Biology 1 Course Standards

Course Description

Biology 1 is an introductory laboratory-based course (minimum of 30 percent hands-on investigation) designed to familiarize the student with the major concepts of biological science: the cell; molecular basis of heredity; biological evolution; interdependence of organisms; matter, energy, and organization in living systems; and behavior and regulation. This course provides numerous opportunities for students to develop science process skills, critical thinking, and an appreciation for the nature of science through inquiry-based learning experiences. Investigative, hands-on lab activities that address the high school inquiry standards are an integral part of this course.

Standards in italics describe classroom learning that is essential for students to perform at a high level but that cannot be tested directly on a state assessment because of formatting, bias, technology, and sensitivity issues. However, these standards are appropriate for classroom assessment.

I. Inquiry

Inquiry is not an isolated unit of instruction and should be embedded throughout the content area of physical science. The nature of science and technology is incorporated within this area.

A. Identify Questions and Concepts That Guide Scientific Investigations

Experimental design should demonstrate logical connections between a knowledge base and conceptual understanding.

1. Demonstrate an understanding of the process of developing scientific hypotheses (e.g., formulate a testable hypothesis based on literature research and prior knowledge, select the correct form for a hypothesis statement based on a given scenario).
2. Identify and select experimental variables (independent and dependent) and devise methods for controlling relevant conditions.

B.

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Design and Conduct Investigations

Science builds on prior knowledge; thus prior knowledge about major concepts, laboratory apparatus, laboratory techniques, and safety should be used in designing and conducting a scientific investigation.

1. Demonstrate an understanding of the process of testing scientific hypotheses (e.g., design and conduct a scientific investigation based on the major concepts in the area being studied).
2. Select and use appropriate instruments to make the observations necessary for the investigation, taking into consideration the limitations of the equipment.
3. Select the appropriate safety equipment needed to conduct an investigation (e.g., goggles, aprons) and identify safety precautions for the handling of materials and equipment used in an investigation.
4. Describe the proper response to emergency situations in the laboratory.
5. Identify possible sources of procedural error (e.g., incorrect measurement) and identify appropriate methods of control (e.g., repeated trials, systematic manipulation of variables) in an experimental design.
6. Organize and display data in useable and efficient formats, such as tables, graphs, maps, cross sections, and mathematical expressions.
7. Draw conclusions based on qualitative and/or quantitative data.
8. Discuss the impact of sources of error on experiments.
9. Communicate and defend the scientific thinking that has resulted in conclusions.

C. Use Technology and Mathematics to Improve Investigations and Communications

Scientific investigations can be improved through the use of technology and mathematics. While it is acknowledged that the System International of Units (called the SI system) is the accepted measurement system in science, opportunities to use the U.S. Customary System are encouraged where appropriate.

1. Select and use appropriate technologies (e.g., computers, calculators, calculator-based laboratories [CBLs], electronic balances, calipers) to achieve appropriate precision and accuracy of data collection, analysis, and display.
2. Discriminate between valid and questionable data.
3. Select and use mathematical formulas and calculations to express and interpret laboratory measurements.
4. Demonstrate an understanding of trends and patterns in data (e.g., calculate interpolated data points, predict extrapolated data points) and demonstrate the ability to interpret these phenomena.
5. *Draw a "best fit" curve through data points by using computer software and/or graphing calculators.*

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6. Calculate the slope of the curve and use correct units for the value of the slope for linear relationships.
7. Perform dimensional analysis calculations.
8. Perform calculations using numbers expressed in scientific notation.

D. Formulate and Revise Scientific Explanations and Models Using Logic and Evidence

Scientific explanations and models are developed and revised through discussion and debate.

1. Construct scientific explanations or models (physical, conceptual, and mathematical) by using discussion, debate, logic, and experimental evidence.
2. Develop explanations and models that demonstrate scientific integrity. (P)
3. Revise explanations or models.

E. Recognize and Analyze Alternative Explanations and Models

Scientific criteria are used to discriminate among plausible explanations.

1. Compare current scientific models with experimental results.
2. Select and defend, on the basis of scientific criteria, the most plausible explanation or model.

F. Communicate and Defend a Scientific Argument

Experimental processes, data, and conclusions are communicated in a clear and logical manner.

