Ohio Science

Biology Content Elaborations: Grades 9-12

Adopted 2018

Biology

Heredity

1. Cellular genetics B.H.1
    1. Students understand that life is specified by genomes. B.H.1.1
    2. Students understand that each organism has a genome that contains all the biological information needed to develop and maintain that organism. B.H.1.2
    3. Students understand the biological information contained in a genome is encoded in its deoxyribonucleic acid (DNA) and is divided into discrete units called genes. B.H.1.3
    4. Students understand that genes code for proteins. B.H.1.4
    5. Students understand that different parts of the genetic instructions are used in different types of cells, influenced by the cell's environment and history. B.H.1.5
    6. Students understand that the many body cells in an individual can be very different from one another, even though they are all descended from a single cell and thus have essentially identical genetic instructions. (AAAS) B.H.1.6
2. Structure and function of DNA in cells B.H.2
    1. Students understand Mendel's laws of inheritance (introduced in grade 8) are interwoven with current knowledge of DNA and chromosome structure and function to build toward basic knowledge of modern genetics. B.H.2.1
    2. Students understand that genes are segments of DNA molecules. B.H.2.2
    3. Students understand that the sequence of DNA bases in a chromosome determines the sequence of amino acids in a protein. B.H.2.3
    4. Students understand that inserting, deleting or substituting segments of DNA molecules can alter genes. B.H.2.4
    5. Students understand that sorting and recombination of genes in sexual reproduction and meiosis specifically result in a variance in traits of the offspring of any two parents. B.H.2.5
    6. Students understand that this content can be explicitly connected to evolution. B.H.2.6
3. Genetic mechanisms and inheritance B.H.3
    1. Students understand that genetic variation in traits among offspring is a result of the movement of chromosomes crossing over, independent assortment, and recombination during gamete formation. B.H.3.1
    2. Students understand that in high school, genetic mechanisms, both classical and modern, including incomplete dominance, sex-linked traits, and dihybrid crosses, are investigated through real-world examples. B.H.3.2
    3. Students understand that statistics and probability allow us to compare observations made in the real world with predicted outcomes. B.H.3.3
    4. Students understand that dihybrid crosses can be used to explore linkage groups, gene interactions and phenotypic variations. B.H.3.4
    5. Students understand that chromosome maps reveal linkage groups. B.H.3.5

4. Mutations B.H.4
    1. Students understand that genes can be altered by insertion, deletion, or substitution of a segment of DNA molecules. B.H.4.1
    2. Students understand that an altered gene is a mutation and will be passed on to every cell that develops from it. B.H.4.2
    3. Students understand that the resulting features may help, harm or have little or no effect on the offspring's success in its environments. B.H.4.3
    4. Students understand that gene mutations in gametes are passed on to offspring. B.H.4.4
5. Modern genetics B.H.5
    1. Students understand that technological developments that lead to the current knowledge of heredity are introduced for study. B.H.5.1
    2. Students understand that the development of the model for DNA structure was the result of experimentation, hypothesis, testing, statistical analysis and technology as well as the studies and ideas of many scientists. B.H.5.2
    3. Students understand that James Watson and Francis Crick developed the current model based on the work of Rosalind Franklin and others. B.H.5.3
    4. Students understand that scientists continue to extend the model and use it to devise technologies to further our understanding and application of genetics. B.H.5.4
    5. Students understand that the emphasis is not on the memorization of specific steps of gene technologies, but rather on the interpretation and application of the results. B.H.5.5

