

Massachusetts Tutorials are designed specifically for the Learning Standards found in the Massachusetts Curriculum Frameworks to prepare students for the MCAS tests.

Biology Tutorials offer targeted instruction, practice, and review designed to help students develop fluency, deepen conceptual understanding, and apply scientific thinking skills. Students engage with the content in an interactive, feedback-rich environment as they progress through standards-aligned modules. By constantly honing their ability to explain and analyze biological scenarios, students build the depth of knowledge and higher-order skills required to demonstrate their mastery when put to the test.

In each module, the Learn It and Try It make complex ideas accessible through focused content, guided analysis, multi-modal representations, and personalized feedback as students reason through increasingly challenging problems. The Review It offers a high-impact summary of key concepts and relates those concepts to students' lives. The Test It assesses students' mastery of the module's concepts, providing granular performance data to students and teachers after each attempt. To help students focus on the content most relevant to them, unit-level pretests and posttests can quickly identify where students are strong and where they're still learning.

1. NATURE AND CHEMISTRY OF LIFE

• CHARACTERISTICS OF LIFE

- **B.I.2.A.2.2** Compare and contrast, at the cellular level, prokaryotes and eukaryotes (general structures and degrees of complexity).
- **B.I.2.A.2.1** Relate cell parts/organelles (plasma membrane, nuclear envelope, nucleus, nucleolus, cytoplasm, mitochondrion, endoplasmic reticulum, Golgi apparatus, lysosome, ribosome, vacuole, cell wall, chloroplast, cytoskeleton, centriole, cilium, flagellum, pseudopod) to their functions. Explain the role of cell membranes as a highly selective barrier (diffusion, osmosis, facilitated diffusion, and active transport).
- **B.I.2.A.2.4** Identify the reactants, products, and basic purposes of photosynthesis and cellular respiration. Explain the interrelated nature of photosynthesis and cellular respiration in the cells of photosynthetic organisms.
- **B.I.2.A.2.6** Describe the cell cycle and the process of mitosis. Explain the role of mitosis in the formation of new cells, and its importance in maintaining chromosome number during asexual reproduction.
- **B.I.2.A.2.8** Compare and contrast a virus and a cell in terms of genetic material and reproduction.
- **B.I.4.A.4.6** Recognize that the sexual reproductive system allows organisms to produce offspring that receive half of their genetic information from their mother and half from their father and that sexually produced offspring resemble, but are not identical to, either of their parents.

• BIOMOLECULES

- **B.I.1.A.1.1** Recognize that biological organisms are composed primarily of very few elements. The six most common are C, H, N, O, P, S.
- **B.I.1.A.1.2** Describe the basic molecular structures and primary functions of the four major categories of organic molecules (carbohydrates, lipids, proteins, and nucleic acids).
- **B.I.3.A.3.1** Describe the basic structure (double helix, sugar/phosphate backbone, linked by complementary nucleotide pairs) of DNA, and describe its function in genetic inheritance.

• ENZYMES

- **B.I.1.A.1.3** Explain the role of enzymes as catalysts that lower the activation energy of biochemical reactions. Identify factors, such as pH and temperature, which have an effect on enzymes.

2. CELL STRUCTURE AND FUNCTION

- **PROKARYOTIC AND EUKARYOTIC CELLS**

- **B.I.2.A.2.1** *Relate cell parts/organelles (plasma membrane, nuclear envelope, nucleus, nucleolus, cytoplasm, mitochondrion, endoplasmic reticulum, Golgi apparatus, lysosome, ribosome, vacuole, cell wall, chloroplast, cytoskeleton, centriole, cilium, flagellum, pseudopod) to their functions. Explain the role of cell membranes as a highly selective barrier (diffusion, osmosis, facilitated diffusion, and active transport).*
- **B.I.2.A.2.2** *Compare and contrast, at the cellular level, prokaryotes and eukaryotes (general structures and degrees of complexity).*

- **PLANT AND ANIMAL CELLS**

- **B.I.2.A.2.1** *Relate cell parts/organelles (plasma membrane, nuclear envelope, nucleus, nucleolus, cytoplasm, mitochondrion, endoplasmic reticulum, Golgi apparatus, lysosome, ribosome, vacuole, cell wall, chloroplast, cytoskeleton, centriole, cilium, flagellum, pseudopod) to their functions. Explain the role of cell membranes as a highly selective barrier (diffusion, osmosis, facilitated diffusion, and active transport).*