1. *Develop a set of laboratory instructions that someone else can follow.*
2. *Develop a presentation to communicate the process and the conclusion of a scientific investigation.*

G. Understandings about Scientific Inquiry

Historical and current scientific knowledge, current research, technology, mathematics, and logic form the basis for conducting investigations and drawing conclusions.

1. *Analyze how science and technology explain and predict relationships.*

    a. *Defend the idea that conceptual principles and knowledge guide scientific inquiry.*

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b. *Discuss how the available body of scientific knowledge, historical and current, influences the design, interpretation, and evaluations of investigations.*

2. Discuss the reasons why scientists and engineers conduct investigations and the methods they use to conduct these investigations.
3. Demonstrate and discuss the use of technology as a method of enhancing data collection and data manipulation and of advancing the fields of science and technology.
4. Discuss how mathematics is important to scientific inquiry.
5. Discuss why scientific models and explanations need to be based on the available body of scientific knowledge.

Demonstrate the understanding that scientific explanations must be logical, supported by the evidence, and open to revision.

II. Biology

A. The Cell

1. **Cells have particular structures that underlie their function. Inside the cell is a concentrated mixture of thousands of different molecules which form a variety of specialized structures that carry out such cell functions as energy production, transport of molecules, waste disposal, synthesis of new molecules, and the storage of genetic material.**

   a. Compare and contrast prokaryotic and eukaryotic cells.
   b. Identify and explain the functions of the cellular structures that are responsible for energy production, waste disposal, molecular synthesis, storage of genetic material, cell movement, and active and passive transport
   c. Trace the development of cell theory. (H)
   d. Discuss uses of technologies that enable in-depth studies of the cell, such as microscopes, ultracentrifuge techniques, and radioscopy studies. (T)

2. **Most cell functions involve chemical reactions. Food molecules taken into the cell react to provide the chemical constituents needed to synthesize other molecules. Both breakdown and synthesis are made possible by a large set of protein catalysts, called enzymes. The breakdown of some of the food molecules enables the cell to store energy in specific chemicals that are used to carry out the many functions of the cell.**

   a. Demonstrate an understanding of the roles of enzymes in chemical reactions within the cell.

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b. Differentiate among the functions of carbohydrates, proteins, lipids, and nucleic acids in the cell.

3. Cells store and use information to guide their functions. The genetic information stored in DNA is used to direct the synthesis of the thousands of proteins each cell requires.

a. Compare DNA and RNA.
b. Illustrate the steps of protein synthesis and explain the role of the triplet codon in protein synthesis.

4. Cell functions are regulated. Regulation occurs through changes in the activity of the functions performed by proteins and by the selective expression of certain genes. This regulation allows cells to respond to their environment and to control and coordinate cell growth and division.

a. Demonstrate an understanding of the importance of DNA and proteins in cell regulation.
b. Discuss mishaps in cell regulation (e.g., tumors). (P)

5. Cells can differentiate and complex multicellular organisms are formed as a highly organized arrangement of differentiated cells. In the development of these multicellular organisms, the progeny from a single cell form an embryo in which the cells multiply and differentiate to form the many specialized cells, tissues and organs that comprise the final organism. This differentiation is regulated through the expression of different genes.

a. Demonstrate the understanding that cells can differentiate and form complex multicellular organisms that are a highly organized arrangement of differentiated cells (e.g., illustrate the development of both an animal and a plant multicellular organism: cells, specialized cells, tissues, organs, organ systems, and organisms).
b. Determine how organs and systems in both plants and animals function as a physiological unit. [Note: this concept has been taught at a previous grade level.]
c. Evaluate how a degenerative disease involves the deterioration of organs or tissues.

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B. The Molecular Basis of Heredity

1. **In all organisms, the instructions for specifying the characteristics of the organism are carried in DNA, a large polymer formed from subunits of four kinds (A, T, G, and C). The chemical and structural properties of DNA explain how the genetic information that underlies heredity is both encoded in genes (as a string of molecular "letters") and replicated (by a templating mechanism). Each DNA molecule in a cell forms a single chromosome.**

   a. Demonstrate an understanding of the key features of DNA, genes, and chromosomes and the relationships that exist among them.
   b. Analyze the chemical structure of DNA and explain how DNA replication occurs.

   c. *Evaluate the impact of DNA technology on society (e.g., bioengineering, forensics, genome project, DNA fingerprinting).* (T, P)