Evolution

1. Mechanisms B.E.1
    1. Students understand that natural selection is used to describe the process by which traits become more or less common in a population due to consistent environmental pressures upon the survival and reproduction of individuals with the trait. B.E.1.1
    2. Students understand that mathematical reasoning is applied to solve problems (e.g., use Hardy-Weinberg principle to explain deviations in observed gene frequency patterns in a population compared to expected patterns based on the assumptions of the principle). B.E.1.2
    3. Students understand that populations evolve over time. B.E.1.3
    4. Students understand that evolution through natural selection is the consequence of the interactions of: B.E.1.4
        a. Students understand the potential for a population to increase its numbers; B.E.1.4.A
        b. understand the genetic variability of offspring due to mutation and recombination of genes; B.E.1.4.B
        c. understand that a finite supply of the resources required for life; and B.E.1.4.C
        d. understand that the differential survival and reproduction of individuals based on phenotype(s). B.E.1.4.D
    5. Students understand that mutations are described in the content elaboration for Heredity. B.E.1.5
    6. Students understand how to apply the knowledge of mutation and genetic drift to real-world examples. B.E.1.6
    7. Students understand that biological evolution explains the natural origins for the diversity of life. B.E.1.7
    8. Students understand that emphasis shifts from thinking in terms of selection of individuals with a particular trait to changing proportions of a trait in populations as a result of the mechanisms of natural selection, genetic drift, movement of genes into and out of populations and sexual selection. B.E.1.8
2. Speciation B.E.2
    1. Students understand that biological classification expanded to molecular evidence Classification systems are frameworks, developed by scientists, for describing the diversity of organisms; indicating the degree of relatedness among organisms. B.E.2.1
    2. Students understand that the recent molecular sequence data generally support earlier hypotheses regarding lineages of organisms based upon morphological comparisons. B.E.2.2
    3. Students understand that both morphological and molecular comparisons can be used to describe patterns of biodiversity (cladograms present hypotheses to

explain descent from a common ancestor with modification). B.E.2.3

4. Students understand that the concept of descent from a common ancestor with modification provides a natural explanation for the diversity of life on Earth as partially represented in the fossil record and in the similarities of existing species. B.E.2.4
5. Students understand that the variation of organisms within a species due to population genetics and gene frequency Different phenotypes result from new combinations of existing genes or from mutations of genes in reproductive cells. B.E.2.5
6. Students understand that at the high school level, the expectation is to combine grade 8 knowledge with an explanation of genes and the function of chromosomes. B.E.2.6
7. Students understand that natural selection works on the phenotype. B.E.2.7
8. Students understand that heritable characteristics influence how likely an organism is to survive and reproduce in a particular environment. B.E.2.8
9. Students understand that when an environment changes, the survival value of inherited characteristics may change. B.E.2.9
    a. Students also understand that this may or may not cause a change in species that inhabit the environment. B.E.2.9.A
10. Students understand that use real-world examples to illustrate natural selection, gene flow, sexual selection, and genetic drift. B.E.2.10

Diversity And Interdependence Of Life

1. Biodiversity B.DI.1
    1. Students understand the great diversity of organisms and ecological niches they occupy result from more than 3.8 billion years of evolution. B.DI.1.1
    2. Students understand that populations of individual species and groups of species comprise a vast reserve of genetic diversity. B.DI.1.2
    3. Students understand that the loss of diversity alters energy flow, cycles of matter and persistence within biological communities. B.DI.1.3
    4. Students understand that the loss of genetic diversity in a population increases its probability of extinction. B.DI.1.4
2. Ecosystems B.DI.2
    1. Students understand that ecosystems change as geological and biological conditions vary due to natural and anthropogenic factors. B.DI.2.1
    2. Students understand that like many complex systems, ecosystems have cyclical fluctuations around a state of equilibrium. B.DI.2.2
        a. Students understand that the rate of these fluctuations in ecosystems can increase due to anthropogenic factors. B.DI.2.2.A
    3. Students understand that changes in ecosystems may lead to disequilibrium, which can be seen in variations in carrying capacities for many species. B.DI.2.3
    4. Students understand that authentic data are used to study the rate of change in matter and energy relationships, population dynamics, carbon and nitrogen cycling, population changes and growth within an ecosystem. B.DI.2.4
    5. Students understand that graphs, charts, histograms and algebraic thinking are used to explain concepts of carrying capacity of populations and homeostasis within ecosystems by investigating changes in populations that occur locally or regionally. B.DI.2.5
    6. Students understand that mathematical models can include the exponential growth model and the logistic growth model. B.DI.2.6
    7. Students understand that the simplest version of the logistic growth model is Population Growth Rate = rN(K-N)/K, which incorporates the biological concept of limited (non-infinite) carrying capacity, based upon intra- and interspecies competition for resources such as food, as represented by the variable K. B.DI.2.7
    8. Students understand that carrying capacity is defined as the population equilibrium size when births and deaths are equal; hence Population Growth Rate = zero. B.DI.2.8
3. Loss of diversity B.DI.3
    1. Students understand that an ecosystem will maintain equilibrium with small fluctuations in its abiotic and biotic components, but significant fluctuations can result in long-term alterations of the ecosystem and ultimately a loss of biodiversity. B.DI.3.1

    a. Students understand that this can be caused by natural and anthropogenic events. B.DI.3.1.A

