Georgia Milestones Assessment System

Study/Resource Guide for Students and Parents

Biology

Study/Resource Guide

The Study/Resource Guides are intended to serve as a resource for parents and students. They contain practice questions and learning activities for the course. The standards identified in the Study/Resource Guides address a sampling of the state-mandated content standards.

For the purposes of day-to-day classroom instruction, teachers should consult the wide array of resources that can be found at www.georgiastandards.org.

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THE GEORGIA MILESTONES ASSESSMENT SYSTEM

Dear Student,

The **Georgia Milestones Biology EOC Study/Resource Guide for Students and Parents** is intended as a resource for parents and students.

This guide contains information about the core content ideas and skills that are covered in the course. There are practice sample questions for every unit. The questions are fully explained and describe why each answer is either correct or incorrect. The explanations also help illustrate how each question connects to the Georgia state standards.

In addition, the guide includes activities that you can try to help you better understand the concepts taught in the course. The standards and additional instructional resources can be found on the Georgia Department of Education website, www.georgiastandards.org.

Get ready—open this guide—and get started!

GEORGIA MILESTONES END-OF-COURSE (EOC) ASSESSMENTS

The EOC assessments serve as the final exam in certain courses. The courses are:

English Language Arts

- Ninth Grade Literature and Composition
- American Literature and Composition

Mathematics

- Algebra I
- Analytic Geometry
- Coordinate Algebra
- Geometry

Science

- Physical Science
- Biology

Social Studies

- United States History
- Economics/Business/Free Enterprise

All End-of-Course assessments accomplish the following:

- Ensure that students are learning
- Provide data to teachers, schools, and school districts
- Identify instructional needs and help plan how to meet those needs
- Provide data for use in Georgia's accountability measures and reports

HOW TO USE THIS GUIDE

Let's get started!

First, preview the entire guide. Learn what is discussed and where to find helpful information. Even though the focus of this guide is Biology, you need to keep in mind your overall good reading habits.

- Start reading with a pencil or a highlighter in your hand and sticky notes nearby.
- Mark the important ideas, the things you might want to come back to, or the explanations you have questions about. On that last point, your teacher is your best resource.
- You will find some key ideas and important tips to help you prepare for the test.
- You can learn about the different types of items on the test.
- When you come to the sample items, don't just read them, *do* them. Think about strategies you can use for finding the right answer. Then read the analysis of the item to check your work. The reasoning behind the correct answer is explained for you. It will help you see any faulty reasoning in the ones you may have missed.
- Use the activities in this guide to get hands-on understanding of the concepts presented in each unit.
- With the Depth of Knowledge (DOK) information, you can gauge just how complex the item is. You will see that some items ask you to recall information and others ask you to infer or go beyond simple recall. The assessment will require all levels of thinking.
- Plan your studying and schedule your time.
- Proper preparation will help you do your best!

OVERVIEW OF THE BIOLOGY EOC ASSESSMENT

ITEM TYPES

The Biology EOC assessment consists of selected-response and technology-enhanced items.

A **selected-response** item, sometimes called a multiple-choice item, is a question, problem, or statement that is followed by four answer choices. These questions are worth one point.

A **technology-enhanced** item has a question, problem, or statement. You may be asked to select more than one right answer. Or, you may be asked to answer the first part of the question. Then, you will answer the second part of the question based on how you answered part one. These questions are worth 2 points. Partial credit may be awarded if you select some but not all of the correct answers or if you get one part of the question correct but not the other.

DEPTH OF KNOWLEDGE DESCRIPTORS

Items found on the Georgia Milestones assessments, including the Biology EOC assessment, are developed with a particular emphasis on the kinds of thinking required to answer questions. In current educational terms, this is referred to as Depth of Knowledge (DOK). DOK is measured on a scale of 1 to 4 and refers to the level of cognitive demand (different kinds of thinking) required to complete a task, or in this case, an assessment item. The following table shows the expectations of the four DOK levels in detail.

The DOK table lists the skills addressed in each level as well as common question cues. These question cues not only demonstrate how well you understand each skill but they relate to the expectations that are part of the Characteristics of Science and Nature of Science standards.

Level 1—Recall of Information

Level 1 generally requires that you identify, list, or define. This level usually asks you to recall facts, terms, concepts, and trends and may ask you to identify specific information contained in documents, maps, charts, tables, graphs, or illustrations. Items that require you to "describe" and/or "explain" could be classified as Level 1 or Level 2. A Level 1 item requires that you just recall, recite, or reproduce information.

Skills Demonstrated	Question Cues
• Make observations • Recall information • Recognize formulas, properties, patterns, processes • Know vocabulary, definitions • Know basic concepts • Perform one-step processes • Translate from one representation to another • Identify relationships	• Tell what, when, or where • Find • List • Define • Identify; label; name • Choose; select • Compute; estimate • Express • Read from data displays • Order

Level 2—Basic Reasoning

Level 2 includes the engagement (use) of some mental processing beyond recalling or reproducing a response. A Level 2 "describe" and/or "explain" item would require that you go beyond a description or explanation of recalled information to describe and/or explain a result or "how" or "why."

Skills Demonstrated	Question Cues
• Apply learned information to abstract and real-life situations • Use methods, concepts, theories in abstract and real-life situations • Perform multi-step processes • Solve problems using required skills or knowledge (requires more than habitual response) • Make a decision about how to proceed • Identify and organize components of a whole • Extend patterns • Identify/describe cause and effect • Recognize unstated assumptions; make inferences • Interpret facts • Compare or contrast simple concepts/ideas	• Apply • Calculate; solve • Complete • Describe • Explain how; demonstrate • Construct data displays • Construct; draw • Analyze • Extend • Connect • Classify • Arrange • Compare; contrast

Level 3—Complex Reasoning	
Level 3 requires reasoning, using evidence, and thinking on a higher and more abstract level than Level 1 and Level 2. You will go beyond explaining or describing "how and why" to justifying the "how and why" through application and evidence. Level 3 questions often involve making connections across time and place to explain a concept or a "big idea."	
Skills Demonstrated	**Question Cues**
• Solve an open-ended problem with more than one correct answer • Create a pattern • Generalize from given facts • Relate knowledge from several sources • Draw conclusions • Make predictions • Translate knowledge into new contexts • Compare and discriminate between ideas • Assess value of methods, concepts, theories, processes, formulas • Make choices based on a reasoned argument • Verify the value of evidence, information, numbers, and data	• Plan; prepare • Predict • Create; design • Ask "what if?" questions • Generalize • Justify; explain why; support; convince • Assess • Rank; grade • Test; judge • Recommend • Select • Conclude

Level 4—Extended Reasoning	
Level 4 requires the complex reasoning of Level 3 with the addition of planning, investigating, applying significant conceptual understanding, and/or developing that will most likely require an extended period of time. You may be required to connect and relate ideas and concepts *within* the content area or *among* content areas in order to be at this highest level. The Level 4 items would be a show of evidence, through a task, a product, or an extended response, that the cognitive demands have been met.	
Skills Demonstrated	**Question Cues**
• Analyze and synthesize information from multiple sources • Examine and explain alternative perspectives across a variety of sources • Apply mathematical models to illuminate a problem or situation • Design a mathematical model to inform and solve a practical or abstract situation • Combine and synthesize ideas into new concepts	• Design • Connect • Synthesize • Apply concepts • Critique • Analyze • Create • Prove

DEPTH OF KNOWLEDGE EXAMPLE ITEMS

Example items that represent the applicable DOK levels across various Biology content domains are provided on the following pages.

All example and sample items contained in this guide are the property of the Georgia Department of Education.

Example Item 1

Selected-Response

DOK Level 1: This is a DOK level 1 item because it requires the student to recall information about the function of the cell membrane in controlling the passage of substances in and out of the cell.

Biology Domain: Cells

Standard: SB1. Students will analyze the nature of the relationships between structures and functions in living cells.

a. Explain the role of cell organelles for both prokaryotic and eukaryotic cells, including the cell membrane, in maintaining homeostasis and cell reproduction.

Standard: SCSh3. Students will identify and investigate problems scientifically. c. Collect, organize and record appropriate data.

A student is making a table to show the ways in which cell structures help to maintain homeostasis.

How Cell Parts Help Maintain Homeostasis

	Produces ATP When Needed	Allows and Controls the Passage of Substances
Cell Part	Mitochondrion	**?**

Which cell structure should the student use to BEST complete the table?

A. nucleus
B. cytoplasm
C. cell membrane
D. endoplasmic reticulum

Correct Answer: C

Explanation of Correct Answer: The correct answer is choice (C) cell membrane. Choice (A) is incorrect because the nucleus does not directly allow substances into the cell. Choice (B) is incorrect because cytoplasm does not control substances entering and exiting the cell. Choice (D) is incorrect because the endoplasmic reticulum is responsible for packaging and transporting substances.

Example Item 2

Selected-Response

DOK Level 2: This is a DOK level 2 item because it requires the student to apply learned information to abstract and real-life situations.

Biology Domain: Genetics

Standard: SB2. Students will analyze how biological traits are passed on to successive generations.

c. Using Mendel's laws, explain the role of meiosis in reproductive variability.

Standard: SCSh3. Students will identify and investigate problems scientifically.
e. Develop reasonable conclusions based on data collected.

People who have Tay-Sachs disease cannot metabolize some lipids effectively. Tay-Sachs is a recessive disorder. A student used a Punnett square to determine the probability of offspring inheriting the disease. The results from a Punnett Square are 25% TT, 50% Tt, and 25% tt. (T represents the dominant allele for this condition; t represents the recessive allele.)

Which conclusion can be made regarding the genotypes of the parents and the probability of inheriting a Tay-Sachs allele?

A. The parents must be TT and tt, which yields a 25% chance of expressing the disease.
B. The parents must be Tt and tt, which yields a 50% chance of inheriting an allele for the disease.
C. The parents must be TT and TT, which yields a 25% chance of inheriting an allele for the disease.
D. The parents must be Tt and Tt, which yields a 75% chance of inheriting an allele for the disease.

Correct Answer: D

Explanation of Correct Answer: The correct answer is choice (D) The parents must be Tt and Tt, which yields a 75% chance of inheriting an allele for the disease.

	T	t
T	TT	Tt
t	Tt	tt

Choice (A) is incorrect because this combination would yield 100% Tt. Choice (B) is incorrect because this combination would yield 50% Tt and 50% tt. Choice (C) is incorrect because this combination would yield 100% TT.

Example Item 3

Selected-Response

Biology Domain: Organisms

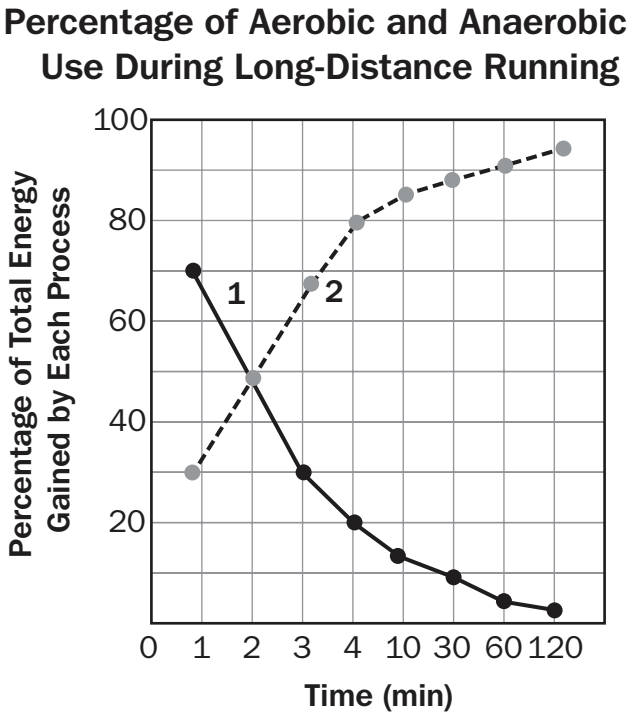
DOK Level 3: This is a DOK level 3 item because it requires the student to form a conclusion.

Standard: SB3. Students will derive the relationship between single-celled and multi-celled organisms and the increasing complexity of systems.

a. Explain the cycling of energy through the processes of photosynthesis and respiration.

Standard: SCSh3. Students will identify and investigate problems scientifically.
d. Graphically compare and analyze data points and/or summary statistics.

A scientist studied the energy contribution of different types of cellular respiration to a runner during an endurance running event. The scientist then created the graph shown from the data collected.



Which conclusion can be made regarding the mechanisms for obtaining energy in Line 1 and Line 2?

A. ATP is obtained through aerobic respiration for Line 1 while anaerobic respiration occurs for Line 2.

B. ATP is obtained through anaerobic respiration for Line 1 while aerobic respiration occurs for Line 2.

C. Line 1 shows energy is obtained through production of glucose molecules while Line 2 shows energy obtained through the production of protein molecules.

D. Line 1 shows energy is obtained through the production of fat molecules while Line 2 shows energy obtained through the production of carbohydrate molecules.

Correct Answer: B

Explanation of Correct Answer: The correct answer is choice (B) ATP is obtained through anaerobic respiration for Line 1 while aerobic respiration occurs for Line 2. Anaerobic respiration will supply the majority of energy initially because it provides energy quickly, but it cannot supply energy for long periods of time so the contribution decreases over time. Aerobic respiration takes longer to begin supplying energy but can do so for long periods of time. Choice (A) is incorrect because the mechanisms are reversed. Choice (C) is incorrect because glucose molecules are not made during glycolysis and energy production does not produce proteins. Choice (D) is incorrect because fat and carbohydrate molecules are not produced during energy production.

DESCRIPTION OF TEST FORMAT AND ORGANIZATION

The Georgia Milestones Biology EOC assessment consists of a total of 75 items. You will be asked to respond to selected-response (multiple-choice) and technology-enhanced items.

The test will be given in two sections.

- You may have up to 70 minutes per section to complete Sections 1 and 2.
- The total estimated testing time for the Biology EOC assessment ranges from approximately 90 to 140 minutes. Total testing time describes the amount of time you have to complete the assessment. It does not take into account the time required for the test examiner to complete pre-administration and post-administration activities (such as reading the standardized directions to students).
- Sections 1 and 2 may be administered on the same day or across two consecutive days, based on the district's testing protocols for the EOC measures (in keeping with state guidance).

Effect on Course Grade

It is important that you take this course and the EOC assessment very seriously.

- For students in Grade 10 or above beginning with the 2011–2012 school year, the final grade in each course is calculated by weighing the course grade 85% and the EOC score 15%.
- For students in Grade 9 beginning with the 2011–2012 school year, the final grade in each course is calculated by weighing the course grade 80% and the EOC score 20%.
- A student must have a final grade of at least 70% to pass the course and to earn credit toward graduation.

PREPARING FOR THE BIOLOGY EOC ASSESSMENT

STUDY SKILLS

As you prepare for this test, ask yourself the following questions:

- How would you describe yourself as a student?
- What are your study skills strengths and/or weaknesses?
- How do you typically prepare for a classroom test?
- What study methods do you find particularly helpful?
- What is an ideal study situation or environment for you?
- How would you describe your actual study environment?
- How can you change the way you study to make your study time more productive?

