SOL Review Scientific Method

The student will demonstrate an understanding of scientific reasoning, logic and the nature of science by planning and conducting investigations

Key concepts include:
1a. observations of living organisms are recorded in the lab and in the field
1b. hypothesis are formulated based on direct observations and information from scientific literature
1c. variables are defined and investigations are designed to test hypothesis
1d. graphing and arithmetic calculations are used as tools in data analysis
1e. conclusions are formed based on recorded quantitative data
1f. sources of error inherent in experimental design are identified and discussed
1g. validity of data is determined
1h. chemicals and equipment are used in a safe manner
1i. appropriate technology including computers, graphing calculators, and probeware is used for gathering and analyzing data, communicating results, modeling concepts, and simulating experimental conditions
1j. research utilizes scientific literature
1k. differentiation is made between a scientific hypothesis, theory and law
1l. alternative scientific explanations and models are recognized and analyzed
1m. current applications of biological concepts are used

In order to meet this standard, it is expected that students will:

✓ Conduct investigations
✓ Collect observations; qualitative and quantitative
✓ Make clear distinctions among observations, inferences and predictions
✓ Formulate hypotheses based on cause and effect relationships
✓ Justify hypotheses based on preliminary observations and scientific literature
✓ Identify the independent variable (IV) and values of the IV that will be used in the experiment
✓ Select dependent variables (DV) that allow collection of quantitative data
✓ Identify variable that must be held constant
✓ Establish controls as appropriate
✓ Write clear, replicable procedures
✓ Identify and use appropriate technology for data collection and analysis
✓ Record quantitative data in clearly labeled tables with units
✓ Include labeled diagrams in the data table
✓ Determine the range, mean, and values for data
✓ Plot data graphically, showing independent and dependent variables
✓ Describe trends from the data where appropriate
✓ Recognize and discuss contradictory or unusual data
✓ Determine the extent to which data support/do not support a hypothesis, and propose further hypothesis and directions for continued research
✓ Discuss the validity of results as related to accuracy, confidence, and sources of experimental error based on number of trial and variance in the data
✓ Use evidence, apply logic, and construct and argument for conclusions based on reported data
✓ Recognize that in order to ensure the validity of scientific investigations, they must be evaluated by other members of the scientific community
✓ Compare and contrast hypotheses, theory and law
✓ Identify and describe scientific theories that have been changed or modified over time

**SOL Review Chemistry**
The student will investigate and understand the chemical and biochemical principles essential for life.

Key Concepts include:
- 2a. water chemistry and its impact on life processes
- 2b. the structure and function of macromolecules
- 2c. the nature of enzymes
- 2d. the capture, storage, transformation, and flow of energy through the processes of photosynthesis and respiration

*In order to meet this standard, it is expected that students will:*
✓ Explain the importance of the chemical and physical properties of water that make it vital to life
✓ Recognize that the main components of a living cell are carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur. Carbon atoms can easily bond to several other carbon atoms in chains and rings to form large complex molecules
✓ Explain the role and function of the four major categories of macromolecules (lipids, carbohydrates, proteins and nucleic acids)
✓ Identify the functions of different types of proteins and recognize the significance that their conformation play in their functions
✓ Describe the structure of enzymes and explain their role in acting as catalysts to control the rate of metabolic reactions
✓ Explain how light is the initial source of energy for most communities
✓ Recognize the equations for photosynthesis and respiration and identify the reactants and products
✓ Describe the role of ATP in the storage and release of chemical energy in the cell; and
✓ Explain the interrelatedness of photosynthesis and cell respiration

**SOL Review Cells**
The student will investigate and understand relationships between cell structure and function.

Key concepts include:
- 3a evidence supporting cell theory
- 3b characteristics of prokaryotes and eukaryotes
- 3c similarities between the activities of the organelles in a single cell and a whole organism
- 3d the cell membrane model; and
- 3e the impact of surface area to volume ratio on cell division, material transport, and other life processes

