Connecticut State Department of Education
Science - Biology Enrichment Standards
High School Grades 9-12

Essential Questions

Cell Biology
How are organisms structured to ensure efficiency and survival?
Genetics
What processes are responsible for life's unity and diversity?
Ecology
How do materials cycle through the Earth's systems?
Evolution
What processes are responsible for life's unity and diversity?
Physiology
How are organisms structured to ensure efficiency and survival?

Biology Enrichment Standards

Cell Biology
The fundamental life processes of plants and animals depend on a variety of chemical reactions that occur in specialized areas of the organism's cells.

Cells are enclosed within semipermeable membranes that regulate their interaction with their surroundings.

Enzymes are proteins that catalyze biochemical reactions without altering the reaction equilibrium and the activities of enzymes depend on the temperature, ionic conditions and the pH of the surroundings.

Prokaryotic cells, eukaryotic cells (including those from plants and animals), and viruses differ in complexity and general structure.

The central dogma of molecular biology outlines the flow of information from transcription of ribonucleic acid (RNA) in the nucleus to translation of proteins on ribosomes in the cytoplasm.

The endoplasmic reticulum and Golgi apparatus have a role in the secretion of proteins.

Usable energy is captured from sunlight by chloroplasts and is stored through the synthesis of sugar from carbon dioxide.

The role of the mitochondria is to make stored chemical-bond energy available to cells by completing the breakdown of glucose to carbon dioxide.

Most macromolecules (polysaccharides, nucleic acids, proteins, lipids) in cells and organisms are synthesized from a small collection of simple precursors.

Genetics

Mutation and sexual reproduction lead to genetic variation in a population.

Meiosis is an early step in sexual reproduction in which the pairs of chromosomes separate and segregate randomly during cell division to produce gametes containing one chromosome of each type.

Only certain cells in a multicellular organism undergo meiosis.

Random chromosome segregation explains the probability that a particular allele will be in a gamete.

New combinations of alleles may be generated in a zygote through the fusion of male and female gametes (fertilization).

Approximately half of an individual's DNA sequence comes from each parent.

Genes on specific chromosomes determine an individual's sex.

Possible combinations of alleles in a zygote can be predicted from the genetic makeup of the parents.

A multicellular organism develops from a single zygote, and its phenotype depends on its genotype, which is established at fertilization.

The probable outcome of phenotypes in a genetic cross can be predicted from the genotypes of the parents and mode of inheritance (autosomal or X-linked, dominant or recessive).

Mendel's laws of segregation and independent assortment are the basis of genetics.

The probable mode of inheritance can be predicted from a pedigree diagram showing phenotypes.

Data on frequency of recombination at meiosis can be used to estimate genetic distances between loci and to interpret genetic maps of chromosomes.

Genes are a set of instructions encoded in the DNA sequence of each organism that specify the sequence of amino acids in proteins characteristic of that organism.

Ribosomes synthesize proteins, using tRNAs to translate genetic information in the mRNA.

The sequence of amino acids in a protein can be predicted from the sequence of codons in the RNA, by applying universal genetic coding rules.

Mutations in the DNA sequence of a gene may or may not affect the expression of the gene or the sequence of amino acids in an encoded protein.

Specialization of cells in multicellular organisms is usually due to different patterns of gene expression rather than to differences of the genes themselves.

Proteins can differ from one another in the number and sequence of amino acids.

Proteins having different amino acid sequences typically have different shapes and chemical properties.

The genetic composition of cells can be altered by incorporation of exogenous DNA into the cells.

Base-pairing rules are used to explain the precise copying of DNA during semiconservative replication and transcription of information from DNA into mRNA.

Genetic engineering (biotechnology) is used to produce novel biomedical and agricultural products.

DNA technology (restriction digestion by endonucleases, gel electrophoresis, ligation and transformation) is used to construct recombinant DNA molecules.

Exogenous DNA can be inserted into bacterial cells to alter their genetic makeup and support expression of new protein products.

Ecology

Stability in an ecosystem is a balance between competing effects.

Biodiversity is the sum total of different kinds of organisms and is affected by alterations of habitats.

Changes in an ecosystem can result from changes in climate, human activity, introduction of nonnative species, or changes in population size.

Fluctuations in population size in an ecosystem are determined by the relative rates of birth, immigration, emigration and death.

Water, carbon and nitrogen cycle between abiotic resources and organic matter in the ecosystem and oxygen cycles through photosynthesis and respiration.

A vital part of an ecosystem is the stability of its producers and decomposers.

At each link in a food web some energy is stored in newly made structures, but much energy is dissipated into the environment as heat.

The accommodation of an individual organism to its environment is different from the gradual adaptation of a lineage of organisms through genetic change.

Evolution

The frequency of an allele in a gene pool of a population depends on many factors and may be stable or unstable over time.

Natural selection acts on the phenotype rather than the genotype of an organism.

Alleles that are lethal in a homozygous individual may be carried in a heterozygote and thus maintained in a gene pool.

New mutations are constantly being generated in a gene pool.

Variation within a species increases the likelihood that at least some members of a species will survive under changed environmental conditions.

Evolution is the result of genetic changes that occur in constantly changing environments.

Natural selection determines the differential survival of groups of organisms.

A great diversity of species increases the chance that at least some organisms survive major changes in the environment.

Genetic drift affects the diversity of organisms in a population.

Reproductive or geographic isolation affects speciation.

Fossil evidence contributes to our understanding of biological diversity, episodic speciation and mass extinction.

Several independent molecular clocks, calibrated against each other and combined with evidence from the fossil record, can help to estimate how long ago various groups of organisms diverged evolutionarily from one another.

Physiology

As a result of the coordinated structures and functions of organ systems, the internal environment of the human body remains relatively stable (homeostatic) despite changes in the outside environment.

The complementary activity of major body systems provides cells with oxygen and nutrients and removes toxic waste products such as carbon dioxide.

The nervous system mediates communication between different parts of the body and the body's interactions with the environment.

Feedback loops in the nervous and endocrine systems regulate conditions in the body.

The neurons transmit electrochemical impulses.

Sensory neurons, interneurons and motor neurons all have a role in sensation, thought and response.

Digestion includes the secretion of stomach acid, digestive enzymes (amylases, proteases, nucleases, lipases) and bile salts into the digestion system.

The kidneys have a homeostatic role in the removal of nitrogenous wastes from the blood.

The liver has a homeostatic role in detoxification and keeping the blood glucose balance.

Actin, myosin, Ca2 and ATP have a role in the cellular and molecular basis of muscle contraction.

Hormones (including digestive, reproductive, osmoregulatory) provide internal feedback mechanisms for homeostasis at the cellular level and in whole organisms.

Organisms have a variety of mechanisms to combat disease.

The skin provides nonspecific defenses against infection.

Antibodies have a role in the body's response to infection.

Vaccination protects an individual from infectious diseases.

There are important differences between bacteria and viruses with respect to their requirements for growth and replication, the body's primary defenses against bacterial and viral infections, and effective treatments of these infections.

An individual with a compromised immune system (for example, a person with AIDS) may be unable to fight off and survive infections by microorganisms that are usually benign.

Phagocytes, B-lymphocytes and T-lymphocytes have a role in the immune system.