ORGANIZATION—OR TAKING CONTROL OF YOUR WORLD

- Establish a study area that has minimal distractions.
- Gather your materials in advance.
- Develop and implement your study plan.

ACTIVE PARTICIPATION

The most important element in your preparation is *you*. You and your actions are the key ingredient. Your active studying helps you stay alert and be more productive. In short, you need to interact with the course content. Here's how you do it.

- Carefully read the information and then DO something with it. Mark the important material with a highlighter, circle it with a pen, write notes on it, or summarize the information in your own words.
- Ask questions. As you study, questions often come into your mind. Write them down and actively seek the answers.
- Create sample test questions and answer them.
- Find a friend who is also planning to take the test and quiz each other.

TEST-TAKING STRATEGIES

Part of preparing for a test is having a set of strategies you can draw from. Include these strategies in your plan:

- Read and understand the directions completely. If you are not sure, ask a teacher.
- Read each question and all of the answer choices carefully.
- If you use scratch paper, make sure you copy your work to your test accurately.
- Underline important parts of each task. Make sure that your answer goes on the answer sheet.

- Be aware of time. If a question is taking too much time, come back to it later.
- Answer all questions. Check your answers for accuracy.
- Stay calm and do the best you can.

PREPARING FOR THE BIOLOGY EOC ASSESSMENT

Read this guide to help prepare for the Biology EOC assessment.

The section of the guide titled "Content of the Biology EOC Assessment" provides a snapshot of the Biology course. In addition to reading this guide, do the following to prepare to take the assessment:

- Read your textbooks and other materials.
- Think about what you learned, ask yourself questions, and answer them.
- Read and become familiar with the way questions are asked on the assessment.
- Answer the practice Biology questions.
- There are additional items to practice your skills available online. Ask your teacher about online practice sites that are available for your use.

CONTENT OF THE BIOLOGY EOC ASSESSMENT

Up to this point in the guide, you have been learning how to prepare for taking the EOC assessment. Now you will learn about the topics and standards that are assessed in the Biology EOC assessment and will see some sample items.

- The first part of this section focuses on what will be tested. It also includes sample items that will let you apply what you have learned in your classes and from this guide.
- The next part contains a table that shows the standard assessed for each item, the DOK level, the correct answer (key), and a rationale/explanation of the right and wrong answers.
- You can use the sample items to familiarize yourself with the item format found on the assessment.

All example and sample items contained in this guide are the property of the Georgia Department of Education.

The Biology EOC assessment will assess the Biology standards documented at www.georgiastandards.org. The Biology items also relate to a Characteristics of Science and a Nature of Science standard. Because science consists of a way of thinking and investigating, and includes a growing body of knowledge about the natural world, you will need to understand the **Characteristics of Science** standards, the **Nature of Science** standards, and the **Content** standards for Biology. The Characteristics of Science and Nature of Science standards can also be found at www.georgiastandards.org.

The content of the assessment is organized into five groupings, or domains, of standards for the purposes of providing feedback on student performance.

- A content domain is a reporting category that *broadly* describes and defines the content of the course, as measured by the EOC assessment.
- On the actual test, the standards for Biology are grouped into five domains: Cells; Genetics; Organisms; Ecology; and Evolution.
- Each domain was created by organizing standards that share similar content characteristics.
- The content standards describe the level of understanding each student is expected to achieve. The Characteristics of Science and Nature of Science standards describe the practices used by scientists to acquire these understandings. Both sets of standards combined include the knowledge and skills assessed on the EOC assessment, and they are used to plan instruction throughout the course.

SNAPSHOT OF THE COURSE

This section of the study guide is organized into four units that review the material covered within the five domains of the Biology course. The material is presented by topic rather than by category or standard. In each unit you will find sample items similar to what you will see on the EOC assessment. The next section of the guide contains a table that shows for each item the standard assessed, the Characteristics of Science alignment, the DOK level, the correct answer (key), and a rationale/explanation about the key and distractors.

All example and sample items contained in this guide are the property of the Georgia Department of Education.

The more you understand about the topics in each unit, the greater your chances of getting a good score on the EOC assessment.

As you read through each unit, you will find that some material is repeated in two or more texts. The units are designed to show how the key ideas within the units apply in many different ways.

UNIT 1: ORGANIZATION

Life is organized at all levels from cells to biosphere.

AREAS OF FOCUS

Cells

- Cells have particular structures that underlie their functions. (SB1a)
- All cells are composed of many different molecules that are organized into specialized structures that carry out cell functions. (SB1c)
- Multi-cellular organisms are formed as highly organized arrangements of differentiated cells. (SB3b)
- Cellular processes of prokaryotic and eukaryotic cells are similar in spite of their structural differences. (SB1a)

Organisms

- Viruses are complex structures, and their evolutionary relationship is still under investigation. (SB3d)
- Organisms carry out common life processes differently. (SB3b)
- All organisms and systems are organized from simple parts into complex systems that must maintain homeostasis in order to survive. (SB3b)

Evolution

- The million different species of plants, animals, and microorganisms that live on Earth today are related by descent from common ancestors. (SB5b)
- The great diversity of organisms is the result of more than 3.5 billion years of evolution that has filled every available niche with life forms. (SB5b)
- Modern classification systems are based upon biochemical and genetic evidence that indicates evolutionary relationships. (SB3c)
- Molecular evidence supports anatomical evidence from fossils about the sequence of descent. (SB5c)

Ecology

- Patterns of ecological organization are similar to those of cells and organisms. (SB4a)

KEY IDEAS

Differentiate Between Prokaryotic and Eukaryotic

Biologists once looked for clues to aging and diseases by studying organs, tissues, and cultures of cells. With the development of the microscope, biologists focused their attention upon smaller elements of living things: the organelles within the cells. With advancements in the microscope, biologists discovered two types of cells: **prokaryotic** and **eukaryotic cells.**

PROKARYOTES:	**EUKARYOTES:**
Prokaryotes are single-celled organisms that lack internal structures surrounded by membranes. They lack a true nucleus. Examples: Bacteria Archaea	Eukaryotes are single-celled and multi-cellular organisms that have cells containing internal membrane-bound structures. They have a true nucleus containing the cell's DNA. Examples: Plants Animals Mushrooms (fungi) Amoebas (protists)

Cells Must Have Boundaries

Each cell has a **cell membrane** that serves as a boundary between the cell and its external environment. The cell membrane is flexible and allows the cell to vary its shape if necessary. It controls the movement of materials entering and exiting the cell. The cell membrane also helps maintain a chemical balance within the cell.

An additional boundary outside of the cell membrane is the **cell wall**. The cell wall is thicker than the cell membrane and is inflexible. It protects the cell and gives the cell its shape. Plants, fungi, most bacteria, and a few protists have cell walls. Animal cells ***do not*** have cell walls.

Some examples of organelles and their functions

Nucleus: contains DNA, which controls cellular function

Chloroplasts: capture solar energy for photosynthesis

Golgi bodies: modify, sort, and ship proteins and lipids

Mitochondria: ATP formation

Ribosomes: synthesis of polypeptide chains

It is very important that you refer to your textbook for a complete list of cell organelles and their specific functions.

Compare the Structures and Functions in Organisms of Different Kingdoms

The Six Kingdoms

The number of kingdoms in early classification systems varied greatly. In Aristotle's time, scientists had not yet studied geological time frames. These early classification systems were based on visible structural differences. As scientists discovered evolutionary relationships among species, the classification systems changed or were modified to fit these new discoveries. Comparisons of DNA sequences and similarities in proteins have helped to identify relationships among different organisms. From Aristotle's two divisions, plants and animals, we now have the six-kingdom system.

The six kingdoms are composed of the following:

Six Kingdoms

Eubacteria
Archaebacteria
Protists
Fungi
Plants
Animals

All prokaryotic organisms are either in the kingdom **Eubacteria** (true bacteria) or the kingdom **Archaebacteria**. The Eubacteria contain all of the bacteria that cause disease as well as the bacteria that are beneficial. The Archaebacteria are mainly found in extreme environments such as the deep oceans, hot springs, and swamps. The **Protist** kingdom contains eukaryotic organisms that are either unicellular or multi-cellular. They lack complex organ systems and live in moist environments. **Fungi** are consumers that do not move. They are unicellular or multi-cellular heterotrophic eukaryotes that absorb nutrients from decomposing dead organisms and wastes in the environment. **Plants** are photosynthetic multi-cellular eukaryotes. Most plants have cellulose cell walls and tissues that have been organized into organs and organ systems. **Animals** are multi-cellular eukaryotic consumers. Animal cells do not have cell walls. Their tissues have been organized into complex organ systems such as the nervous system, muscle system, and digestive system.

Taxonomy is the branch of biology dealing with the grouping and naming of organisms. The person who studies taxonomy is called a **taxonomist**. There is a vast array of organisms that we know of, but taxonomists are still identifying newly discovered organisms. They compare the internal and external structures, analyze the chemical makeup, and compare the evolutionary relationships of species. The numbers of species identified by taxonomists are growing at different rates among different groups of organisms. With the advancing technology of the microscope, many more microorganisms have been discovered. Scientists are also exploring tropical forest canopies and deep-ocean areas where they are discovering new species. Knowledge of relationships among species helps the taxonomist identify and group these newly discovered species.

The Modern Classification System

Have you ever been to a zoo and were overwhelmed by the number of different species of animals you saw? Or have you taken a walk in a forest and been amazed by the different plants that you see on the forest floor? What you have seen is a small fraction of what actually inhabits our planet with us. In an attempt to make sense of the diversity of life, one tool that scientists use is the classification system.

Classification is the grouping of objects based on similarities. Modern classification uses the following levels to classify organisms:

Levels of Classification

Kingdom
Phylum
Class
Order
Family
Genus
Species

All organisms are grouped into kingdoms based on genetic and anatomic similarities. At the phylum level, organisms are subdivided again based on evolutionary traits. Organisms are further divided into different classes based upon shared physical characteristics. Within each class, organisms are grouped into orders based on a more specific and limited set of characteristics. This subdividing and grouping has seven levels in the modern classification system. The most specific level is species. Members of a species are considered to be the same "kind" of animal and can reproduce with other members of their species.

Compare and Contrast Viruses with Living Organisms

Viruses are infectious particles made of a protein shell called a capsid, which contains either DNA or RNA. The genetic material is single-stranded or double-stranded, depending on the kind of virus. Some viruses have an outer membranous envelope that covers the capsid. These viral envelopes, derived from the host cell membrane, may contain both viral and host cell lipids and proteins.

Viruses are not considered living organisms because they are not cells and they cannot reproduce outside of a host cell. Viruses must infect a living cell, a host, in order to reproduce their viral genetic material and make new viral proteins. Like living organisms, viruses contain genetic material (either DNA or RNA), can reproduce, respond to their environment, and evolve. Unlike living organisms, viruses are not cells, do not contain organelles, and are unable to reproduce in the absence of a host cell. Further, viruses are able to form crystals and still be viable. Living cells are not able to survive crystallization.

Relationships among Organisms, Populations, Communities, Ecosystems, and Biomes

When you watch the news or read a newspaper, it seems that not a day goes by without a story on the environment: "El Niño," "American Songbirds Vanish," "Coral Reef Dies in the Virgin Islands." These are just a few of the headlines that you might have seen. The single thread that connects these very different environments is called **ecology**. Ecology is the scientific study of the interactions between different kinds of living things and their environment. The word *ecology* comes from the Greek word *oikos,* which means "house." Ecology is the study of our house, our planet—Earth. An **ecologist** is a scientist who studies ecology.

The term **biosphere** includes all organisms and the environments in which they live (biotic and abiotic factors). Organisms adapt to survive in particular environments. Penguins are adapted to live in cold water, and ostriches are adapted to live on dry savannas. They have adaptations for obtaining food, for protection, and for reproducing.

Within an ecosystem, two types of environmental factors can be found: biotic factors and abiotic factors. All the living organisms in an ecosystem are known as **biotic factors**, while the nonliving factors are known as **abiotic factors**. On the Biology EOC assessment, you may be asked to identify biotic and abiotic factors and describe how they interact within an ecosystem.

Some Examples of Environmental Factors

Biotic	Abiotic
Plants	Climate
Animals	Light
Bacteria	Soil
	Water

Organization of Life

Ecologists study the interactions of organisms at five main levels of organization. Yet all the levels are interdependent. To study only one level would not give the ecologist the whole picture.

Organisms: Ecologists study the daily movements, feeding, and general behavior of individual organisms.

Populations: A population includes all the organisms in the same species in a given area. Ecologists study the relationships between populations and the environment, focusing on population size, density, and rate of growth.

Communities: A community is a collection of populations that interact with each other in a given area. Ecologists study the interactions among the different populations in a community and the impact of additions to or losses of species within communities.

Ecosystems: An ecosystem includes all biotic and abiotic factors in a given area. Ecologists study interactions of the biotic and abiotic factors of an ecosystem with emphasis on factors that may disrupt an ecosystem. Earth supports a diverse range of ecosystems. The type of ecosystem in a particular part of the world largely depends on the climate of that region. Ecosystems are identified by their climax communities. **Terrestrial ecosystems** are those found on land. **Aquatic ecosystems** are in either fresh or salt water. **Saltwater ecosystems** are also called **marine** ecosystems.

Biomes: A group of ecosystems in the same region having similar types of vegetation governed by similar climatic conditions. Ecologists study biomes such as tropical rain forests, prairies, and deserts.

Within each community, particular species have particular jobs to help maintain balance. An example would be a forest community. On a forest floor, fungi have the job of breaking down the organic material from a decaying log. Underneath the log are worms, centipedes, and beetles also at work. At first glance, it looks like they are all competing for food. But a closer look reveals that they are feeding on different things, in different ways, and at different times. The role that a species plays in its community is called its **niche**. A niche includes not only what an organism eats, but also where it feeds and how it affects the energy flow in an ecosystem. The place where the organism lives is called its **habitat**. Even though several species may share a habitat, the food, shelter, and other resources of that habitat can be divided into several niches.

Biomes

Biomes are a group of ecosystems in the same region that have similar types of vegetation and that are governed by similar climatic conditions. The six terrestrial biomes are:

1. Tundra
2. Tropical rain forest
3. Desert
4. Grassland
5. Taiga
6. Temperate deciduous forest

Refer to your science textbook and class notes for the locations of these biomes.