*In order to meet this standard, it is expected that students will:*
✓ Describe the key events leading to the development of the cell theory
✓ Compare and contrast characteristics of prokaryotic and eukaryotic cells
✓ Compare and contrast the activities of an organelle in a single cell and a whole organism
✓ Identify the following essential cell structures and their functions;
✓ The nucleus (contains DNA; site where RNA is made),
✓ Ribosome (site of protein synthesis),
✓ Mitochondrion (site of cell respiration),
✓ Chloroplast (site of photosynthesis),
✓ Endoplasmic reticulum (transports materials through the cell),
✓ Golgi (site where products are packaged for export),
✓ Lysosome (contains digestive enzymes),
✓ Cell membrane (controls what enters and leaves the cell),
✓ Cell wall (provides support),
✓ Vacuole (storage of material),
✓ Cytoplasm (contains organelles and site of many chemical reactions),
✓ Centriole (organizes spindle fibers in animal cells),
✓ And cytoskeleton
✓ Describe how the selective permeability of the cell membrane affects the life of a cell
✓ Describe processes associated with movement across the membrane for diffusion, facilitated diffusion, osmosis and active transport
✓ Describe the relationship between a cell’s external solute concentration and its effect on the cell’s internal solute concentration; and
✓ Compare the efficiency of the ability of a cell to transport material based on surface area to volume ratios

**SOL Review Classification**
The student will investigate and understand life functions of Archae, Bacteria and Eukarya.

Key concepts include:
4a comparison of their metabolic activities
4b maintenance of homeostasis
4c how the structures and functions vary among and within the Eukarya kingdoms of protists, fungi, plants and animals, including humans
4d (not tested)
4e how viruses compare with organisms
4f evidence supporting the germ theory of infectious disease

In order to meet this standard, it is expected that students will:
✓ Compare and contrast the metabolic activities of all domains of life
✓ Identify the proper response and organism would exhibit in response to changes in the environment to maintain homeostasis
✓ Categorize and compare Eukarya kingdoms based on cell structure, locomotion, reproduction, response to the environment and metabolism
✓ Compare and contrast a virus and a cell in relation to genetic material and reproduction
✓ Describe how Pasteur’s and Koch’s experimentation and hypotheses led to an understanding of the presence of microorganisms and their relationship to diseases.
**SOL Review Inheritance**

The student will investigate and understand common mechanisms of inheritance and protein synthesis.

Key concepts include:
- 5a cell growth and division
- 5b gamete formation
- 5c cell specialization
- 5d prediction of inheritance of traits based on the Mendelian laws of heredity
- 5e historical development of the structural model of DNA
- 5f genetic variation
- 5g the structure, function, and replication of nucleic acids
- 5h events involved in the construction of proteins
- 5i use, limitations, and misuse of genetic information
- 5j exploration of the impact of DNA technologies

*In order to meet this standard, it is expected that students will:*

- Create a diagram to model the stages of mitosis and explain the processes occurring at each stage
- Describe the importance of cell specialization in the development of multicellular organisms
- Create a diagram to model the stages of meiosis and explain the processes occurring at each stage
- Compare and contrast the process of mitosis and meiosis and determine under which conditions each process will occur
- Explain how the Mendelian laws of heredity apply to the patterns of inheritance
- Identify the traits expressed from a given genotype
- Use a Punnett square to show all possible combinations of gametes and the likelihood that particular combinations will occur in monohybrid and dihybrid crosses
- Evaluate karyotype charts and make a determination of the gender and genetic health of the individual
- Provide examples of reasons for genetic diversity and why it can be an advantage for populations
- Provide examples of mutations that are lethal, harmful, and beneficial
- Describe the basic structure of DNA and its function in inheritance
- Describe the key events leading to the development of the structural model of DNA
- Given a DNA sequence, write a complementary mRNA strand (A-U, T-A, C-G, and G-C)
- Explain the process of DNA replication
- Explain the process of protein synthesis, including DNA transcription and translation
- Evaluate examples of genetic engineering and the potential for controversy
- Describe the uses, limitations, and potential for misuse of genetic information

**SOL Review Classification Systems**

The student will investigate and understand bases for modern classification systems.