2. **Most of the cells in a human contain two copies of each of 22 different chromosomes. In addition, there is a pair of chromosomes that determines sex: a female contains two X-chromosomes and a male contains one X and one Y chromosome. Transmission of genetic information to offspring occurs through egg and sperm cells that contain only one representative from each chromosome pair. An egg and sperm unite to form a new individual. The fact that the human body is formed from cells that contain two copies of each chromosome—and therefore two copies of each gene—explains many features of human heredity, such as how variations that are hidden in one generation can be expressed in the next.**

   a. Compare the key features and differences between mitosis and meiosis.
   b. Make predictions concerning inheritance based on Gregor Mendel's laws of heredity.
   c. Discuss significant advancements in the study of heredity since Mendel, including the chromosome theory. (H)

3. **Changes in DNA (mutations) occur spontaneously at low rates. Some of these changes make no difference to the organism, whereas others can change cells and organisms. Only mutations in germ cells can create the variation that changes an organism's offspring.**

   a. Demonstrate an understanding of the characteristics and implications of both chromosomal and genetic mutations (e.g., the occurrence of genetic disorders such as sickle cell anemia, Tay-Sachs disorder, cystic fibrosis, and hemophilia). (P)

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b. Demonstrate an understanding of how mutations contribute to genetic diversity.

C. Biological Evolution

1. **Species evolve over time. Evolution is the consequence of the interactions of (1) the potential for a species to increase its numbers, (2) the genetic variability of offspring due to mutation and recombination of genes, (3) a finite supply of the resources required for life, and (4) the ensuing selection by the environment of those offspring better able to survive and leave offspring.**

   a. Demonstrate an understanding of the factors that affect evolution, such as the number of offspring, genetic variability, finite supply of resources, and environmental factors.
   b. Demonstrate an understanding of the scientific evidence that establishes that change occurs over time.

2. **Natural selection and its evolutionary consequences provide a scientific explanation for the fossil record of ancient life forms, as well as for the striking molecular similarities observed among the diverse species of living organisms.**

   a. Demonstrate an understanding of the process of natural selection and its consequences.
   b. Infer how a fossil record can reveal evolutionary changes over time.
   c. Discuss the various lines of scientific evidence that underlie our understanding of the evolution and diversification of life over time.
   d. Describe how carbon dating is utilized in the study of evolution. (H, T)
   e. Discuss Charles Darwin's contribution to the study of evolution. (H)

3. **Biological classifications are based on how organisms are related. Organisms are classified into a hierarchy of groups and subgroups based on similarities which reflect their evolutionary relationships. Species is the most fundamental unit of classification.**

   a. Investigate the modern kingdom classification system, which is based on fossil record interpretation and similarities in structural and chemical makeup.
   b. Demonstrate an understanding of how to classify organisms on the basis of structural adaptations, physiology, nutritional strategies, biochemical similarities, genetic similarities, embryological similarities, and methods of reproduction.
   c. Develop a working definition of "living things," and justify why many scientists group viruses in a category separate from living things.

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D. Interdependence of Organisms

1. **The atoms and molecules on the earth cycle among the living and nonliving components of the biosphere.**

   a. Demonstrate an understanding of how organisms interact with the biosphere as part of the geochemical cycles (e.g., carbon, nitrogen, phosphorous, water cycles).

   b. Identify important nutrient cycles and evaluate how they affect ecosystems.

2. **Energy flows through ecosystems in one direction, from photosynthetic organisms to herbivores to carnivores and decomposers.**

   a. Demonstrate an understanding of the flow of energy, beginning with the sun, through various trophic levels.
   b. Assess the value of the carbon cycle to the flow of energy through the ecosystems.

3. **Organisms both cooperate and compete in ecosystems. The interrelationships and interdependencies of these organisms may generate ecosystems that are stable for hundreds or thousands of years.**

   a. Relate the concepts of cooperation and competition to organisms within an ecosystem.
   b. Evaluate how interrelationships and interdependencies of living things contribute to the homeostasis of ecosystems.
   c. Demonstrate an understanding of how living things maintain their high level of order at the expense of increasing the disorder of their physical surroundings.