Terrestrial Biomes

Tundra

Abiotic Factors: –40°C to 10°C; annual precipitation is less than 25 cm; windy; permafrost

Biotic Factors: vegetation—nearly treeless; mainly grasses, sedges, and lichens
animals—arctic hare, lemming, arctic fox, snowy owl

Tropical Rain Forest

Abiotic Factors: 20°C to 30°C; annual precipitation is greater than 200 cm

Biotic Factors: vegetation—broad-leafed evergreen trees, ferns, orchids
animals—monkey, tapir, flying squirrel, birds/parrots, jaguar

Desert

Abiotic Factors: from –30°C to 38°C in cool deserts to 20°C up to 49°C in hot deserts; annual precipitation is less than 25 cm

Biotic Factors: vegetation—brush, cacti, small plants
animals—camels, antelope, rabbits, many reptiles, arachnids

Grassland

Abiotic Factors: –10°C to 25°C; annual precipitation is 25 cm to 75 cm

Biotic Factors: vegetation—grasses, small plants, mosses, lichens
animals—grazing herbivores: bison, antelope, zebra, elephant, wildebeest; predators: wolves, lions, leopards

Taiga

Abiotic Factors: –30°C to 20°C; annual precipitation is 30 cm to 50 cm; soil thaws completely in summer

Biotic Factors: vegetation—coniferous trees, ferns, mosses, mushrooms
animals—snowshoe hare, timber wolf, weasel, black bear, woodpecker

Temperate Deciduous Forest

Abiotic Factors: –10°C to 25°C; annual precipitation is 75 cm to 125 cm

Biotic Factors: vegetation—sugar maple, birch, pine, oak, flowering plants, moss
animals—white-tailed deer, cottontail rabbit, squirrel, raccoon

There are also aquatic biomes, divided into freshwater and marine ecosystems. Freshwater ecosystems are the lakes, rivers, streams, and ponds. Marine ecosystems include the open ocean, the rocky intertidal zones, and the estuaries.

Aquatic Biomes

Open Ocean

Abiotic Factors: temperature range varies with latitude and water depth, sunlight decreases with water depth, water density changes with temperature and salt content, etc.

Biotic Factors: phytoplankton, fish, dolphins, whales, seals, sea birds, etc.

Rocky Intertidal

Abiotic Factors: alternating exposure to direct sunlight and submergence, salinity changes, rocky substrate, etc.

Biotic Factors: algae, sea urchins, clams, mussels, starfish, etc.

Estuaries

Abiotic Factors: large fluctuations in salinity, extreme temperature changes, etc.

Biotic Factors: algae, mosses, aquatic plants, insects, shrimp, crabs, amphibians, birds, etc.

Freshwater

Abiotic Factors: seasonal fluctuations of depth and temperature

Biotic Factors: freshwater plants, algae, insects, fish, wading birds, phytoplankton, zooplankton

Explain the History of Life in Terms of Biodiversity, Ancestry, and the Rates of Evolution

The work of Charles Darwin and Gregor Mendel laid a foundation to explain the large diversity of species found today. **Adaptive radiation** is when species diversity occurs in a relatively short time. One way it can occur is when a population colonizes a new area. A good example is the large number of finch species that Darwin observed on the different Galápagos Islands. He counted over a dozen different species of finches that he believed evolved from a single founding species.

Another mode of evolution is **convergent evolution**. This is where unrelated species may independently evolve superficial similarities because of their adaptations to similar environments. One example is the development of wings for flight in bats and insects. They both developed similar adaptations to the environment, but the wings evolved from very different original structures.

When molecular biologists developed new techniques for analyzing DNA, new understanding developed about how these different modes of evolution can occur. As more and more data were gathered, evolutionary biologists became intrigued with DNA and the information that it provided about the relationships among organisms. Data collected show that segments of DNA, and even entire sequences of the amino acids in some proteins, seem to be identical in many organisms.

The similarity between the DNA of all living organisms shows that once life began, it diversified by changing the genetic code of organisms. This resulted in the biodiversity of life on Earth today. **Biodiversity** is the variety of organisms, their genetic information, and the communities in which they live. Researchers use three different terms when talking about biodiversity:

1. **Ecosystem diversity** includes the variety of habitats, living communities, and ecological processes in the living world.
2. **Species diversity** includes the vast number of different organisms on Earth.
3. **Genetic diversity** refers to the sum total of all the different forms of genetic information carried by all living organisms on Earth. It gives rise to inheritable variation, which scientists believe provides the raw material for evolution.

Speciation is the evolution of a new species that occurs due to changes in gene flow in populations of the ancestral species. Evolution of new species due to **geographic isolation** occurs when physical barriers cause populations to divide and prevent mating of individuals. Volcanoes, sea-level changes, and earthquakes are a few examples of natural occurrences that divide populations. So over time, each smaller population will adapt to their new environment through the process of natural selection. Eventually, this causes the gene pool of each group to become different so that a new species is formed.

Fossil and Biochemical Evidence Support the Theory

The fossil record provides biologists with an incomplete picture of the evolution of plants and animals. Most fossils are the remains of the hard parts of an organism. Shells, bones, or the remains of plants with thick cell walls are most likely to leave a fossil. Very few fossils capture the details of skin or internal organs. There are also impressions left behind in sediments along rivers and lakes.

One problem with the fossil record is that there are few remains of any "intermediate" or transition forms. There are several reasons that few transition species are found. Approximately two-thirds of all the organisms that ever lived were soft-bodied; these organisms do not usually become fossilized. It also depended on where and how an organism died as to whether its remains could be fossilized. Fossils also could have been destroyed by erosion or pressure from overlaying rocks. Exposure to wind, rain, and soil erosion could prevent fossils from forming.

Fossil Age

Biologists use **radioisotope dating** to determine the relative ages of fossils within a time period. These isotopes act as clocks for measuring time. To use this method, scientists must know the following:

1. The half-life of the isotope being measured
2. How much of the isotope was originally present in the fossil or in the rock containing the fossil
3. How much of the isotope is left

Carbon-14 (^{14}C) is the primary isotope used in radioisotope dating. When an organism dies, there is no additional carbon that is added to it. Scientists measure this carbon-14 to carbon-12 (^{12}C), which is in living matter (that is, the ratio of ^{14}C to ^{12}C). This ratio will change every year as the half-life of ^{14}C decreases over time. The half-life of ^{14}C is 5,770 years. That means that it takes 5,770 years for half of the carbon to become stable, while the other half is still radioactive. One problem in this is that the half-life of carbon is relatively short compared to how old some scientists believe Earth really is. So after about 50,000 years, the traceable amounts of carbon are gone. Scientists often use other isotopes such as uranium-235, which will decay into the daughter element, lead-207, in approximately 713 million years.

Biologists use a number of ways to determine the age of fossils. They recognize distinct groups of fossils in specific rock layers. By matching rock layers with fossils, geologists can determine the age of the rocks, while paleontologists can determine the age of the fossils. This is called **relative dating**.

By using the ages of fossils, interrelationships among organisms can be determined. Organizing similar fossils by age shows how species become more complex over time. An example of advancing complexity is horse evolution. A phylogeny is a description of the lines of descent of plants and animals. A phylogenetic tree shows the interrelationship of several species. Fossil collections are often not complete enough to determine any evolutionary patterns or traits. In many cases, a biologist will infer likely phylogenies by comparing morphological features, DNA sequences, and chromosomal characteristics.

SAMPLE ITEMS

Item 1

Selected-Response

About one in one million people are born with dyskeratosis congenita. This disease affects many areas of the body. It causes fingernails and toenails to grow abnormally and discoloration of the skin. Dyskeratosis congenita is caused by a mutation in a gene responsible for the production of ribosomes; therefore, ribosome functioning is impaired.

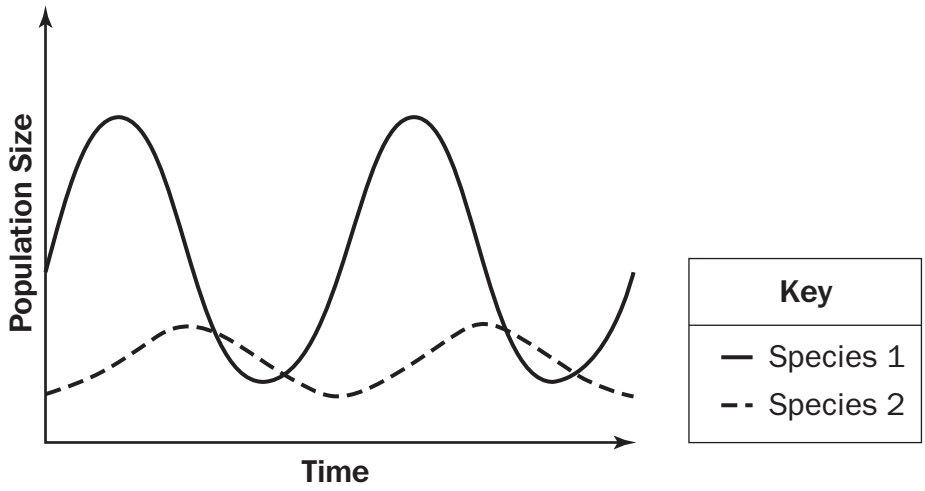
Which cell process would be most directly affected by this disease?

A. the production of energy
B. the production of proteins
C. the removal of substances
D. the breakdown of chemicals

Item 2

Selected-Response

The graph shows the changes in population size of two species that live in the same habitat.



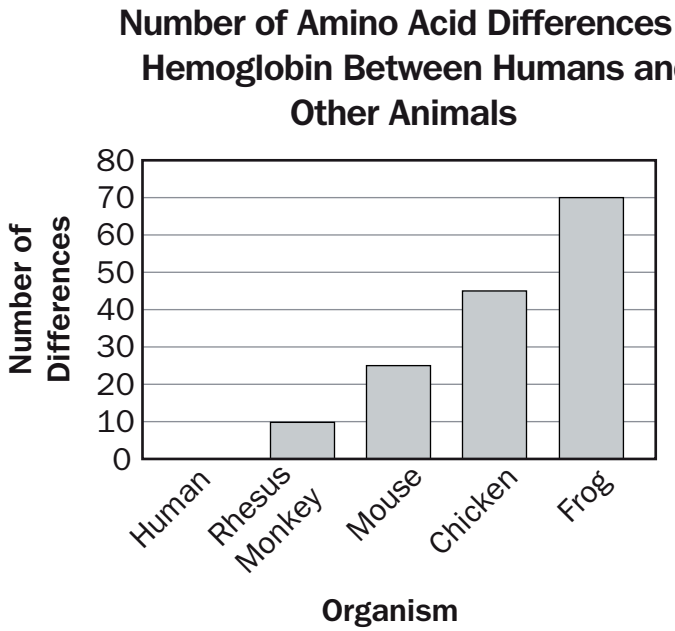
Which conclusion can be made regarding the species?

A. Species 1 is a predator of Species 2.
B. Species 2 is a predator of Species 1.
C. Species 1 and 2 have a mutualistic relationship.
D. Species 1 and 2 have a commensalistic relationship.

Item 3

Selected-Response

The graph shows the number of differences in the amino acids of a particular hemoglobin polypeptide in different organisms.



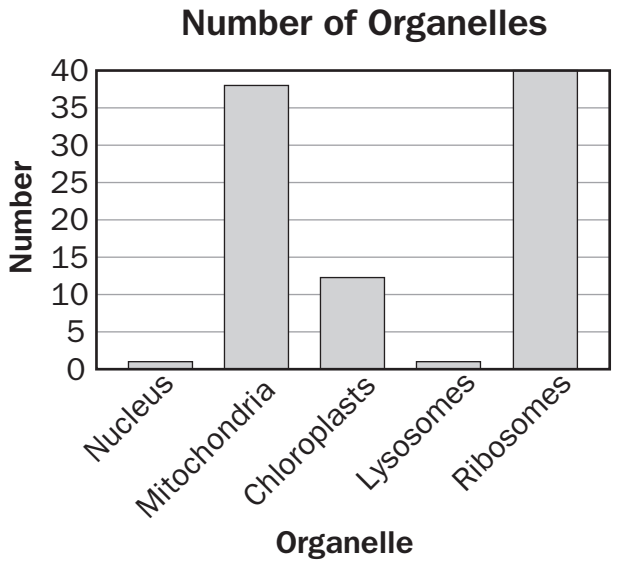
What inference can be made from the data in the graph?

A. Rhesus monkeys and mice do not share a common ancestor.
B. Hemoglobin is more important to frogs than to other organisms.
C. Humans and rhesus monkeys are more similar than chickens and frogs.
D. Amino acids are the building blocks of hemoglobin in all organisms except humans.

Item 4

Selected-Response

An organism is multicellular and can be seen without a microscope. The bar graph shows the numbers of some of the organelles in one of the cells from the organism.



From which kingdom is this organism?

A. Animalia
B. Archaebacteria
C. Fungi
D. Plantae

ACTIVITY

Levels of Organization Flipbook

Standard: SB4a

Duration: 1 week

Materials:

- Paper
- Lab/field notebooks
- Colored pencils
- Other materials that students want to use and provide

Procedure:

1. Work with a family member or friend.
2. Create pages in a flipbook for each level of organization from the cell to the biosphere. (An example for making a flipbook can be found at http://www.ehow.com/how_12022164_make-layered-flip-book.html.)
3. For each level of organization, include the definition, a picture, and an example of cells, tissues, organs, organ systems, organisms, population, community, ecosystem, and biosphere.
4. Present your flipbook to a family member or friend.

Discuss the following with a family member or a friend:

Explain how the complexity changes from cells to the biosphere.

Explain how a change in one level of organization affects the other levels.

UNIT 2: ENERGY TRANSFORMATIONS

Energy can be neither created nor destroyed but can be transformed from one form to another as it flows through organisms and ecosystems.

AREAS OF FOCUS

Cells

- Most cell functions involve chemical reactions that utilize enzymes that either break down or synthesize compounds. (SB1b, SB1c)
- Chemical bonds of food molecules contain energy that is released in the process of cellular respiration; the products are used to synthesize needed molecules. (SB1b, SB1c, SB3a)
- Photosynthetic organisms use sunlight to combine inorganic molecules to form energy-storing organic molecules and release oxygen that is vital to most living things. (SB3a)

Evolution

- The interrelationships and interdependencies of organisms may generate ecosystems that are stable for hundreds or thousands of years. (SB5b)

Organisms

- Organisms both cooperate and compete in ecosystems. (SB4a)
- Living organisms have the capacity to produce populations of infinite size but are limited as environments and resources are limited. (SB5d)

Ecology

- The process of photosynthesis provides the vital connection between the sun and the energy needs of living systems. (SB3a)
- Energy flows through ecosystems in one direction from photosynthetic organisms to herbivores to carnivores and decomposers. (SB4b)
- Carbon and oxygen cycle through the processes of photosynthesis and respiration. (SB3a, SB4b)
- The atoms and molecules on Earth cycle among the living and nonliving components of the biosphere. (SB4b)
- The distribution and abundance of organisms in populations and ecosystems are limited by the availability of matter and energy and the ability of the ecosystem to recycle materials. (SB4a, SB4b)

KEY IDEAS

Understand the Characteristics of Enzymes

All cells maintain, increase, and decrease the concentration of substances inside them by developing metabolic pathways. A metabolic pathway is an orderly sequence of reactions with specific **enzymes** that act at each step along the way.