3. PASSIVE TRANSPORT AND ACTIVE TRANSPORT

- **PASSIVE TRANSPORT**

- **B.I.2.A.2.1** *Relate cell parts/organelles (plasma membrane, nuclear envelope, nucleus, nucleolus, cytoplasm, mitochondrion, endoplasmic reticulum, Golgi apparatus, lysosome, ribosome, vacuole, cell wall, chloroplast, cytoskeleton, centriole, cilium, flagellum, pseudopod) to their functions. Explain the role of cell membranes as a highly selective barrier (diffusion, osmosis, facilitated diffusion, and active transport).*
- **B.I.2.A.2.3** *Use cellular evidence (such as cell structure, cell number, and cell reproduction) and modes of nutrition to describe six kingdoms (Archaeobacteria, Eubacteria, Protista, Fungi, Plantae, Animalia).*

- **ACTIVE TRANSPORT**

- **B.I.2.A.2.1** *Relate cell parts/organelles (plasma membrane, nuclear envelope, nucleus, nucleolus, cytoplasm, mitochondrion, endoplasmic reticulum, Golgi apparatus, lysosome, ribosome, vacuole, cell wall, chloroplast, cytoskeleton, centriole, cilium, flagellum, pseudopod) to their functions. Explain the role of cell membranes as a highly selective barrier (diffusion, osmosis, facilitated diffusion, and active transport).*

4. CELLULAR ENERGETICS

- **PHOTOSYNTHESIS**

- **B.I.2.A.2.1** *Relate cell parts/organelles (plasma membrane, nuclear envelope, nucleus, nucleolus, cytoplasm, mitochondrion, endoplasmic reticulum, Golgi apparatus, lysosome, ribosome, vacuole, cell wall, chloroplast, cytoskeleton, centriole, cilium, flagellum, pseudopod) to their functions. Explain the role of cell membranes as a highly selective barrier (diffusion, osmosis, facilitated diffusion, and active transport).*
- **B.I.2.A.2.4** *Identify the reactants, products, and basic purposes of photosynthesis and cellular respiration. Explain the interrelated nature of photosynthesis and cellular respiration in the cells of photosynthetic organisms.*
- **B.I.2.A.2.5** *Explain the important role that ATP serves in metabolism.*
- **B.I.6.A.6.4** *Explain how water, carbon, and nitrogen cycle between abiotic resources and organic matter in an ecosystem and how oxygen cycles through photosynthesis and respiration.*

- **CELLULAR RESPIRATION**

- **B.I.2.A.2.4** *Identify the reactants, products, and basic purposes of photosynthesis and cellular respiration. Explain the interrelated nature of photosynthesis and cellular respiration in the cells of photosynthetic organisms.*
- **B.I.2.A.2.5** *Explain the important role that ATP serves in metabolism.*
- **B.I.6.A.6.4** *Explain how water, carbon, and nitrogen cycle between abiotic resources and organic matter in an ecosystem and how oxygen cycles through photosynthesis and respiration.*
- **B.I.2.A.2.1** *Relate cell parts/organelles (plasma membrane, nuclear envelope, nucleus, nucleolus, cytoplasm, mitochondrion, endoplasmic reticulum, Golgi apparatus, lysosome, ribosome, vacuole, cell wall, chloroplast, cytoskeleton, centriole, cilium,*

flagellum, pseudopod) to their functions. Explain the role of cell membranes as a highly selective barrier (diffusion, osmosis, facilitated diffusion, and active transport).

5. CELL GROWTH AND REPRODUCTION

• THE CELL CYCLE

- **B.I.2.A.2.6** Describe the cell cycle and the process of mitosis. Explain the role of mitosis in the formation of new cells, and its importance in maintaining chromosome number during asexual reproduction.
- **B.I.3.A.3.2** Describe the basic process of DNA replication and how it relates to the transmission and conservation of the genetic code. Explain the basic processes of transcription and translation, and how they result in the expression of genes. Distinguish among the end products of replication, transcription, and translation.
- **B.I.1.A.1.2** Describe the basic molecular structures and primary functions of the four major categories of organic molecules (carbohydrates, lipids, proteins, and nucleic acids).

• MITOSIS

- **B.I.2.A.2.6** Describe the cell cycle and the process of mitosis. Explain the role of mitosis in the formation of new cells, and its importance in maintaining chromosome number during asexual reproduction.