2. Students understand that humans are a biotic factor in ecosystems and can impact critical variables within these systems. B.DI.3.2
3. Students understand that climate is dependent on a number of feedback loops between sunlight, the ocean, the atmosphere and the biosphere. B.DI.3.3
4. Students understand that increasing mean global temperatures cause increased variance in weather that impacts both biotic and abiotic factors. B.DI.3.4
5. Students understand that the multiple changes happening simultaneously can stress ecosystems. Extreme events such as prolonged drought, floods, or the introduction or removal of species can result in long-term alterations to ecosystems and their functions. B.DI.3.5
6. Students understand that the current rate of extinction is at least 100-1000 times the average background rate observed in the fossil record. B.DI.3.6
7. Students understand that observed rates of biodiversity loss are indicative of a severe and pervasive disequilibrium in ecosystems. B.DI.3.7
8. Students understand that at the high school level, students should examine the factors that contribute to the accelerated extinction rates observed today and the implications of declining biodiversity carrying capacity. B.DI.3.8
9. Students understand that misconceptions about population growth capacity, interspecies and intraspecies competition for resources, and what occurs when members of a species immigrate to or emigrate from ecosystems are included in this topic. B.DI.3.9
10. Students understand that technology can be used to access real-time/authentic data to study population changes and growth in specific locations. B.DI.3.10

Cells

1. Cell structure and function B.C.1
    1. Students understand that every cell produces a membrane through which substances pass differentially, maintaining homeostasis. B.C.1.1
    2. Students understand that the molecular properties and concentration of the substances determine which molecules pass freely and which molecules require the input of energy. B.C.1.2
    3. Students understand that in all but quite primitive cells, a complex network of proteins provides organization and shape. B.C.1.3
    4. Students understand that within the cell are specialized parts that transport materials, transform energy, build proteins, dispose of waste and provide information feedback and movement. B.C.1.4
    5. Students understand that the many chemical reactions that occur in some cells of multicellular organisms do not occur in most of the other cells of the organism. B.C.1.5
    6. Students understand that prokaryotes, simple single-celled organisms, are first found in the fossil record about 3.8 billion years ago. B.C.1.6
    7. Students understand that cells with nuclei, eukaryotes, developed one billion years ago and from these increasingly complex multicellular organisms descended. B.C.1.7
2. Cellular processes B.C.2
    1. Students understand that living cells interact with, and can have an impact on, their environment. B.C.2.1
    2. Students understand that carbon is a necessary element that cells acquire from their environment. B.C.2.2
    3. Students understand that cells use carbon, along with hydrogen, oxygen, nitrogen, phosphorous and sulfur, during essential processes like respiration, photosynthesis, chemosynthesis and biosynthesis of macromolecules (e.g., proteins, lipids, carbohydrates). B.C.2.3
    4. Students understand that the chemical reactions that occur within a cell can cause the storage or release of energy by forming or breaking chemical bonds. B.C.2.4
    5. Students understand that specialized proteins called enzymes lower the activation energy required for chemical reactions, increasing the reaction rate. B.C.2.5
    6. Students understand that positive and negative feedback mechanisms regulate internal cell functions as external conditions vary. B.C.2.6
    7. Students understand that most cells function within a narrow range of temperature and pH. B.C.2.7
    8. Students understand that the variations in external conditions that exceed the optimal range for a cell can affect the rate at which essential chemical reactions

occur in that cell. B.C.2.8

9. Students understand that at very low temperatures, reaction rates are slow. B.C.2.9
10. Students understand that high temperatures can irreversibly change the structure of most protein molecules. B.C.2.10
11. Students understand that the changes in pH beyond the optimal range of the cell can alter the structure of most protein molecules and change how molecules within the cell interact. B.C.2.11
12. Students understand that the sequence of DNA bases on a chromosome determines the sequence of amino acids in a protein. B.C.2.12
13. Students understand that enzymatic proteins catalyze most chemical reactions in cells. B.C.2.13
14. Students understand that protein molecules are long, folded chains made from combinations of 20 common amino-acids. B.C.2.14
15. Students understand that the activity of each protein molecule results from its sequence of amino acids and the shape the chain takes as a result of that sequence. B.C.2.15