Enzymes are catalytic molecules. That is, they speed up specific reactions without being used up in the reaction. Enzymes are proteins.

All enzymes have three special features in common:

1. Enzymes do not create processes that would not take place on their own. They just make the processes take place faster!
2. Enzymes are not permanently altered or used up in reactions.
3. Each enzyme catalyzes only one specific type of reaction but can catalyze many of this particular reaction one after another.

Substrates are molecules that a specific enzyme can chemically recognize and to which it can bind. Substrates undergo chemical changes to form new substances called **products**.

Each substrate fits into an area of the enzyme called the *active site*. It is like a **lock-and-key mechanism**. Once the enzyme-substrate complex is together, the enzyme holds the substrate in a position where the reaction can occur. Once the reaction is complete, the enzyme *unlocks* the product and the enzyme is free to facilitate another reaction. **The rate of a reaction depends in part on the concentration of the enzyme.** If the enzyme is diluted, its concentration is lowered, which slows the reaction rate.

Once substrates have reached the transition state, they react spontaneously. Substrate molecules must collide with a minimum amount of energy to reach the transition state. This amount of energy is called the **activation energy**. It is like traveling over a hill. The lower the hill, the less energy it takes to get to the top and the faster you can go over it. The higher the hill, the more energy it takes to get to the top and the longer it will take you to go over it.

It takes less energy to boost reactants to the transition state of a lower-energy hill. The reaction will proceed more rapidly.

Enzymes are critical to life processes. Carbonic anhydrase is an enzyme that speeds up the process by which carbon dioxide leaves cells and enters the bloodstream so it can be removed from the body. The enzyme lipase is produced by the pancreas and functions in the digestion of lipids. RNA polymerase is an enzyme that facilitates the process of transcription. Some diseases, such as Tay-Sachs and phenylketonuria, occur when the body fails to make a critical enzyme. The human genetic disease Tay-Sachs can cause seizures, blindness, and eventual death because a critical enzyme that breaks down lipids in brain cells does not function properly. In another human genetic disease, PKU (or phenylketonuria), an enzyme is either lacking or totally deficient that is needed to break down one amino acid (phenylalanine) to form a second essential amino acid (tyrosine). Without this enzyme, phenylalanine and other chemicals accumulate in the blood and body tissues and cause eventual death.

For the Biology EOC assessment, it is important to understand how enzymes work and the pathways that they follow. Refer to your textbook and study the different biological pathways that enzymes follow. Study the activation sites, the activation energies, and the effects of temperature and pH on enzyme activity.

Understand the Characteristics of the Four Major Macromolecules

Carbohydrates, lipids, proteins, and nucleic acids are the foundations for the structure and function of every living cell in every organism. They are the building materials of the body and the storehouse for energy for every activity.

Carbohydrates

A carbohydrate is a simple sugar or a molecule composed of two or more simple sugars. In general, the ratio of carbon, hydrogen, and oxygen atoms is 1:2:1 in a carbohydrate molecule. There are three classes of carbohydrates: *monosaccharides*, *oligosaccharides*, and *polysaccharides*. Glucose, sucrose, starch, and cellulose are examples of carbohydrates. In all living organisms, carbohydrates are broken down to provide usable chemical energy for cells. In plants, the carbohydrate cellulose is used for structural support in making cell walls.

Saccharide means "sugar." ***Mono*** means "one." Put the two together and you have one sugar unit. ***Oligo*** means "few." An oligosaccharide is a short chain of two or more covalently bonded sugar units. ***Poly*** means "many." A polysaccharide is a straight or branched chain of sugar units in which there may be hundreds or thousands of the same or different kinds of sugars bonded to one another.

Lipids

Lipids are organic compounds that have more carbon-hydrogen (C-H) bonds and fewer oxygen atoms than carbohydrates. They are extremely important for the proper functioning of organisms. Lipids are commonly called *fats* and *oils*. They are insoluble in water due to the nonpolarity of the molecules. Lipids are used by cells for long-term energy storage. Lipids are also a major component of cell membranes. *Waxes* are long-chain fatty acids attached to an alcohol. An example is *cutin* in plants. It helps the plants retain water.

Proteins

Proteins belong to the most diverse group. They are large, complex polymers essential to all life. They are composed of chains of amino acids made of carbon, hydrogen, oxygen, nitrogen, and sometimes sulfur. Proteins are important in muscle contraction, transporting oxygen in the blood, and the immune system. Proteins, like lipids, are an important component of cell membranes. Collagen, enzymes, hemoglobin, insulin, and antibodies are examples of proteins.

Nucleic Acids

Nucleic acids are complex macromolecules that store and transmit genetic information in cells in the form of a code. To form nucleic acids, four different kinds of *nucleotides* are strung together. A nucleotide is a small organic compound that consists of a five-carbon sugar, a nitrogen-containing base, and a phosphate group. Nucleotides are the structural units of *adenosine phosphates*, *nucleotide coenzymes*, and *nucleic acids*. Examples of nucleic acids include ATP, NAD^+, $NADP^+$, DNA, and RNA.

Explain the Flow of Energy Needed By All Organisms to Carry Out Life Processes

Energy in a Cell

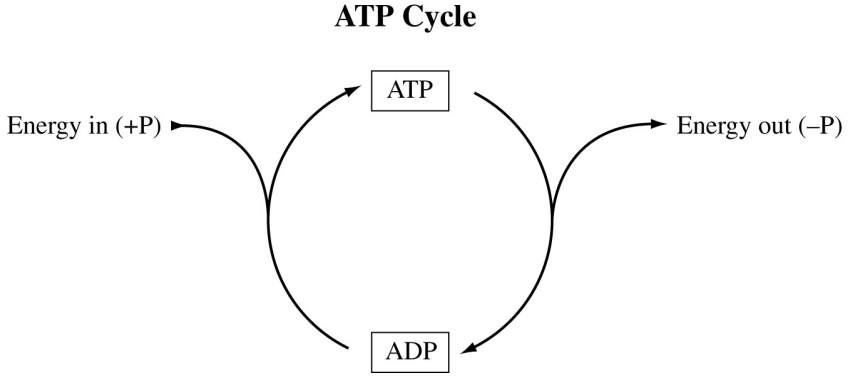
All life on Earth depends on the flow of energy. The primary source of this energy is the Sun. Plants and other photosynthetic organisms (for example, cyanobacteria, or blue-green algae) are the entry point for this flow of energy. The process of photosynthesis supports almost all life on Earth directly or indirectly. Photosynthesis is the process that converts solar energy to chemical energy in the form of carbohydrates. Carbohydrates are then broken down by the metabolism of the cells of these photosynthetic organisms or by the cells of other organisms, such as animals, fungi, or microbes that consume plant materials. In all cells, the processes of life are constantly moving and rearranging atoms, ions, and molecules. All this biological work requires energy.

Understanding ATP

ATP, **adenosine triphosphate**, is a special molecule that stores and releases the energy in its bonds in response to the energy needs of the cell. Cells work constantly to maintain a vast supply of this energy storage molecule. The stored energy is released when ATP is split into ADP, **adenosine diphosphate**, and an inorganic phosphate. Remember that ATP and ADP are nucleotides. When the appropriate enzyme is present, the terminal phosphate group of an ATP molecule can be transferred to a variety of other compounds. This process is known as **phosphorylation**.

The energy released when ATP is split is stored in other energy-intermediate molecules and is used to power other biological processes. Most of these processes are energy-requiring biological reactions in cells.

Consider the following cycle:



By removing a phosphate group, energy is released for chemical reactions to occur in the cell, and ATP becomes ADP. When the cell has an excess of energy, the energy is stored in the bond when the phosphate group is added to the ADP.

ATP is the major energy link between energy-using and energy-releasing reactions. The amount of energy released when the phosphate group bond breaks is suitable for use in most cellular reactions.

The Biology EOC assessment will assess your knowledge and understanding of the ATP-ADP cycle and the importance of energy to all life.

Examples of Ways That Cells Use Energy

Cells use energy to make new molecules, including enzymes, and to build cell organelles and membranes. Cells also use energy to maintain homeostasis. Some cells, such as muscle cells, use energy from ATP in order to move. Nerve cells are able to transmit impulses by using ATP to power the active transport of certain ions. Lightning bugs, certain caterpillars, and some deep-sea organisms produce light by a process known as **bioluminescence**. The light that is produced is a result of a chemical reaction that is powered by the breakdown of ATP.

Many of the carbon atoms and oxygen molecules that you breathe once cycled through the tissues of a plant. Plants, algae, and other photosynthetic organisms are important to the maintenance and balance of life on Earth. They convert solar energy to chemical energy in the form of carbohydrates. Photosynthetic organisms must also break down carbohydrates to form ATP. These carbohydrates are usually in the form of simple sugars, mainly glucose. The process of breaking down carbohydrates for ATP is called **cellular respiration**.

Trapping Energy—Photosynthesis

Autotrophs are organisms that can manufacture their own energy-providing food molecules. Most autotrophic organisms trap energy from the Sun and use this energy to build carbohydrates in a process known as **photosynthesis**. This trapped energy is used to convert the inorganic raw materials CO_2 and H_2O to carbohydrates and O_2. The key to this process is the pigment **chlorophyll**, which is the molecule in the chloroplasts of plants that absorbs energy from sunlight.

The general equation for photosynthesis is as follows:

$$\mathbf{6CO_2 + 6H_2O + \text{energy from sunlight} \rightarrow C_6H_{12}O_6 + 6O_2}$$

Two Main Reactions of Photosynthesis

1. Light reactions: These reactions split water molecules, providing hydrogen and an energy source for the Calvin cycle. Oxygen is given off.
2. Calvin cycle: This cycle is the series of reactions that form simple sugars using carbon dioxide and hydrogen from water.

The light reaction is the *photo* part of photosynthesis.
The Calvin cycle is the *synthesis* part of photosynthesis.

Using Energy—Cellular Respiration

The general equation for cellular respiration is as follows:

$$\mathbf{C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{energy}}$$

Once light energy is used to make carbohydrates, any organism can then use the carbohydrates for energy for life processes. Organisms get energy from carbohydrates through the process of cellular respiration to make ATP.

Three Main Reactions of Cellular Respiration

1. Glycolysis: The series of reactions takes place in the cell's cytoplasm and is anaerobic (without oxygen). The glucose that entered the cell by active transport is broken down by enzymes into pyruvic acid. Two molecules of ATP are also produced.
2. Krebs Cycle: This cycle breaks down the products of glycolysis to produce molecules used in the electron transport chain.
3. Electron Transport Chain: This chain consists of a series of proteins in the mitochondrial membranes that convert ADP to ATP by transferring electrons.

The Biology EOC assessment will assess your knowledge and understanding of the process of photosynthesis, the ATP-ADP cycle, the process of cellular respiration, and the importance of energy to all life.

Investigate the Relationships among Organisms, Populations, Communities, Ecosystems, and Biomes

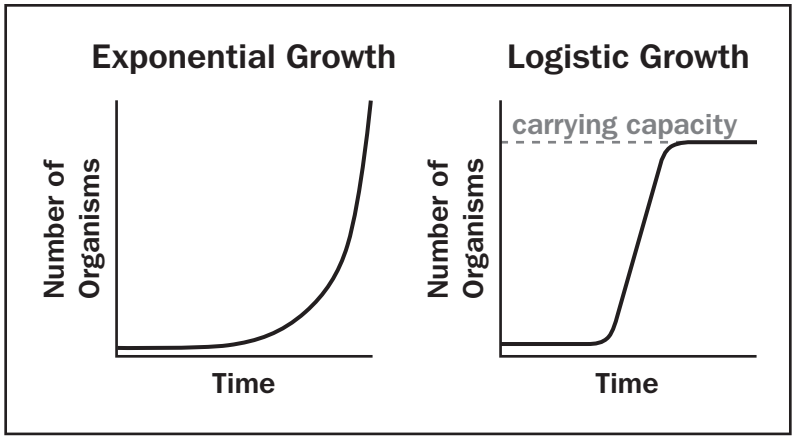
Populations

A **population** is a group of organisms of one species that lives in the same place at the same time. Organisms in a population compete for food, water, mates, and other resources. The way that organisms in a population share the resources of their environment will determine how far apart the members of the population will live and how large that population will be. **Population density** is the number of organisms living in a given area. Some organisms, such as tigers, require much space, while others, such as pine trees, can live close together. Keep in mind that some species have adaptations that minimize the competition within a population. An example is the frog. The first stage of a frog's life is a tadpole. Tadpoles are completely different from adult frogs. Their food source is different. They have gills and live in the water. Many insects have juvenile stages that require very different resources from their adult counterparts. This minimizes competition within a population.

Communities

A population usually does not live independently of other species. Each population is connected. A **community** is made up of several populations interacting with each other. This is where balance becomes very important. If there is a change in one population, it can dramatically affect the others living within the community. An increase in one population can cause a decrease in another, sometimes with devastating effects. This change in population size is known as **growth rate**. A growth rate can be positive, negative, or zero. If a population is provided with ideal conditions, it will increase in number. Healthy organisms reproduce at a rate greater than their death rate. As long as these ideal conditions continue, as the population grows larger the rate of growth increases. This growth is called **exponential growth**. This pattern of exponential growth is in the shape of a J curve. But growth has limits. If bacteria were allowed to continually reproduce, the planet would be overrun with bacteria! However, as the population increases, the resources that are available become limited and the growth of the population slows and begins to stabilize. This pattern of **logistic growth** is an S-shaped curve. The point at which the population becomes stable is known as

the **carrying capacity**. It is the maximum stable population size an environment can support over time. On the Biology EOC assessment, you may be given a chart or graph and may be asked to identify growth rates.



Remember, when working with graphs, carefully read the title and the label on each axis.

When a population reaches its carrying capacity, a number of factors help stabilize it at that size. They are called density-dependent and density-independent limiting factors.

Density-Dependent Limiting Factors
Competition
Predation
Parasitism
Crowding/Stress

Density-Independent Limiting Factors
Weather
Fires
Droughts/Floods
Human Activities

The Flow of Matter and Energy through Ecosystems

Energy Flow

Energy is constantly flowing through ecosystems. The primary source of this energy is the Sun. Plants and some bacteria are **producers**. Producers harness the Sun's energy to make energy-rich molecules that they and all other organisms can use to make living tissues. The process of photosynthesis uses the Sun's energy to convert carbon dioxide and water into glucose and oxygen. Glucose is the molecule that provides all organisms with a source of energy. Producers are also called **autotrophs**, meaning "self-feeding," because they do not need other organisms to provide them with energy-rich molecules.

Because animals cannot harness energy from the Sun, they need to eat other organisms to obtain energy and matter. Animals are **consumers**. They are also known as **heterotrophs**, meaning they need to feed on other organisms. Animals store energy in their bodies in the forms of complex carbohydrates, fats, and proteins. **Decomposers** are organisms that feed on dead bodies of animals and plants or on their waste products. Organisms are grouped into **trophic levels** based on their source of energy—organisms with the same energy sources are on the same trophic level.