6. DNA STRUCTURE AND FUNCTION

• COMPONENTS OF DNA

- **B.I.1.A.1.2** Describe the basic molecular structures and primary functions of the four major categories of organic molecules (carbohydrates, lipids, proteins, and nucleic acids).
- **B.I.3.A.3.1** Describe the basic structure (double helix, sugar/phosphate backbone, linked by complementary nucleotide pairs) of DNA, and describe its function in genetic inheritance.
- **B.I.3.A.3.2** Describe the basic process of DNA replication and how it relates to the transmission and conservation of the genetic code. Explain the basic processes of transcription and translation, and how they result in the expression of genes. Distinguish among the end products of replication, transcription, and translation.

• THE GENETIC CODE

- **B.I.1.A.1.2** Describe the basic molecular structures and primary functions of the four major categories of organic molecules (carbohydrates, lipids, proteins, and nucleic acids).
- **B.I.3.A.3.1** Describe the basic structure (double helix, sugar/phosphate backbone, linked by complementary nucleotide pairs) of DNA, and describe its function in genetic inheritance.
- **B.I.3.A.3.2** Describe the basic process of DNA replication and how it relates to the transmission and conservation of the genetic code. Explain the basic processes of transcription and translation, and how they result in the expression of genes. Distinguish among the end products of replication, transcription, and translation.

• DNA REPLICATION

- **B.I.3.A.3.1** Describe the basic structure (double helix, sugar/phosphate backbone, linked by complementary nucleotide pairs) of DNA, and describe its function in genetic inheritance.
- **B.I.3.A.3.2** Describe the basic process of DNA replication and how it relates to the transmission and conservation of the genetic code. Explain the basic processes of transcription and translation, and how they result in the expression of genes. Distinguish among the end products of replication, transcription, and translation.

7. GENE EXPRESSION

• TRANSCRIPTION

- **B.I.1.A.1.2** Describe the basic molecular structures and primary functions of the four major categories of organic molecules (carbohydrates, lipids, proteins, and nucleic acids).
- **B.I.3.A.3.1** Describe the basic structure (double helix, sugar/phosphate backbone, linked by complementary nucleotide pairs)

of DNA, and describe its function in genetic inheritance.

- **B.1.3.A.3.2** Describe the basic process of DNA replication and how it relates to the transmission and conservation of the genetic code. Explain the basic processes of transcription and translation, and how they result in the expression of genes. Distinguish among the end products of replication, transcription, and translation.
- **B.1.2.A.2.1** Relate cell parts/organelles (plasma membrane, nuclear envelope, nucleus, nucleolus, cytoplasm, mitochondrion, endoplasmic reticulum, Golgi apparatus, lysosome, ribosome, vacuole, cell wall, chloroplast, cytoskeleton, centriole, cilium, flagellum, pseudopod) to their functions. Explain the role of cell membranes as a highly selective barrier (diffusion, osmosis, facilitated diffusion, and active transport).

• TRANSLATION

- **B.1.1.A.1.2** Describe the basic molecular structures and primary functions of the four major categories of organic molecules (carbohydrates, lipids, proteins, and nucleic acids).
- **B.1.3.A.3.2** Describe the basic process of DNA replication and how it relates to the transmission and conservation of the genetic code. Explain the basic processes of transcription and translation, and how they result in the expression of genes. Distinguish among the end products of replication, transcription, and translation.
- **B.1.3.A.3.1** Describe the basic structure (double helix, sugar/phosphate backbone, linked by complementary nucleotide pairs) of DNA, and describe its function in genetic inheritance.

8. MUTATIONS

• GENETIC CHANGES IN DNA

- **B.1.3.A.3.3** Explain how mutations in the DNA sequence of a gene may or may not result in phenotypic change in an organism. Explain how mutations in gametes may result in phenotypic changes in offspring.

• GENETIC CHANGES IN CHROMOSOMES

- **B.1.2.A.2.7** Describe how the process of meiosis results in the formation of haploid cells. Explain the importance of this process in sexual reproduction, and how gametes form diploid zygotes in the process of fertilization.
- **B.1.3.A.3.3** Explain how mutations in the DNA sequence of a gene may or may not result in phenotypic change in an organism. Explain how mutations in gametes may result in phenotypic changes in offspring.
- **B.1.4.A.4.6** Recognize that the sexual reproductive system allows organisms to produce offspring that receive half of their genetic information from their mother and half from their father and that sexually produced offspring resemble, but are not identical to, either of their parents.