4. **Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite. This fundamental tension has profound effects on the interactions between organisms.**

   a. Describe and give examples of demographic characteristics of populations (e.g., birth and death rates, age structure, sex ratio).
   b. Give examples and explain how limiting factors such as water, food, oxygen, and living space play a role in the stability of ecosystems.
   c. Predict how interactions among organisms such as predation, competition, and parasitism affect population growth.
   d. Demonstrate an understanding of the characteristics, stages, and implications of succession on terrestrial ecosystems.

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e. Evaluate dynamic equilibrium as a result of checks and balances within populations, communities, and ecosystems.

5. **Human beings live within the world's ecosystems. Increasingly, humans modify ecosystems as a result of population growth, technology, and consumption. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems will be irreversibly affected.**

   a. *Identify events that lead to awareness of environmental concerns such as fish kills, destruction of the ozone layer, global warming, and the decline of the bald eagle. (H)*
   b. *Discuss the conflicts that could occur between land developers and conservationists.* (P)
   c. Describe the effects of human overpopulation and activities on the survival of other species.
   d. *Debate the consequences of extinction and the introduction of species within ecosystems.*
   e. Assess the consequences of acid rain on ecosystems. (P)
   f. *Give examples of how technology has advanced the study of environmental science.* (T, P)

E. Matter, Energy and Organization in Living Systems

1. **The energy for life primarily derives from the sun. Plants capture energy by absorbing light and using it to form strong (covalent) chemical bonds between the atoms of carbon-containing (organic) molecules. These molecules can be used to assemble larger molecules with biological activity (including proteins, DNA, sugars, and fats). In addition, the energy stored in bonds between the atoms (chemical energy) can be used as sources of energy for life processes.**

   a. Summarize the basic process by which photosynthesis converts solar energy into chemical energy (food molecules).
   b. Summarize the basic aerobic and anaerobic processes by which cellular respiration breaks down food molecules into energy that can be used by cells.

2. **The chemical bonds of food molecules contain energy. Energy is released when the bonds of food molecules are broken and new compounds with lower energy bonds are formed. Cells usually store this energy temporarily in phosphate bonds of a small high-energy compound called ATP.**

   a. Analyze bond energy as it relates to food molecules.
   b. Discuss the importance of ATP and how it is cycled.

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3. **The complexity and organization of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy used to sustain the organism.**

    a. Demonstrate an understanding of the factors involved in obtaining and processing matter and energy for the development, growth, and maintenance of organisms.
    b. Demonstrate an understanding of homeostasis and the effect of an energy deficit on that state.

4. **As matter and energy flow through different levels of organization of living systems (cells, organs, organisms, communities) and between living systems and the physical environment, chemical elements are recombined in different ways. Each recombination results in storage and dissipation of energy into the environment as heat. Matter and energy are conserved in each change.**

    a. Demonstrate an understanding of the dynamics of energy and entropy as they apply to biological systems.
    b. Analyze energy in biological systems in terms of transformation, conservation, and efficiency.

F. Behavior and Regulation

1. **Multicellular animals have nervous systems that generate behavior. Nervous systems are formed from specialized cells that conduct signals rapidly through the long cell extensions that make up nerves. The nerve cells communicate with each other by secreting specific excitatory and inhibitory molecules. In sense organs, specialized cells detect light, sound, and specific chemicals and enable animals to monitor what is going on in the world around them.**

    a. Demonstrate an understanding of how cells of multicellular animals communicate through signals conducted by a nervous system.
    b. Demonstrate an understanding of the adaptive value of the reflexes (e.g., blinking of the eye, opening/closing of the iris, responses to hot and cold).
    c. Give examples of specialized cells in sense organs that detect stimuli (e.g., taste buds, touch receptors, rods and cones).

2. **Organisms have behavioral responses to internal change and external stimuli. Responses to external stimuli can result from interactions with the organism's own species and others, as well as environmental changes; these responses can be either innate or learned. The broad patterns of behavior exhibited by animals have evolved to ensure reproductive success. Animals often live in unpredictable**

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environments, and so their behavior must be flexible enough to deal with uncertainty and change. Plants also respond to stimuli.

a. Investigate how different organisms maintain homeostasis.
b. Give examples of feedback mechanisms.
c. Identify pathogens and understand how organisms react to them.
d. Assess both the positive and the negative effects of introducing chemical substances into the body. (P)
e. Give examples of innate behavior and learned behavior.
f. Demonstrate an understanding of tropisms in plants as responses to external stimuli.

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