Consumer	Energy Source	Example
Herbivores	Eat plants	Deer
Carnivores	Eat other animals	Lions
Omnivores	Eat both plants and animals	Raccoons
Decomposers	Break down dead organisms	Bacteria

Because energy cannot be recycled, there must be a way for it to move through an ecosystem. As sunlight hits Earth, the energy flows first to primary producers, then to consumers, and finally to decomposers. This is called a **food chain**.

A food chain shows how energy and matter flow through an ecosystem.

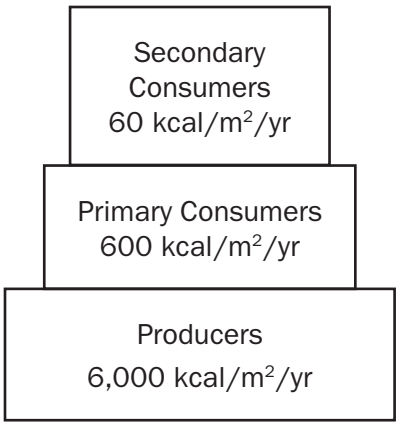
A Food Chain

Sun → grass → mice → hawk

On the Biology EOC assessment, you may be given a diagram of a food chain or web and may be asked to describe the roles of different organisms.

A food chain is a simplified way for ecologists to study how energy and matter flow. But it is not always that simple. Relationships exist between organisms that feed on more than one species. In an actual ecosystem, there are many more plants and animals involved. A more complex interconnected system of food chains is called a **food web**.

Ecologists use energy pyramids to show how energy decreases at each succeeding trophic level. The total energy transferred from one trophic level to the next is only about 10%. Not all the food consumed at each level is actually used for growth. Every time one organism eats another, most of the energy is used for energy by the organism or lost as heat rather than being stored as living tissue. Ecologists construct energy pyramids based on the available energy at each trophic level. This explains why population sizes decrease through the trophic levels.



Recycling of Matter

Unlike energy, which flows in one direction through an ecosystem, matter is recycled. Matter (or elements) cycles from one organism to another through food webs. Matter cannot be replenished in an ecosystem, unlike the energy from the Sun. For example, carbon is found in the environment as carbon dioxide (CO_2) gas. From the atmosphere, carbon dioxide is used during photosynthesis to form sugar. Respiration and decay are two ways that carbon returns to the atmosphere as a gas. Carbon also returns to the atmosphere when fossil fuels are burned.

As a second example, nitrogen gas makes up 78% of Earth's atmosphere, but it is in an unusable form. Lightning and some bacteria convert atmospheric nitrogen into usable nitrogen-containing compounds. Plants use these nitrogen compounds to make proteins and nucleic acids. Herbivores eat the plants and convert plant proteins into animal proteins and nucleic acids. Organisms return nitrogen to the atmosphere through decay.

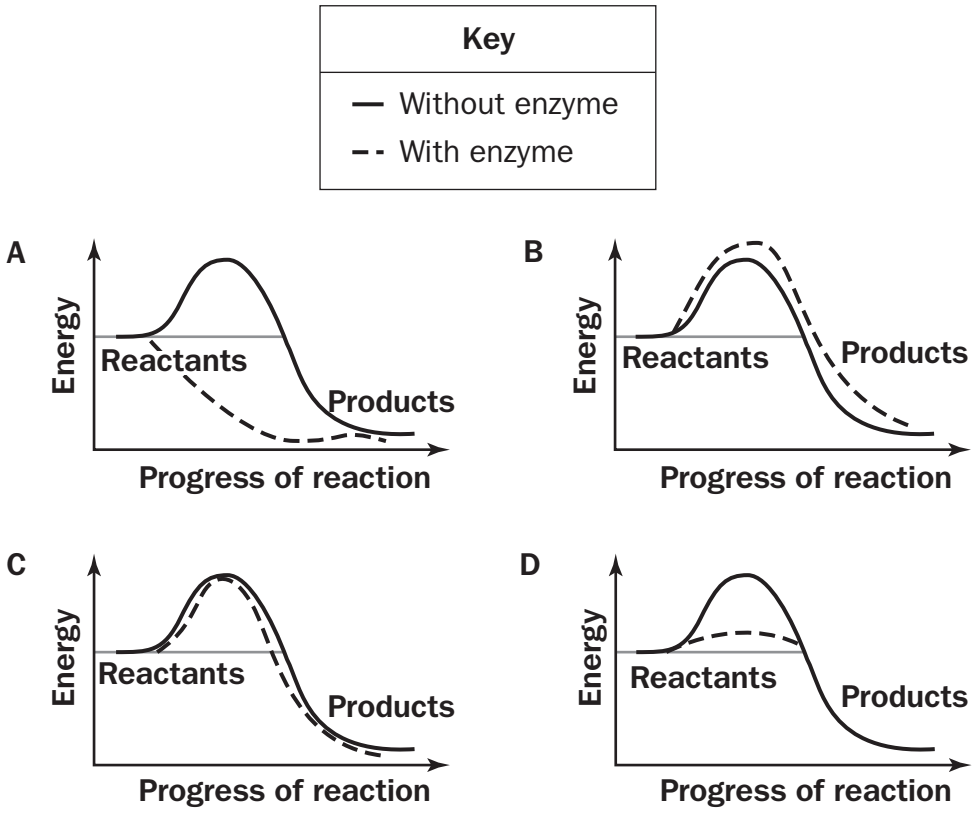
Refer to your textbook for diagrams and additional information about the cycles of the elements carbon, oxygen, hydrogen, nitrogen, and phosphorous. On the Biology EOC assessment, you may be asked to describe the interactions of biotic and abiotic factors in these various cycles.

SAMPLE ITEMS

Item 5

Selected-Response

Which graph shows the most effective enzyme reduction of the amount of required activation energy?



Item 6

Selected-Response

Scientists conducted an experiment to determine how different wavelengths of light affected photosynthesis. They used two groups of the same plants. The leaves of Group 1 were covered with transparent green plastic. The leaves of Group 2 were not covered with any plastic.

The results show that the plants photosynthesized best when their leaves were not covered in any plastic.

Which hypothesis do the results support?

A. If leaves are uncovered, then their chloroplasts will produce more oxygen than the leaves that are covered in green plastic.
B. If leaves are covered in green plastic, then their mitochondria will absorb more carbon dioxide than the mitochondria of uncovered leaves.
C. If leaves are uncovered, then their chloroplasts will release more carbon dioxide than the chloroplasts of leaves covered in green plastic.
D. If leaves are covered in green plastic, then their mitochondria will produce more oxygen than the leaves that are uncovered.

Item 7

Selected-Response

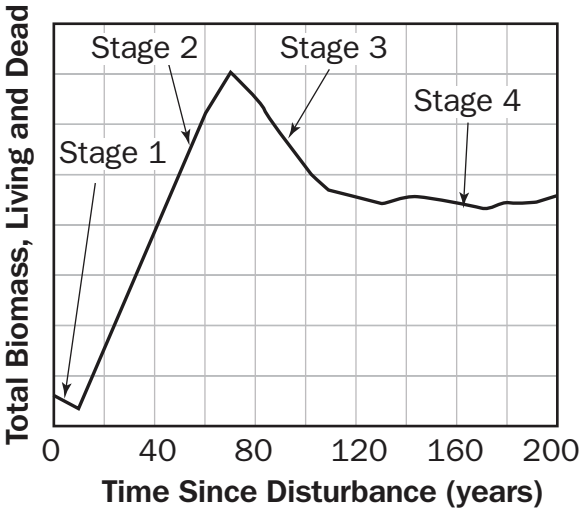
Energy is transferred between trophic levels in a food pyramid. If 150,000 joules of sunlight are captured by plants, how much energy is transferred to secondary consumers?

A. 150 joules
B. 1,500 joules
C. 15,000 joules
D. 150,000 joules

Item 8

Selected-Response

Over many years, scientists study a community in an area after a volcanic eruption and create a graph like the one shown.



Which conclusion can be made regarding the cause of Stage 4?

A. Stage 4 occurred because this period is necessary for populations to increase.
B. Stage 4 occurred because energy input and output within populations remained balanced.
C. Stage 4 occurred because populations in the community have plenty of resources to grow.
D. Stage 4 occurred because populations have reached a climax in which not enough resources exist to sustain growth.

ACTIVITY

The Effect of Environmental Factors on Plant Photosynthesis

Standard: SB3a

Note: If leafy plants are not available outdoors, this activity can be done indoors with two or three different plants.

Duration: 2 weeks

Materials:

- 1–2 plants in small plastic containers
- Lab/field notebooks
- Colored pencils
- Plastic bags for covering leaves
- Rubber bands or twist ties
- Opaque paper, or foil, for blocking sunlight on leaves

Procedure:

1. Obtain 2 plants of the same type and size. All plants will be kept under similar conditions, with the exception of the experimental variances.
2. Place plastic bags over one leaf of the first plant. Seal the bags around the leaves with twist ties to ensure that there is a tight seal.
3. On one leaf of the second plant, place a piece of opaque paper or foil. Then cover each leaf with a plastic bag and seal with twist ties to ensure a tight seal.
4. Record observations over a 2-week period.

Discuss the following with a family member or a friend:

What structures and processes of the plant were affected by this activity?

What flow of energy and matter did you affect in this activity?

What evidence was generated as proof that the flow of energy and matter was affected?

What long-term effects would such changes have on the plants?

UNIT 3: GROWTH AND HEREDITY

Organisms must be able to grow and reproduce to ensure species survival.

AREAS OF FOCUS

Cells

- The instructions for specifying the characteristics of an organism are carried in DNA, a large polymer formed from the combination of four subunits (adenine, guanine, cytosine, and thymine), located in the cell(s) of that organism. (SB1a, SB2a,b)
- Using the DNA code, cells manufacture needed proteins that determine an organism's phenotype. (SB1a, SB2a,b)
- Cells in sexually reproducing organisms contain two copies of each chromosome; therefore, two copies of each gene explain many features of heredity such as how variations that are hidden in one generation can be expressed in the next. (SB1a, SB2b,c)
- Sexual reproduction leads to diversity and asexual reproduction does not. (SB2e)

Genetics

- Hereditary information, coded by DNA, is passed down from generation to generation in a predictable way. (SB2c)
- The development and use of technologies may cause social, moral, ethical, and legal issues. (SB2f)

Evolution

- Changes in DNA occur spontaneously at low rates; some of these changes make no difference to the organism, whereas others can change cells and organisms. (SB2d)
- Sexual and asexual reproduction have different advantages in different environments. (SB2e)
- Only mutations in germ cells can contribute to the variations that change an organism's offspring. (SB2d, SB5e)
- Favorable variations among individuals that increase the chance of survival tend to be passed on to successive generations. (SB5d)

Ecology

- The reproductive patterns of organisms are affected by environmental conditions. (SB2e, SB4d)
- Predictable changes occur after a disturbance to an ecosystem. (SB4c)

KEY IDEAS

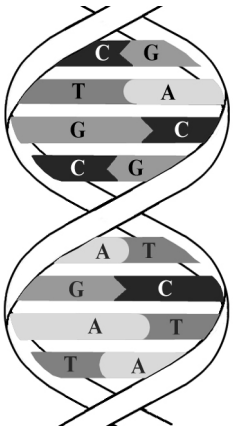
Explain the Role of Genetic Information in Storing and Transmitting Cellular Information

When you visit a library, you will find a host of information readily available to you on many subjects. A library can be considered a storehouse of information. Our bodies contain millions of cells that are considered storehouses as well. Just as each book in a library contains information, cells also contain information that is used to carry out cell functions. An acorn from an oak tree will grow into another oak tree, not into a maple tree or a pine tree. For thousands of years, people have wondered how sons and daughters have characteristics similar to their parents. How does this happen? Where does it all take place? The phrase "like begets like" becomes very clear when we study genetics.

Genetics is the branch of biology that studies heredity, the passing on of characteristics from parents to offspring. These characteristics are called **traits**.

DNA

DNA forms a complex biological polymer called a **nucleic acid** that is used for information storage. Nucleic acids are made up of smaller subunits called **nucleotides**. The components of a DNA nucleotide are deoxyribose, a phosphate group, and a nitrogen base. DNA has four nitrogen bases—adenine (A), guanine (G), cytosine (C), and thymine (T).



In DNA, nucleotides combine to form two long chains similar to a ladder that has twisted into a spiral. Another name for this spiral is the **double helix**, or double-stranded DNA. The two strands of nucleotides are held together by hydrogen bonds between the nitrogen-containing bases. The sides of the ladder consist of phosphate groups alternating with five-carbon sugars. In DNA, deoxyribose is the five-carbon sugar. The hydrogen bonding in DNA allows for only certain base pairings. In DNA, adenine bonds with thymine (A-T) and guanine bonds with cytosine (G-C). DNA carries information in a triplet code; each sequence of three nucleotides codes either for a particular amino acid or indicates the beginning or end of a sequence. The genetic code is unique for each organism.

How can organisms be so different if their genetic material is made of the same molecules? A squirrel is different from a tree because the order of nucleotides in their DNA—their genetic code—is different.

DNA has the unique ability to make an exact copy of itself in a process called **replication**. During DNA replication, an enzyme breaks the hydrogen bonds between nitrogen bases that hold the two DNA strands together. This enzyme "unzips" the two DNA molecules, allowing free nucleotides to bond to the two single strands by base pairing. This process will continue until the entire molecule has been replicated. Each new strand formed is a complement of one of the original, or parent, strands. At the end of replication, there are two copies of the genetic information that will be passed on to new cells through mitosis or to new generations through meiosis.

In eukaryotic cells, DNA is found inside the nucleus, coiled into chromosomes. Prokaryotes lack nuclei and their DNA is either attached to the cell membrane or is free-floating in the cytoplasm. A small amount of DNA is also found in mitochondria and chloroplasts.

RNA

RNA, like DNA, is made of nucleotides. The sugar in RNA is **ribose**, and the nitrogen-containing base **uracil** replaces the thymine found in DNA. The uracil in RNA pairs with adenine during complimentary base pairing. RNA is a single strand of nucleotides. In the process of transcription, RNA transfers the genetic information from DNA to the ribosomes in the cytoplasm. At the ribosomes, the process of translation uses the genetic code on the RNA to form proteins from amino acids.

Transcription is similar to the DNA process of replication, but only one strand of nucleotides is formed. DNA is used as a template to make messenger RNA (mRNA). The mRNA carries the genetic information from DNA to ribosomes in the cytoplasm.

Translation is the process of converting the information in the mRNA into a sequence of amino acids that make proteins. Transfer RNA (tRNA) brings the amino acids to the mRNA at the ribosomes so protein synthesis can take place. To have the correct translation of the code, mRNA **codons** must join with the correct **anticodon** of the tRNA. A codon is a group of three nitrogenous bases on an mRNA molecule that carries the code for a specific amino acid. An anticodon is a set of three nitrogenous bases on a tRNA molecule that matches a codon on an mRNA molecule.

Review your textbook for additional information and diagrams to help you understand these processes.