9. HEREDITY

• MENDELIAN LAWS OF HEREDITY

- **B.1.3.A.3.4** Distinguish among observed inheritance patterns caused by several types of genetic traits (dominant, recessive, incomplete dominance, codominant, sex-linked, polygenic, and multiple alleles).
- **B.1.3.A.3.5** Describe how Mendel's laws of segregation and independent assortment can be observed through patterns of inheritance (such as dihybrid crosses).
- **B.1.4.A.4.6** Recognize that the sexual reproductive system allows organisms to produce offspring that receive half of their genetic information from their mother and half from their father and that sexually produced offspring resemble, but are not identical to, either of their parents.
- **B.1.3.A.3.6** Use a Punnett Square to determine the probabilities for genotype and phenotype combinations in monohybrid crosses.

• MULTIPLE ALLELES AND ALLELES WITHOUT DOMINANCE

- **B.1.3.A.3.4** Distinguish among observed inheritance patterns caused by several types of genetic traits (dominant, recessive, incomplete dominance, codominant, sex-linked, polygenic, and multiple alleles).
- **B.1.3.A.3.6** Use a Punnett Square to determine the probabilities for genotype and phenotype combinations in monohybrid crosses.

10. REPRODUCTION

• MEIOSIS

- **B.I.2.A.2.7** Describe how the process of meiosis results in the formation of haploid cells. Explain the importance of this process in sexual reproduction, and how gametes form diploid zygotes in the process of fertilization.
- **B.I.3.A.3.5** Describe how Mendel's laws of segregation and independent assortment can be observed through patterns of inheritance (such as dihybrid crosses).
- **B.I.4.A.4.6** Recognize that the sexual reproductive system allows organisms to produce offspring that receive half of their genetic information from their mother and half from their father and that sexually produced offspring resemble, but are not identical to, either of their parents.
- **B.I.5.A.5.1** Explain how evolution is demonstrated by evidence from the fossil record, comparative anatomy, genetics, molecular biology, and examples of natural selection.

• SEXUAL AND ASEQUAL REPRODUCTION

- **B.I.2.A.2.7** Describe how the process of meiosis results in the formation of haploid cells. Explain the importance of this process in sexual reproduction, and how gametes form diploid zygotes in the process of fertilization.
- **B.I.4.A.4.6** Recognize that the sexual reproductive system allows organisms to produce offspring that receive half of their genetic information from their mother and half from their father and that sexually produced offspring resemble, but are not identical to, either of their parents.
- **B.I.2.A.2.6** Describe the cell cycle and the process of mitosis. Explain the role of mitosis in the formation of new cells, and its importance in maintaining chromosome number during asexual reproduction.

11. EVOLUTION

• MULTIPLE LINES OF EVIDENCE

- **B.I.5.A.5.1** Explain how evolution is demonstrated by evidence from the fossil record, comparative anatomy, genetics, molecular biology, and examples of natural selection.

• THE FOSSIL RECORD

- **B.I.5.A.5.1** Explain how evolution is demonstrated by evidence from the fossil record, comparative anatomy, genetics, molecular biology, and examples of natural selection.
- **B.I.6.A.6.2** Analyze changes in population size and biodiversity (speciation and extinction) that result from the following: natural causes, changes in climate, human activity, and the introduction of invasive, non-native species.

12. MECHANISMS OF EVOLUTION

• NATURAL SELECTION

- **B.I.5.A.5.1** Explain how evolution is demonstrated by evidence from the fossil record, comparative anatomy, genetics, molecular biology, and examples of natural selection.
- **B.I.5.A.5.3** Explain how evolution through natural selection can result in changes in biodiversity through the increase or decrease of genetic diversity from a population.

• EVOLUTION OF SPECIES

- **B.I.5.A.5.1** Explain how evolution is demonstrated by evidence from the fossil record, comparative anatomy, genetics, molecular biology, and examples of natural selection.
- **B.I.5.A.5.2** Describe species as reproductively distinct groups of organisms. Recognize that species are further classified into a hierarchical taxonomic system (kingdom, phylum, class, order, family, genus, species) based on morphological, behavioral, and molecular similarities. Describe the role that geographic isolation can play in speciation.
- **B.I.5.A.5.3** Explain how evolution through natural selection can result in changes in biodiversity through the increase or decrease of genetic diversity from a population.