Key concepts include:
- 6a structural similarities among organisms
- 6b fossil record interpretation
- 6c comparison of developmental stages in different organisms
6d examination of biochemical similarities and differences among organisms; and  
6e systems of classification that are adaptable to new scientific discoveries

**In order to meet this standard, it is expected that students will:**

- Construct and utilize dichotomous keys to classify groups of objects and organisms
- Describe relationships based on homologous structures
- Compare structural characteristics of an extinct organism, as evidenced by its fossil record, with present familiar organisms
- Recognize similarities in embryonic stages in diverse organisms in the animal kingdom, from zygote through embryo and infer relationships
- Compare biochemical evidence (DNA sequences, amino acid sequences) and describe relationships
- Interpret a cladogram or phylogenetic tree showing evolutionary relationships among organisms
- Investigate flora and fauna in field investigations and apply classification systems

**SOL review Evolution**

The student will investigate and understand how populations change through time.

**Key concepts include:**

- 7a evidence found in fossil records
- 7b how genetic variation, reproductive strategies, and environmental pressures impact the survival of populations
- 7c how natural selection leads to adaptation
- 7d emergence of new species
- 7e scientific evidence and explanations for biological evolution

**In order to meet this standard, it is expected that students will:**

- Determine the relative age of a fossil given information about its position in the rock and absolute dating by radioactive decay
- Differentiate between relative and absolute dating based on fossils in biological evolution
- Recognize that adaptations may occur in populations of organisms over a period of time
- Describe the impact of reproductive strategies and rates on a population’s survival
- Describe how genetic variation can lead to gradual changes in populations and the emergence of new species
- Predict the impact of environmental pressures on populations
- Explain how natural selection leads to changes in gene frequency in a population over time
- Compare and contrast punctuated equilibrium with gradual change over time

**SOL Review Ecology**

The student will investigate and understand dynamic equilibria within populations, communities, and ecosystems

**Key concepts include:**

- 8a interactions within and among populations including carrying capacity, limiting factors, and growth curves
8b nutrient cycling with energy flow through ecosystems
8c succession patterns in ecosystems
8d the effects of natural events and human activities on ecosystems
8e analysis of the flora, fauna, and microorganisms of Virginia ecosystems

In order to meet this standard, it is expected that students will:

- Graph and interpret a population growth curve and identify the carrying capacity of the populations
- Make predictions about changes that could occur in population numbers as the result of population interactions
- Illustrate and/or model the key processes in the water, carbon, and nitrogen cycle and explain the role of living things in each of the life cycles
- Given an illustration of a food chain and a food web, identify each organism as a producer (autotroph), consumer (primary/secondary order) or decomposer and describe their role in the ecosystem
- Interpret how the flow of energy occurs between trophic levels in all ecosystems in each of the following: food chain, food web, pyramid of energy, pyramid of biomass, and pyramid of numbers.
- Identify and describe an ecosystem in terms of the following: effects of biotic and abiotic components, examples of interdependence, evidence of human influences, energy flow and nutrient cycling, and diversity analysis
- Describe the patterns of succession found in aquatic and terrestrial ecosystems of Virginia
- Identify the similarities and differences between primary and secondary succession
- Describe the characteristics of a climax community
- Use local ecosystems to apply ecological principles in the classroom and in the field where appropriate, using field guides and dichotomous keys for identifying and describing flora and fauna that characterize the local ecosystem
- Evaluate examples of human activities that have negative and positive impacts on Virginia’s ecosystems
- Recognize that the Chesapeake Bay Watershed includes the majority of Virginia and human activities play and important role in its health.