In summary, messenger RNA (mRNA) carries the message of the genetic code from the DNA in the nucleus to the ribosomes in the cytoplasm. At the ribosomes, the mRNA sequence is translated into a protein in a process known as translation. Transfer RNA (tRNA) transfers the amino acids in the cytoplasm to the ribosomes. The amino acids are lined up in the coded sequence to form a specific protein.

Using Mendel's Laws, Explain the Role of Meiosis in Reproductive Variability

Gregor Mendel, an Austrian monk, was the first to succeed in predicting how traits are carried from one generation to the next. He used pea plants in his experiments because they reproduce sexually. He was very careful to study one trait at a time to control the variables. He would manipulate flower parts in order to fertilize the female gamete with the male gamete in the desired parent plants. Mendel discovered that when he crossed tall plants with short plants, the first generation of offspring (F_1) were all tall. When he let the F_1 plants self-pollinate, Mendel found that three-fourths of their offspring (F_2) were tall and one-fourth of the F_2 plants were short. The short trait had reappeared in the second generation (F_2). Mendel came to the conclusion that each organism has two factors for each of its traits. Mendel called the trait that appeared in the first generation **dominant** and the trait that seemed to disappear **recessive**. Today, scientists call these factors **genes**. Genes are located on the chromosomes and can exist in alternative forms called **alleles**. Alleles are found on different copies

of chromosomes, one from the female and the other from the male. The **genotype** is a list of the alleles for a particular trait in an organism. The **phenotype** is the physical appearance of an organism, or how the alleles influence the function of that particular gene in the organism.

If the two alleles in a pair are identical, then the trait is called **homozygous**. If the two alleles are different, then the trait is called **heterozygous**. Genetic crosses that involve one trait are called **monohybrid** crosses, while **dihybrid** crosses involve two traits. Outcomes of genetic crosses can be predicted by using the laws of probability. Using a Punnett square will give the possible results of genetic crosses.

Consider the following genetic cross and its corresponding Punnett square:

In rabbits, black fur (B) is dominant over brown fur (b). If one parent rabbit is heterozygous (Bb) and the other parent rabbit is homozygous brown (bb), what is the probability of producing an offspring with brown fur? Use the Punnett square to determine your answer.

For this cross, the Punnett square would look like this:

	B	b
b	Bb	bb
b	Bb	bb

From the Punnett square, you can determine that half (50%) of the offspring would be black (Bb), while the other half (50%) would be brown (bb). Therefore, the probability of producing an offspring with brown fur is 50%, or 2 out of 4.

Mendel's work can be summarized in three laws:

- The **Law of Dominance** states that the dominant allele will prevent the recessive allele from being expressed. The recessive allele will appear when it is paired with another recessive allele in the offspring.
- The **Law of Segregation** (separation) states that gene pairs separate when gametes are formed, so each gamete (sex cell) has only one allele of each pair.
- The **Law of Independent Assortment** states that different pairs of genes separate independently of each other when gametes are formed.

Genetic Terms

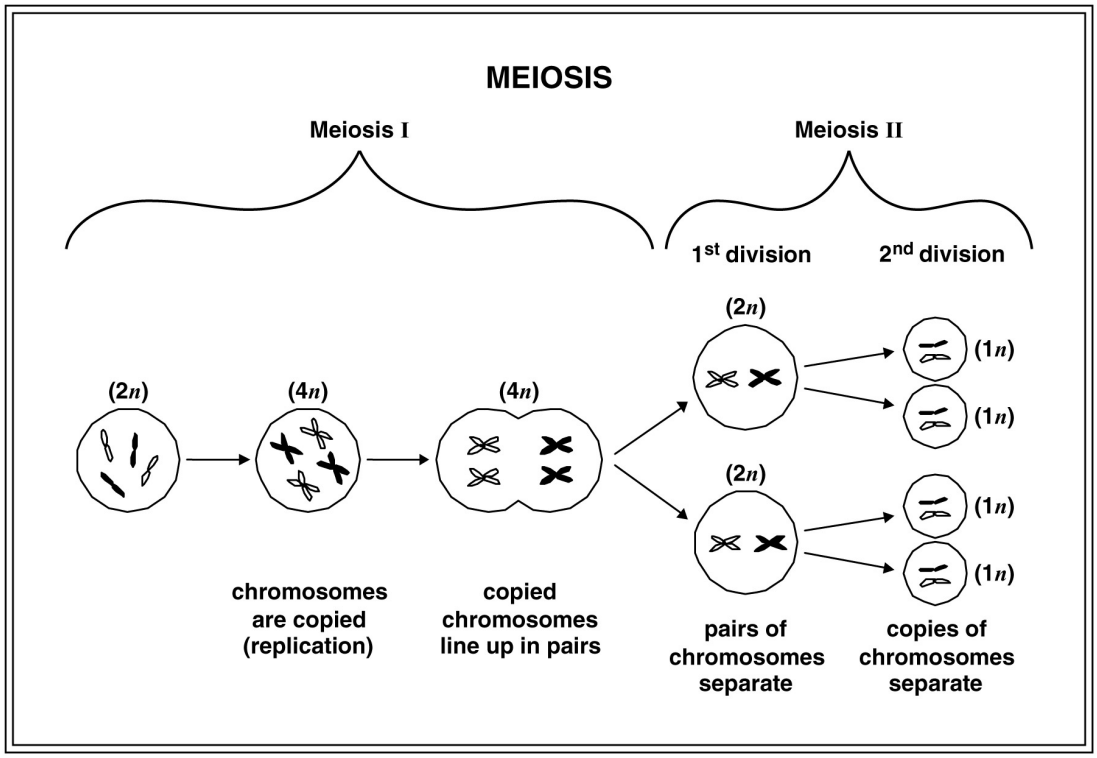
- Allele
- Dihybrid
- Dominant
- Gene
- Genotype
- Heterozygous
- Homozygous
- Monohybrid
- Phenotype
- Recessive
- Trait

Review the terms in the box and study their definitions to gain a better understanding of the concept of heredity through Mendel's experiments.

Meiosis is the process by which gametes (sex cells) are produced. In males, gametes are called sperm, and in females, they are called eggs. Meiosis reduces the number of chromosomes in the gamete to one-half the number of chromosomes in the parent's body cells. When fertilization—the union of two gametes—occurs, a zygote is formed.

Fertilization restores the original chromosome number in the resulting zygote (new individual). Meiosis occurs in two phases, Meiosis I and Meiosis II.

Consider the following diagram, which illustrates meiosis beginning with two pairs of chromosomes:



Meiosis occurs only in the formation of sex cells. This process consists of two cell divisions but only one chromosome replication.

- The first meiotic division produces two cells containing half the number of double-stranded chromosomes. These are called **diploid** (2*n*) cells.
- The second meiotic division results in the formation of four cells, each containing half the number of single-stranded chromosomes. These are called **haploid** (1*n*) cells.

Sources of Variation during Meiosis

The process of meiosis provides the opportunity for the shuffling of chromosomes and the genetic information they contain. The way that the chromosome pairs line up at the equator during meiosis influences how they are distributed to the gametes. (To help you visualize this process, refer to diagrams in your textbook and class notes.) For example, Mendel studied the pea plant, which has seven pairs of chromosomes. Each of these seven pairs of chromosomes can line up during meiosis in two different ways, producing 128 (2^7) different combinations of traits. The number of possible combinations will greatly increase as the number of chromosomes increases within a given species. Human gametes have 23 chromosomes. So the number of different kinds of genetic combinations a person can produce is astounding—more than 8 million! When fertilization occurs, $2^{23} \times 2^{23}$ different genetic combinations can occur. That is 70 trillion!

Another source of variation during meiosis is **crossing over**. Crossing over occurs when two chromosomes physically overlap and exchange chromosome material. This process occurs more often on some chromosomes than on other chromosomes and changes the DNA sequence within each chromosome. This results in an endless number of different possible genetic combinations. Whether by crossing over or by independent assortment of homologous chromosomes, the end result is a reassortment of chromosomes and the genetic information they carry. This is known as **genetic recombination**.

Refer to your textbook and class notes for illustrations of these processes.

Describe the Relationships between Changes in DNA and the Appearance of New Traits

DNA Mutations

Every so often genes do change. Changes in the nucleotide sequence of a DNA molecule are known as gene **mutations**. Mutations may cause a change in the protein resulting from the genetic code for that gene. Some mutations are the result of exposure to agents such as ultraviolet light, ionizing radiation, free radicals, and substances in tobacco products and other chemical compounds. These agents that harm DNA are called **mutagens**. Mutations can also occur in the absence of these mutagens. Spontaneous mutations may occur as a result of replication errors. For example, adenine may incorrectly pair with cytosine. Also, the enzymes that repair a mistake may "fix" the wrong base.

Regardless of the cause of the mutation, there are several types of changes that may result: base-pair substitution, base insertion, and base deletion. **Base-pair substitutions** occur when one nucleotide base is replaced by another. This change may lead to the substitution of one amino acid for another during protein synthesis. An example of this is sickle-cell anemia, a genetic disorder that has structural and physiological consequences. A **base insertion** mutation is an addition of an extra nucleotide base into the DNA sequence. A **base deletion** mutation is the removal of a nucleotide base from the DNA sequence. In both base insertion mutations and base deletion mutations, a frame shift occurs. Remember that the nucleotide sequence is read as a triplet code. A deletion or an insertion in a gene region will shift this reading frame, causing an abnormal protein to be synthesized.

Whether a gene mutation is harmful, neutral, or beneficial will depend on how the resulting proteins interact with other proteins and with the environment in which they are placed.

Review your textbook for more in-depth information regarding genes and gene mutations and alterations during replication.

Compare the Advantages of Sexual and Asexual Reproduction in Different Situations

At the mouth of the Saco River in Biddeford, Maine, thousands of mature salmon have returned from the open ocean to travel upriver to spawn in the place of their birth. The females have turned red, a color that indicates that they will spawn and then die. The trip upriver will be a tough one for the salmon. As the female salmon releases translucent pink eggs into a shallow nest dug out by her fins in the riverbed, a male

salmon comes along and sheds a cloud of sperm that will fertilize the eggs. In about three years the pea-sized eggs will become salmon, made of billions of cells. A portion of these cells will become eggs or sperm. In time, the life cycle of the salmon will begin again: birth, growth, reproduction, and death. As with any organism, growth as well as reproduction depends on cell division.

Advantages of Sexual and Asexual Reproduction

Single-celled and many multi-celled organisms reproduce asexually by a process called **mitosis**, which is simple cell division. In mitosis, DNA is divided equally between two daughter cells. In mitosis in eukaryotes, the DNA is sorted into the two new nuclei formed. A separate process divides the cytoplasm in two. Mitosis keeps the number of chromosomes constant from one cell generation to the next. In multi-cellular organisms, cell division allows them to grow (i.e., increase the size of the organism), develop from a single cell into a multi-cellular organism, and make other cells to repair and replace worn-out cells.

Asexual reproduction does not require another partner, and the resulting organism is identical genetically to the parent organism. Organisms that reproduce asexually can produce many identical offspring in a short period of time. Asexual reproduction is an advantage in a stable environment where the parental genotype is well-suited. Many colonizers of new environments reproduce asexually.

Sexual reproduction involves much more time than asexual reproduction. Gametes must be formed through the process of meiosis, and mating must occur between two organisms of different sexes. There is also time involved in the growth and development of the offspring. The benefit of sexual reproduction is the genetic variability that results from the process of meiosis. Genetic recombination allows offspring greater diversity and increases the likelihood that some offspring will have more advantageous traits than the parents. Sexual reproduction is an advantage in a rapidly changing environment because the diversity of the population increases the possibility that some organisms will both survive and reproduce.

Questions on the Biology EOC assessment may ask you to state the significance of cell division for unicellular and multi-cellular organisms.

Examine the Use of DNA Technology in Forensics, Medicine, and Agriculture

DNA Technology and Genetic Engineering

New DNA technologies have resulted in advances in medicine, forensics, and agriculture. Certain genetic diseases may be cured by reinserting a corrected gene into the patient to replace a damaged gene. Forensic labs use DNA technology to identify people through DNA fingerprinting. Crime scene evidence such as blood or hair samples can be used to connect suspects to the crime by looking for DNA sequence similarities. Plant biologists have used DNA technology to produce plants with many desirable traits. These include increased disease resistance, herbicide resistance, and increased nutritional content.

Today, researchers use recombinant DNA technology to analyze genetic changes. They cut, splice together, and insert modified DNA molecules from different species into bacteria or other types of cells that rapidly replicate and divide. The cells copy

the foreign DNA right along with their own DNA. An example of this is the gene for human insulin. When the gene is transferred into a bacterium, the bacterium will use the "recombined" genetic code to produce human insulin. This is how human insulin is mass-produced. This insulin has saved the lives of many people with diabetes. Genetic engineering not only has applications in medicine and the environment but also has uses in industry and agriculture. Sheep are used in the production of alpha-1 antitrypsin, which is used in the treatment of emphysema. Goats are also producing a human protein used in the treatment of cystic fibrosis.

In the plant world, the buds of cotton plants are vulnerable to worm attacks. The buds of a genetically modified cotton plant resist these worms, resulting in increased cotton production. These gene insertions are ecologically safer than pesticides because they affect only the targeted pest.

Scientists today have developed genetically altered bacteria to eat up oil spills, manufacture alcohol and other chemicals, and process minerals. There is, however, concern about possible risks as genetically engineered bacteria are introduced into the environment.

It is important to remember that recombinant DNA technology and genetic engineering have a great potential for application in medicine, agriculture, and industry. As with any new technology, the potential risks must be taken into account, including social and environmental risks.

SAMPLE ITEMS

Item 9

Selected-Response

The table shows the changes in size of the populations of grasses, shrubs, and trees over 150 years.

Changes in Plant Population Size over Time

	Year 1	Year 50	Year 100	Year 150
Grasses	60	30	15	10
Shrubs	0	12	15	4
Trees	0	2	5	25

What type of succession was taking place?

A. primary succession because trees replaced bushes
B. secondary succession because the type of species changed twice
C. primary succession because there was a decrease in the number of species
D. secondary succession because the first organisms to grow were grasses

Item 10

Selected-Response

After conducting several tests, a scientist determines that the nucleic acid sample he is studying has the following characteristics:

- **Contains nucleotides linked in a chain**
- **Contains 4 nitrogen bases**
- **Made of single strand**
- **Uracil is present**

What is the BEST conclusion the scientist can make based on the observations?

A. The nucleic acid is DNA.
B. The nucleic acid is RNA.
C. The nucleic acid is a protein.
D. More tests would be needed to determine the type of nucleic acid in the sample.

Item 11

Selected-Response

Scientists have studied organisms near steel mills. In one study, the scientists compared the DNA of two groups of mice. One group lived near a steel mill, and the other group lived in a rural area away from the steel mill. The scientists collected data on the number of mutations occurring in each group and created the table shown.