13. CLASSIFICATION

• TAXONOMY

- **B.I.5.A.5.2** Describe species as reproductively distinct groups of organisms. Recognize that species are further classified into a hierarchical taxonomic system (kingdom, phylum, class, order, family, genus, species) based on morphological, behavioral, and molecular similarities. Describe the role that geographic isolation can play in speciation.

• THE SIX KINGDOMS

- **B.I.2.A.2.3** Use cellular evidence (such as cell structure, cell number, and cell reproduction) and modes of nutrition to describe six kingdoms (Archaeobacteria, Eubacteria, Protista, Fungi, Plantae, Animalia).
- **B.I.5.A.5.2** Describe species as reproductively distinct groups of organisms. Recognize that species are further classified into a hierarchical taxonomic system (kingdom, phylum, class, order, family, genus, species) based on morphological, behavioral, and molecular similarities. Describe the role that geographic isolation can play in speciation.

14. HOMEOSTASIS AND ANIMAL SYSTEMS

• HOMEOSTASIS AND DYNAMIC EQUILIBRIUM

- **B.I.4.A.4.8** Recognize that the body's systems interact to maintain homeostasis. Describe the basic function of a physiological feedback loop.
- **C.I.7.A.7.6** Predict the shift in equilibrium when the system is subjected to a stress (LeChatelier's principle) and identify the factors that can cause a shift in equilibrium (concentration, pressure, volume, temperature).

• FEEDBACK MECHANISMS IN ANIMALS

- **B.I.4.A.4.8** Recognize that the body's systems interact to maintain homeostasis. Describe the basic function of a physiological feedback loop.

• THE NERVOUS SYSTEM

- **B.I.4.A.4.4** Explain how the nervous system (brain, spinal cord, sensory neurons, motor neurons) mediates communication between different parts of the body and the body's interactions with the environment. Identify the basic unit of the nervous system, the neuron, and explain generally how it works.
- **B.I.4.A.4.7** Recognize that communication between cells is required for coordination of body functions. The nerves communicate with electrochemical signals, hormones circulate through the blood, and some cells produce signals to communicate only with nearby cells.
- **B.I.4.A.4.8** Recognize that the body's systems interact to maintain homeostasis. Describe the basic function of a physiological feedback loop.

15. MATTER AND ENERGY

• FOOD CHAINS AND WEBS

- **B.I.6.A.6.3** Use a food web to identify and distinguish producers, consumers, and decomposers, and explain the transfer of energy through trophic levels. Describe how relationships among organisms (predation, parasitism, competition, commensalism, and mutualism) add to the complexity of biological communities.
- **B.I.6.A.6.1** Explain how birth, death, immigration, and emigration influence population size.
- **B.I.6.A.6.2** Analyze changes in population size and biodiversity (speciation and extinction) that result from the following: natural causes, changes in climate, human activity, and the introduction of invasive, non-native species.

• PYRAMIDS OF ENERGY, NUMBERS, AND BIOMASS

- **B.I.6.A.6.3** Use a food web to identify and distinguish producers, consumers, and decomposers, and explain the transfer of energy through trophic levels. Describe how relationships among organisms (predation, parasitism, competition, commensalism, and mutualism) add to the complexity of biological communities.

16. CYCLES IN NATURE AND NATURAL IMPACTS ON ECOSYSTEMS

- **THE CARBON CYCLE**

- **E.I.3.A.3.2** Describe the carbon cycle.
- **B.I.6.A.6.4** Explain how water, carbon, and nitrogen cycle between abiotic resources and organic matter in an ecosystem and how oxygen cycles through photosynthesis and respiration.

- **THE NITROGEN AND PHOSPHORUS CYCLES**

- **E.I.3.A.3.3** Describe the nitrogen cycle.
- **B.I.1.A.1.1** Recognize that biological organisms are composed primarily of very few elements. The six most common are C, H, N, O, P, S.
- **B.I.6.A.6.4** Explain how water, carbon, and nitrogen cycle between abiotic resources and organic matter in an ecosystem and how oxygen cycles through photosynthesis and respiration.

- **NATURAL IMPACTS ON ECOSYSTEMS**

- **B.I.6.A.6.2** Analyze changes in population size and biodiversity (speciation and extinction) that result from the following: natural causes, changes in climate, human activity, and the introduction of invasive, non-native species.