reduced and why cutting the chromosome number in half is important for the process of meiosis.
8. Describe how the products of meiosis vary for males versus females.

B. Meiosis increases genetic variation among offspring

9. Explain how chromosome assortment during meiosis (prophase I and metaphase I) contributes to genetic variation.
10. Explain what crossing over is and describe how it contributes to genetic variation.

C. The reproductive system produces gametes and transports reproductive products.

11. Describe the function of each of the following male reproductive structures: *penis, testes, seminiferous tubules*
12. Describe the process of spermatogenesis, including where it occurs *and the hormones that affect this process.*
13. Describe the function of each of the following female reproductive structures: *uterus, fallopian tube, ovary.*
14. Describe the process of oogenesis, including where it occurs *and the hormones that affect this process.*
15. Understand the differences between ovulation, fertilization, cleavage and implantation, including where each occurs within the female reproductive tract.
16. Explain how meiosis and mitosis play a role in human growth and development.
17. Describe the difference between an egg, zygote, and embryo.
18. Explain how a fetus receives nutrients and eliminates waste via the placenta and umbilical cord.

Heredity Concepts

A. Gregor Mendel discovered that patterns of inheritance follow rules of chance.

1. Explain why Gregor Mendel is considered a significant figure in the history of science.
   Discuss the pros and cons of his use of pea plants for genetic studies.
2. Describe the difference between traits, genes, alleles, and chromosomes.
3. Explain the principle of dominance and provide an example that demonstrates this principle (from notes/text).
4. Explain the principle of segregation and provide an example that demonstrates this principle (from notes/text).
5. Explain the principle of independent assortment and provide an example that demonstrates this principle (from notes/text).
6. Distinguish between a monohybrid and dihybrid cross, including the genotype ratios that result from these crosses.
   Explain what a test cross is and how it can be used in genetic studies.

B. Meiosis explains Mendel's principles.

7. Summarize the chromosome theory of inheritance.
8. Explain how the process of meiosis demonstrates the principles of segregation and independent assortment.

C. There are many variations of inheritance patterns.

9. Describe how alleles interact in intermediate inheritance (incomplete dominance) and contrast this with simple dominance.
10. Describe inheritance patterns involving codominance and contrast this with intermediate inheritance.
11. Explain what is meant by "multiple alleles" and how this affects the number of possible genotypes and phenotypes.
12. Explain how blood typing involves simple dominance, codominance, and multiple alleles.
13. Explain why polygenic inheritance results in a wide range of phenotypes.
14. Describe how environmental factors influence an individual's phenotype. Provide an example from notes/text.
15. Explain why males are responsible for determining the gender of offspring. Support your explanation with a Punnett square.
16. Explain how sex-linked genes produce different inheritance patterns in males versus females.
17. Explain why most sex-linked recessive traits are more common in males.

D. Errors in meiosis affect chromosome number.

18. Explain what nondisjunction is and describe how it can result in abnormal chromosome numbers in daughter cells.
19. Explain what a karyotype is and how they can be used to identify certain genetic disorders.

E. Pedigrees can be used to track Mendelian traits.

20. Explain how to interpret a pedigree and determine if a trait is dominant or recessive and sex- linked or not.
21. Explain how to use a pedigree to determine how dominant, recessive, and sex-linked traits are inherited through a family.
22. Explain how pedigrees can be used to predict certain genetic disorders.

Science Skills

- Be able to complete and interpret monohybrid crosses for Mendelian traits.
- Be able to complete and interpret dihybrid crosses for Mendelian traits.
- Be able to complete and interpret monohybrid crosses for the following types of traits: intermediate inheritance (incomplete dominance), multiple alleles, codominance, sex-linked.
- Be able to construct and interpret pedigrees for dominant, recessive, and sex-linked traits.
- Be able to formulate claims based on evidence.
- Be able to use reasoning (apply principles of heredity) to justify why evidence supports a claim.

Molecular Genetics Concepts

A. Each gene (segment of DNA) contains the code for making a specific protein.

1. Trace the information flow from DNA to protein (Central Dogma of Molecular Biology).
2. Describe three structural differences between RNA and DNA.
3. Describe the location and function of the three types of RNA.
4. Describe the process of DNA transcription and identify where it occurs.
5. Explain how mRNA is edited before it leaves the nucleus (introns and exons).
6. Describe the process of translation and identify where it occurs.
7. Explain the triplet code (codons and anticodons) and be able to use it to identify the amino acid sequence that would result from a segment of DNA and from amino acids to DNA.
8. Explain how the proteins that are produced by transcription and translation determine the appearance and functioning of the cell and of the whole organism.

B. Mutations can change the meaning of genes.

9. Explain what a mutation is and what determines whether or not they will be passed on to offspring.
10. Explain what can cause a mutation.

11. Explain the difference between a gene mutation and a chromosome mutation.
12. Explain the difference between point mutations (substitutions) and frameshift mutations (insertions and deletions).
13. Be able to identify the types of gene mutations and describe the potential consequences in organisms.
14. Describe the four types of chromosome mutations (deletion, duplication, inversion, and translocation) and the potential consequences in organisms.

C. Microbes have an enormous impact on Earth and the biosphere

15. Describe the basic structure of a bacterium.
16. Describe the process that bacteria use to increase their genetic variation.
17. Provide three reasons why bacteria are helpful to humans.
18. Describe the basic structure of a virus.
19. Explain how a virus causes disease.
20. Distinguish between the methods used to treat bacterial versus viral infections.