Gene Mutations in Mice

Population Group	Gene	Mice Offspring Counted	Number of DNA Genes Counted	Number of Mutant Genes of DNA	Percent Gene Mutation (%)
Rural	Ms6-hm	110	234	51	21.79
	Hm-2	96	150	23	15.33
Total			**384**	**74**	**19.27**
Steel Mill	Ms6-hm	94	188	50	26.60
	Hm-2	75	96	30	31.25
Total			**284**	**80**	**28.17**

Which prediction can be made from this data?

A. Mice that live in rural areas will have more genes expressed than mice near steel mills.

B. Mice that live near steel mills will have more genes expressed than mice in rural areas.

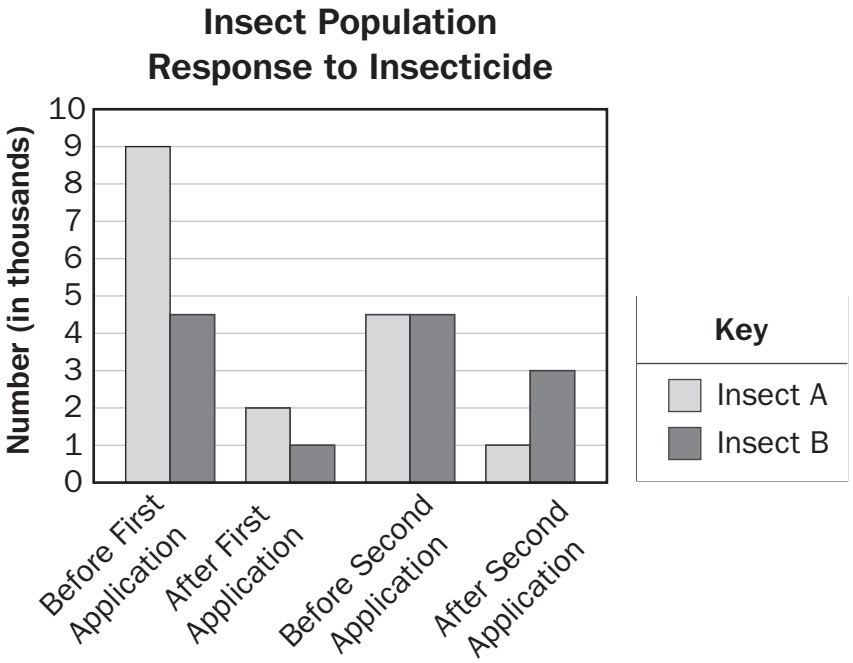
C. Mice that live in rural areas will have higher rates of abnormalities due to mutations than mice near steel mills.

D. Mice that live near steel mills will have higher rates of abnormalities due to mutations than mice in rural areas.

Item 12

Selected-Response

Scientists and farmers studied how populations of insects on a farm changed after the farmer started using an insecticide on the crops. The diagram shows population sizes, both before and after the insecticide was applied.



What conclusion can be made about the Insect A and Insect B populations?

A. The insecticide was specific to Insect B.
B. The insecticide became less effective for Insect A.
C. Some insects passed a beneficial mutation to offspring.
D. The farmer missed spraying insecticide on some plants.

ACTIVITY

Monohybrid Cross Activity

Standard: SB2c

Duration: 1 day

Materials:

- 4 equal-sized squares of paper
- Lab/field notebook
- Paper or plastic bag

Procedure:

1. Each piece of paper will represent an allele for the hairline shape trait. Widow's peak is the dominant form of the trait, and straight hairline is the recessive form of the trait. Mark the papers with the alleles for two heterozygous parents as follows:
   a. Parent 1: Mark one paper with a dominant allele (H) and the second paper with a recessive allele (h).
   b. Parent 2: Mark one paper with a dominant allele (H) and the second paper with a recessive allele (h).
2. Place the parent 1 alleles in a bag labeled "Mom." Place the parent 2 alleles in a bag labeled "Dad."
3. Without looking inside the bag, remove one allele (piece of paper) from each bag. These two alleles will represent one offspring the parents could produce.
4. Record the genotype (allele combination) and phenotype (physical trait) of the offspring in your notebook. An example data table follows (extend as needed).

	Phenotype	Genotype
Offspring 1		
Offspring 2		

5. Return the offspring alleles to their original bag.
6. Repeat steps 3–5 to produce a total of 20 offspring.
7. Calculate the genotypic and phenotypic ratios for the offspring.
8. Now that you have successfully completed a cross using two heterozygous parents, repeat by changing one parent's genotype to homozygous dominant (HH).

Explain why the phenotype and genotype ratios are not the same.

Knowing the genotypes of the parents, were the ratios what were to be expected? Explain.

Explain the role of meiosis in producing offspring during the activity.

UNIT 4: EQUILIBRIUM

Survival and stability requires that living things maintain biological balance at all levels.

AREAS OF FOCUS

Cells

- Regardless of cell type, cellular components function together to maintain homeostasis. (SB1a)
- Environmental conditions affect organisms at cellular levels. (SB1d)
- The regulation of cell functions through the expression of genes (enzymes) allows cells to respond to the environment. (SB1b, SB2b)

Organisms

- Organisms respond to internal changes and external stimuli to maintain homeostasis. (SB3b, SB4e, SB4f)

Evolution

- Species evolve over time. (SB5b)
- Evolution is a gradual process. (SB5b)
- Natural selection is a primary factor in evolutionary change. (SB5d)
- Evolution is a consequence of the interactions of
  - the potential for a species to increase its numbers
  - the genetic variability of offspring due to mutations and recombination
  - a finite supply of resources required for life
  - the selection by the environment of those offspring better able to survive and leave offspring (SB5d)

Ecology

- Human activities and natural phenomena disrupt the homeostatic nature of the environment. (SB4c, SB4d)
- Ecosystems result from dynamic relationships between organisms and their environment. (SB4a)
- Organisms are interdependent on each other and their environment. (SB4a)
- Diversity among organisms is due to adaptations to changing environmental conditions. (SB4e, SB4f, SB5d, SB5e)

KEY IDEAS

The Importance of Homeostasis

Organisms maintain their internal equilibrium by responding and adjusting to environmental stressors. For example, aquatic organisms must respond to changes in water temperature, sunlight, chemicals, and other organisms. All organisms must adjust and respond to changes in their environment. Failure to do so may result in death.

Living cells maintain a balance between materials entering and exiting the cell. Their ability to maintain this balance is called **homeostasis**. It is important for a cell to control internal concentrations of water, glucose, and other nutrients while also eliminating cellular wastes.

Cell Membrane

One function of the cell membrane is to control what comes into and goes out of a cell. In this way, the cell membrane helps maintain the proper concentrations of substances inside the cell.

Selective permeability is the property of the membrane that allows certain materials to pass through the cell while keeping others out. It also allows different cells to perform different activities within the same organism. An example of this is the nerve cell. Nerve cells respond to a certain chemical that is present in the bloodstream. Other cells are exposed to this chemical but are not affected by it.

Passive/Active Transport

There are various mechanisms that transport materials into and out of the cell. **Passive transport** is the movement of materials across the cell membrane without the use of the cell's energy. Different types of passive transport are shown in the box below.

Diffusion: the movement of substances across the cell membrane from an area of high concentration to an area of lower concentration

Osmosis: the diffusion of water molecules through a selectively permeable membrane from an area of low solute concentration to an area of high solute concentration

Facilitated transport (facilitated diffusion): occurs when a carrier molecule embedded in the cell membrane transports a substance across the membrane by means of diffusion

Active transport, endocytosis, and exocytosis are processes that use energy to transport materials into or out of the cell. **Active transport** is the process by which materials are transported through the cell membrane against a concentration gradient, as in the sodium-potassium pump. Endocytosis and exocytosis move large particles into or out of the cell as described in the box below.

Active transport: a process that drives large molecules across the cell membrane from a region of lower concentration to a region of higher concentration

Endocytosis: a process in which a cell surrounds and takes in material from its environment

Exocytosis: a process in which a cell surrounds and removes materials from inside the cell

• ALL REQUIRE ENERGY •

STRATEGY BOX—Word Parts

Studying the following word parts will help you determine the meanings of certain words you will come across on the Biology EOC assessment.

BIO—"life"
ENDO—"inside"
EXO—"outside"
LOGY—"study of"
CYTO—"cell"
OSIS—"process or action"

Relate Plant Adaptations, Including Tropisms, to the Ability to Survive Stressful Environmental Conditions

Even though plants do not have nervous systems, they do possess mechanisms that enable them to respond to their environment. These responses are known as **tropisms**. It is a Greek word that means "to turn." Plants will shift the positions of their roots, stems, leaves, and flowers in response to environmental conditions such as sunlight, temperature, water, and gravity. There are several types of tropisms. **Geotropism** is the response of seedlings to the force of gravity. It is important when seeds are sprouting. Geotropism causes the roots to grow downward and the stems to grow upward, no matter what the position of the seed when it is planted. **Phototropism** is the ability of the plant to respond to light. If a plant is placed near a window or another light source, the plant will grow in the direction of the light source. A phototropic response can happen so quickly that even a seedling will respond within a few hours. **Thigmotropism** is the response of a plant to touch. Climbing plants, ivy, and vines use thigmotropism in order to find their way up or around a solid object for support. It is also used by some plants for protection. Some plants respond to other stimuli from the environment, such as length of day and the seasons. Some flowers bloom once a year, while some others, like some cacti, bloom at night.

Tropism: a plant's response to its environment
Geotropism: a plant's response to gravity
Phototropism: a plant's response to light
Thigmotropism: a plant's response to touch

Most plants control their growth in response to environmental stimuli by using chemical messengers known as **hormones**. A hormone is a chemical that is produced in one part of an organism and transferred to another part to affect the activities of that part of the plant. One type of hormone is called **auxin**. Auxins are responsible for regulating phototropism in a plant by stimulating the elongation of cells. The cells on the auxin-rich shaded side of a stem will grow longer than the cells on the other side, causing the stem to bend toward the light. High concentrations of auxin help promote the growth of fruit and minimize the falling off of fruit from the plant. When auxin concentrations decrease in the autumn, the ripened fruit will fall. The plants will begin to lose their leaves. **Gibberellins** are growth hormones that cause plants to grow taller. They also increase the rate of seed germination and bud development. There are certain tissues in the seeds that release large amounts of gibberellins to signal that it is time to sprout.

Examples of Adaptations

Seeds of many plants will go dormant in unfavorable conditions. In a drought period, many will lay dormant until the rains come. Then they will sprout. Roots and stems are modified in many plants into storage organs in order to survive through winter or drought underground. Tulips, daffodils, and crocuses are examples. Many trees drop their leaves and go dormant for the winter. The leaves of conifers have a waxy coating over them to reduce evaporation and to conserve water. The bark on conifers is thick, helping to insulate the tissues from fire. The branches of conifers are flexible, allowing them to bend instead of breaking under the weight of ice and snow. These adaptations help plants survive adverse conditions in their environment.

Plants also have adaptations for reproduction. For example, flowers can be pollinated in many ways, including wind, insects, birds, or other animals. Maple trees produce seeds that are shaped like wings and are carried over long distances by the wind. Some plants produce seeds that have hooks or barbs on them that attach to the fur of passing animals. These have the nickname "hitchhikers." Many flowers are brightly colored and fragrant to draw the attention of insects that aid in pollination. Pollen will rub off on the insect and then will be carried to another flower. The coconuts from palm trees float, which allows seeds to travel from one island to another.

Remember to review your textbook for further study of plant adaptations to environmental conditions. Questions on the Biology EOC assessment may ask you to describe and identify certain characteristics of adaptations that plants have undergone in order to survive.

Relate Animal Adaptations, Including Behaviors, to the Ability to Survive Stressful Environmental Conditions

Behavior

Behavior is defined as anything an animal does in response to stimuli in its environment. A squirrel's gathering nuts and acorns in the autumn is a behavior that is stimulated by shorter days and colder weather. Gathering food for themselves and their young, caring for their young, avoiding predators, seeking shelter, and finding a mate are important behaviors to the survival of many animals. Many animals have learned and inherited behaviors.

Inherited Behavior

Inheritance plays an important role in an animal's behavior. An animal's genetic composition determines how it responds to stimuli. An animal's hormonal balance, in combination with its nervous system, affects how sensitive an animal is to stimuli. Inherited behavior of animals is also known as **innate behavior**. It includes both automatic responses and instinctive behaviors. When people touch hot surfaces, they automatically withdraw their hands from the source of heat. Bright lights make eyes automatically blink. Such **reflex** behaviors are simple, automatic responses that require no thinking at all.

Instincts are a complex pattern of innate behaviors. Reflexes can happen within a second. Instinctive behaviors may take longer and may be a combination of behaviors. For example, an animal's courtship behavior is instinctive. Animals will recognize certain behaviors exhibited by members of the same species. Each species has its own specific courtship behaviors. The male and female black-headed gull dance in unison side by side and turn their heads away from each other. The female taps the male's bill and he gives her a regurgitated fish. Then the courtship is over and the pair will mate. Different species of fireflies flash distinctive patterns of light. The female will respond only to the male that exhibits the species-correct flashes.

Territorial Behavior

A **territory** is a physical space that contains the breeding grounds, feeding area, shelter, or potential mates of an animal. Animals that have territories use different behaviors to defend their space against an animal of the same or different species. Setting up territories is a way to reduce conflict, control populations, and decrease competition. It is also a problem solver in that it helps provide for efficient use of environmental resources by spacing animals out over an area. There is a greater chance for survival of young, increasing the survival rate of the species.

Aggression is another behavior exhibited by animals to fend off predators and competitors. It is a way to protect young and to protect food sources. Animals of the same species will not usually fight to the death. Usually it will be the stronger animal that will stop the fighting when the weaker animal shows signs of submission.

Migration

Migration is the instinctive seasonal movement of a species. Over half of the birds that nest in the United States fly south for the winter. Many head to South America, where food is more abundant during the winter months. Then they fly north in the spring to

breed. Arctic terns migrate between the Arctic Circle and the Antarctic. Animals use various environmental cues to navigate during migration. Scientists believe that some species use geographical clues such as mountain ranges. Other species use Earth's magnetic field.

Scientists have also found that migration is triggered in part by hormones that are produced in response to environmental changes, such as changing day length. Migration also takes place in response to changing environmental conditions, such as overcrowding or reduced food supplies.

Many animals that do not migrate undergo physiological changes that reduce their need for energy. Some animals and birds **hibernate** during cold winter months. Hibernation is a condition in which the animal's body temperature drops, oxygen consumption decreases, and breathing rates decrease to just a few breaths per minute. **Estivation** is a condition in which animals reduce the rate of their metabolism due to extreme heat, lack of food, or long periods of drought.