D. Biologists can engineer organisms to make useful products because DNA is a universal code.

21. Explain the role of plasmids in engineering bacteria.
22. Explain how biologists use restriction enzymes to cut and paste DNA.
23. Explain how bacteria can be used to clone recombinant DNA to make useful products like insulin.
24. Explain what a Genetically Modified Organism is and how recombinant DNA technology is applied.
25. Describe two pros and two cons of GMOs.
26. Provide three examples of current applications of GMOs in society.

Science Skills

- Be able to use the genetic code to simulate protein synthesis (DNA to protein).
- Be able to describe the experimental design and interpret results from the transformation lab.

Evolution Concepts

A. There is a large body of evidence for evolution.

1. Explain how the fossil record can be used to support the theory of evolution. Use whales and humans as examples in your explanation.
2. Explain how geographic distribution (biogeography) can be used to support the theory of evolution.

3. Explain how similarities in structure (comparative anatomy) can be used to support the theory of evolution. Discuss *homologous structures* and *vestigial structures* in your explanation.
4. Explain how similarities in embryological development can be used to support the theory of evolution. Discuss the development of gill slits, tails, and limbs in your explanation.
5. Explain how molecular data (DNA and amino acid sequences) can be used to support the theory of evolution.

B. Charles Darwin developed the theory of evolution by natural selection.

6. Explain Darwin's concept of descent with modification. Use the species of the Galapagos Islands as examples.
7. Describe the process of natural selection. Use these terms/concepts in your explanation: *overproduction, variation, competition,* and *differential reproductive success.*
8. Identify the sources of variation populations.
9. Explain what the phrase "survival of the fittest" means. Use the pocket mouse as an example.
10. Use the process of natural selection to explain the diversity of finches on the Galapagos Islands.
11. Describe what an adaptation is and how adaptations develop. Explain why an adaptation might become more or less common in a population.
12. Explain how the terms *mutation, variation, adaptation,* and *fitness* are related.
13. Compare and contrast artificial selection and natural selection.

C. Microevolution is a change in gene frequency within a population.

14. Explain what a gene pool is.
15. Explain how selection pressure results in a change in allele frequency for both single gene and polygenic traits.
16. Compare and contrast directional, stabilizing, and disruptive selection.
17. Explain how genetic drift contributes to changes in a gene pool. Include a discussion of the bottleneck effect and the founder effect in your answer.
18. Explain how gene flow contributes to changes in a gene pool. Consider immigration, emigration, and mutation in your answer.
19. Explain how natural selection contributes to changes in a gene pool.
20. Explain what coevolution is and how it is exemplified by plants and their pollinators.
21. Which microevolutionary processes are random? Which are nonrandom?

D. Macroevolution occurs when a new species arises.

22. Explain how variation and reproductive isolation can lead to speciation.
23. Describe how behavioral, temporal, or geographic isolation can lead to reproductive isolation.

24. Explain how adaptive radiation occurs. Include a discussion of the Galapagos Island finches and changes in biodiversity that follow a mass extinction.
25. Explain what analogous structures are and how they relate to convergent evolution.

Science Skills

- Be able to interpret data (presented as a table, graph, or image) to explain the concepts detailed in parts A-D.

Evolutionary Relationships Concepts

A. Modern taxonomy reflects evolutionary history.

1. Provide three reasons why biologists classify livings things.
2. Describe Carolus Linnaeus's system of binomial nomenclature.
3. Describe the hierarchy of biological classification, naming all categories from domain to species and what each taxon includes.
4. Explain why convergent evolution led to confusion about the evolutionary relationships between species.
5. Compare traditional classification with modern classification (cladistics).
6. Describe how a cladogram is used to show evolutionary relationships.
7. Explain how to build a cladogram from a set of characters. What do the branches represent? What do the junctures represent?
8. Explain, in general, the difference between primitive and derived characters and where you would find them on a cladogram.
9. Describe the evidence that scientists use to come up with primitive and derived characters.

B. Classifications represent hypotheses about the evolutionary history of life.

10. Describe the evidence scientists used to establish the three-domain system.
11. Name the three domains of life and describe the characteristics that separate them.
12. Explain why bacteria are important to study in the context of the evolution of life on Earth.
13. Name the six kingdoms of life and describe the characteristics that distinguish them.

C. Protists are the most diverse group of eukaryotes.

14. Describe the characteristics that all protists have in common.
15. Explain why the kingdom Protista is considered sort of a taxonomic "stuff" drawer or catch-all category.
16. Describe how protists are generally grouped by their mode of nutrition.

D. Plants evolved from Protists.

17. List the four plant phyla and the characteristics common to all plants.
18. Identify the ancestor to all plants and the evidence for this determination.
19. Describe the four major milestones in plant evolution and how each event shaped plant evolution.

E. Animals evolved as Heterotrophic Organisms.

20. Describe the characteristics that all animals have in common.
21. Describe the five major trends in animal evolution.
22. Contrast acoelomates, pseudocoelomates, and coelomates and explain why the development of a body cavity was an important step in the evolution of animals.
23. Compare the development of the digestive tract between protostomes and deuterostomes.

Science Skills

- Be able to correctly write a scientific name (genus and species).
- Be able to create a cladogram given a set of organisms and derived characters.
- Be able to interpret a completed cladogram.

Assessment

Student learning will be measured through a variety of assessments including, but not limited to, projects, tests, quizzes and lab work, including lab practicals.

Materials and Resources

Campbell, N., Williamson, B. and Heyden, R. (2006). *Biology.* Needham, Mass.: Pearson.