Learned Behavior

Learned behavior is a result of previous experiences of an animal that modifies its current behavior. Learned behavior has survival value because it allows animals to change their behavior in a changing environment. It allows animals to increase the chance for survival. Feral horses learn to allow people to ride them. Deer have learned to come into yards to feed with no fear of people or barking dogs. This type of learned behavior is called **habituation**. It occurs when an animal is repeatedly given a stimulus that is not harmful and does not have a negative impact on the animal. **Imprinting** is another form of a learned behavior. Examples are when an animal returns to the place of its birth to lay its eggs and when an animal imprints on its mother or other organism in its environment. Kemp's Ridley sea turtles will return to the beach where they were hatched to lay their eggs. It is not yet known exactly what the turtles imprint on, whether it is the sand or in the water. Salmon also return to the same river to spawn.

Adaptations for Defense

Most species of plants and animals have adaptations that serve as defenses against a predator. They fall into two categories: mechanical defenses and chemical defenses.

- A **mechanical defense** is incorporated into the physical structure of the organism.
- A **chemical defense** occurs when the animal produces stinging sensations, paralysis, poisoning, or just a bad taste.

Mechanical Defenses

Many animal defenses are physical structures such as claws, sharp ivory tusks, stingers, and shells. Octopuses squirt a liquid ink that darkens the water and allows them to escape predators. An animal's size is sometimes enough to deter a predator from attacking.

Plants also have mechanical defenses. Many have thorns, spines, and stiff hairs that repel a predator. Some grasses in the African savannas have a thick deposit of silica that wears away the teeth of grazing animals. However, some of these grazing animals have counter-adapted and have developed large, hard molars that resist the abrasive action of the mineral.

Another defense is **camouflage**. It involves colors and patterns that enable the organism to blend into its environment or appear to be something it is not. **Cryptic coloration** is when an organism has the same color or pattern as its background. Gecko lizards, tree frogs, and leafhoppers are examples. **Disruptive coloration** is another example in which an organism's silhouette is broken up by color patterns. **Countershading** is when an organism is two-toned. Light and dark colors reduce visual cues to predators. Many ocean fish are dark on top and light on the bottom. Predators on top can't see the fish against the dark waters below. Fish and some mammals form large groups (schools and herds) to confuse predators and make choosing one individual more difficult.

Chemical Defenses

Chemical defenses are used in a variety of strategies for deterring predators. Many marine organisms have neurotoxins in their tissues that attack the nervous system of their attackers. Bombardier beetles shoot out a boiling-hot chemical to irritate would-be predators. Other chemical defenses include poisons and venoms, which are used by snakes, toads, and stinging bees and wasps. Some animals take on the chemical defenses of other species. The monarch butterfly is an example. As larvae, monarchs feed on milkweed plants, which contain compounds that are poisonous to vertebrates and many insects. After pupation, the tissues of the adult monarch are saturated with the milkweed's poison. Birds that eat the monarch will vomit violently and learn to avoid the monarch's bright coloration.

Chemical defenses are also used in plants. Some plants contain chemical compounds that taste bad, while others contain sap that is an irritant or poison. Another defense is **nutrient exclusion**. Some plants aren't worth eating because their tissues are lacking a sufficient amount of nutrients.

We have covered a lot of information on plant and animal adaptations. Remember to review your textbook for further study.

On the Biology EOC assessment, you may be asked to identify and describe certain behaviors or characteristics of plant tropisms, animal behavior, and survival strategies of organisms as they relate to their environment.

Species Evolve Over Time by Natural Selection

Charles Darwin

When Charles Darwin set sail in 1831 on the HMS *Beagle*, he carried with him Charles Lyell's *Principles of Geology*, published in 1830. While on the *Beagle*, Darwin read Lyell's proposal that plant and animal species had arisen, had developed variations, and then had become extinct over time. Lyell also believed that Earth's physical landscape had changed over a long period of time. Darwin also read an essay written in 1798 by Thomas Malthus called *An Essay on the Principle of Population.* In his essay, Malthus proposed that populations outgrew their food supplies, causing competition between organisms and a struggle for one species to survive against another. But the most important impact on Darwin was his 40,000-mile trip on the *Beagle*. Darwin found a vast treasure of fossilized bones of extinct sloths and giant armadillos in Patagonia. He saw a variety of plants and animals that were very different due to their geographical location.

In the Galápagos Islands, Darwin found many species specific to the various islands. He saw large iguanas swimming in the ocean and eating seaweed. He also found giant tortoises with carvings on their backs from whalers who had passed through a hundred years before. From all the information gathered by Darwin, two central concepts emerged to form the basis of his theory of evolution.

First, Darwin observed that variations within a species were dependent on the environment. **Adaptations** are genetically coded traits that occur in organisms and enable them to be more successful in their environment. Darwin reasoned that the importance of these adaptations is to ensure the survival through reproduction of that species. Successful adaptations help organisms to both survive and reproduce so that these advantageous adaptations are passed on to future generations. **Natural selection** is a mechanism that explains changes in a population that occur when organisms with favorable variations for that particular environment survive, reproduce, and pass on these variations to the next generation.

Second, the organisms on the Galápagos Islands had become geographically separated from one another. This resulted in **reproductive isolation**. There is no interbreeding between organisms of the same species that are located on different islands. For example, finches on one island could not cross the ocean to mate with finches of the same species on another island. Darwin theorized that within a population of a species, adaptations would arise due to reproductive isolation. The organisms would develop adaptations to their specific environment over time that would result in significant differences between the same species on different islands.

While Darwin was composing a theory of evolution, another man, Alfred Russel Wallace, was also formulating his own theory of evolution. He studied plants and animals in Brazil and in Southeast Asia. Wallace's emphasis was based on the idea of competition for resources as the main force in natural selection. Darwin focused on reproductive success. It was the tremendous amount of data gathered by Darwin that supported his idea, and the comprehensive explanation that he put together became the dominant evolutionary theory.

Darwin knew nothing about genes or principles of heredity. Mendel's work was not published until 1866, and it wasn't appreciated for decades. It wasn't until the rediscovery of Mendel's work that scientists were able to put together the concepts of natural selection with genetics. This opened the door for scientists to account for phenotypic variations in populations. It is where scientists derive the term **population genetics**. It is an area of biology in which researchers use mathematical descriptions of genetic phenomena to help them trace evolutionary trends within populations.

Explain the History of Life in Terms of Biodiversity, Ancestry, and the Rates of Evolution

In theory, DNA changes should occur at a constant rate. In reality, it is complicated by a number of factors. Different positions in DNA sequences acquire mutations faster than others. Different organisms acquire mutations at different rates. Some genes are under a more intense pressure from natural selection *not* to change. So, in order for researchers to time recent evolutionary events, they must use "time clocks" that tick fairly quickly. But to estimate how long ago there was a shared ancestry, they must use clocks that tick very slowly. **Molecular clocks** are proteins that have changed very slowly and are shared by many species.

Gradualism is evolution that occurs over a long period of time when adaptive changes accumulate slowly and steadily over time in a population. Darwin believed in gradualism.

Punctuated equilibrium states that speciation occurs quickly in rapid bursts, with long periods of stability.

Whether the rate of evolution occurs slowly over long periods of time or rapidly, the debate will continue as new evidence is compiled and alternative theories are brought to light. It is the nature of science to modify theories as new evidence becomes available.

For the Biology EOC assessment, it is important to review your textbook in order for you to understand and explain the history of the evolutionary theory. Also review terms and definitions that will help you in understanding this concept.

You may also be asked to identify and describe historical ideas that led to modern thinking on theories of origin. Remember that scientific theories are subject to change as new information becomes available. Keep in mind that technological advances are taking us places we have not been before. Marine biologists have discovered gigantic tubeworms near the deep-sea vents in the Marianas Trench. Paleontologists are uncovering fossils never seen before in Montana.

Relate Natural Selection to Changes in Organisms

Remember that the key to Darwin's theory of evolution came from the concept that some organisms have an advantage over others. This advantage increases the organism's survival rate and increases the chances that this favorable advantage will be passed on to the next generation. Within each species is a vast array of phenotypic differences. Natural selection acts on an organism's phenotype and indirectly on its genotype. Natural selection results in adaptations that allow populations to survive in their environments.

Fitness

Geneticists define the term **fitness** as the relative reproductive efficiency of various individuals or genotypes in a population. The fitness of an individual depends on the probability that the one individual will both survive and reproduce successfully. It is not necessarily the strongest, biggest, or most aggressive animal that has the highest fitness rating. It is a measure of how well the organism's structure, physiology, biochemistry, and behavior allow the organism to survive and reproduce in its environment. When a population has a variety of phenotypes and biological capabilities, it enables the population to survive under a wide range of environmental factors.

Environment plays an important role in determining which alleles are optimum for a population's survival. Natural selection does not always increase the complexity of an organism's structures or behaviors. Also, natural selection does not produce new genotypes and phenotypes, but it eliminates the less fit, leaving the more fit to reproduce and ensure the species' survival. If environmental conditions change so that a population lacks alleles for survival, the population (and possibly the species) goes extinct.

Stabilizing Selection

Stabilizing selection, also called normalizing selection, is responsible for maintaining the status quo for an organism's genetic makeup in an environment. It is common in environments that have remained stable over long periods of time. Possibly, the phenotype has not changed much because it has become very well adapted to its environment, such as the open sea or the high-pressured regions of the sea floor.

Directional Selection

Directional selection involves changes from one phenotypic property to another. When environmental conditions favor the survival of individuals carrying a genetic variant, the outcome is an increase in the frequency of that variant in the population. For example, many insects have become resistant to pesticides. Those with the ability to survive the insecticides sprayed on them reproduce, passing on the genes for this survival ability.

Disruptive Selection

Disruptive selection results in the disappearance of forms that are considered intermediate between several extreme variants. Disruptive selection will split a species into two or more groups by strongly selecting against the intermediate or average phenotypes.

Natural selection can take on many forms and produce diverse effects on populations. In summary, natural selection may maintain the status quo for a population in its genotype or in its phenotype. Trends may occur in different directions, decreasing a phenotype or increasing a phenotype. Increasing the diversity in genotype and phenotype may result in a new species.

It is important for you to review your textbook. On the Biology EOC assessment, you may be asked to identify and describe the different variations of natural selection and their impact on a species.

Relate Environmental Conditions to Successional Changes in Ecosystems

Succession

Ecosystems are constantly changing. Some changes happen quickly, such as a forest fire, flood, or volcanic eruption. Some changes happen slowly over a period of time, such as new saplings growing into tall, mature trees. When an ecosystem changes, the organisms in that ecosystem may need to change to survive. Succession is the natural change that takes place within a community of an ecosystem. There are two types of succession that ecologists study.

Primary succession is the gradual development of a new community where no organisms have lived before. An example is the changes that take place after a volcanic eruption, when the lava flow cools, hardens, and weathers. In 1963, scientists were able to observe the birth of a new volcanic island, named Surtsey. The island measured 1 square mile. Seabirds were the first to arrive. Seeds, whether airborne or "hitchhikers" on the feathers of the birds, then reached the island. The first plant, a sea rocket, bloomed in 1965. Spiders were visible, and lichens and mosses soon grew. As these pioneer organisms died, their remains formed soil. Seals used Surtsey's beaches to have their young. However, over time, Surtsey has lost about one-fourth of its mass due to erosion.

Eventually, primary succession slows down and the community becomes stable. This community is known as a **climax community**.

Secondary succession occurs when a natural disaster or human activity partially destroys a community. Like in primary succession, the community of organisms inhabiting an area changes over time. However, when secondary succession takes place, soil is already present. In secondary succession, the species replacing the pioneer species are often different. It also takes less time to become a climax community.

In Yellowstone National Park, thousands of acres burned as a result of a lightning strike. After the fire, wildflowers grew first. Wildflowers do not usually grow in forest shade. Within three years, flowers, grasses, ferns, and saplings began to take hold and grow. Once the saplings began to grow, they shaded the forest floor and a mature forest began to develop.

Assess and Explain Human Activities That Influence and Modify the Environment

In today's world, there is high demand for resources. There are natural resources that humans use every day. When we turn on a light to read a book that is made from paper, we are using natural resources. They include soil, plants, water, crops, animals, gas, and oil. A natural resource that is replaced or replenished by natural processes is known as a **renewable resource**.

Nonrenewable resources are those that are available only in limited amounts. Once they are gone, they are gone! Metals such as tin, silver, gold, uranium, and copper are some examples of nonrenewable resources. Minerals, such as phosphorus, are recycled so slowly in the environment that they are considered nonrenewable. Topsoil is also considered a nonrenewable resource because it takes hundreds of years to develop from decomposed plant material. Fossil fuels are always being formed, but they too are considered nonrenewable because they form slowly over long periods of time. Humans use them faster than they are replaced.

One of the major ways humans affect the environment is pollution. **Pollution** is the contamination of soil, water, or air and is a result of human activity. Although pollution has been around for many years, it has increased worldwide as countries have become more industrialized. Pollution affects living organisms, including humans, as well as the physical environment. Cow and horse manure can be considered a good plant fertilizer. But if too much manure is produced due to overcrowding and the decomposers cannot break the manure down as fast as it is produced, large amounts of nitrogen run off into waterways. This nitrogen will increase the growth rate of algae in water systems, causing a decrease in the amount of oxygen in the water. This can result in the death of the fish, insects, and other animals in the water.

Air pollution is caused primarily by the burning of fossil fuels to produce electricity. However, the burning of fuel for other activities such as driving cars, heating homes, and flying planes has also contributed to air pollution. Examples of air pollutants include dust, smoke, ash, carbon monoxide, and sulfur oxides. Smoke that is released by burning fuels contains gases and **particulates**. These are solid particles of soot that can harm living organisms now or have an impact later in life. Workers in coal mines develop black lung disease from breathing in the dust from the coal. A combination of smoke, gases, and fog is called **smog**. Smog containing sulfur oxides reacts with water vapor in the atmosphere to produce sulfuric acid. This sulfuric acid falls to the ground

as **acid rain**, which damages crops, kills organisms in aquatic ecosystems, and erodes buildings and monuments. Acid precipitation leaches calcium, potassium, and other valuable nutrients from the soil, making the soil less fertile. This causes a decrease in the number of living things that can grow (e.g., plants, trees, and ferns). It also has a great effect on lake ecosystems by causing a decrease in the pH level. This excess acidity disrupts the natural balance of the organisms living there.

Another form of air pollution is the increased production of carbon dioxide. When fossil fuels such as oil, coal, and natural gas are burned, carbon dioxide is released into the atmosphere. Excess carbon dioxide in the air can contribute to the greenhouse effect, which is believed to cause global warming. Gases in the atmosphere trap much of the radiant energy from the Sun that reaches the surface of Earth. The surface of Earth heats up and radiates heat back into the atmosphere. The atmosphere prevents much of this heat from escaping. This is known as the **greenhouse effect**. If this process did not occur, Earth would be too cold for any living thing to survive. All the Sun's energy would be radiated back into space. The **ozone layer** that surrounds Earth prevents lethal doses of ultraviolet radiation from the Sun from reaching organisms here on Earth. Scientists have discovered that the ozone layer is thinning because of the release of CFCs (chlorofluorocarbons) into the atmosphere. CFCs are manufactured for coolants in refrigerators and air conditioners as well as for making disposable foam products.

Water pollution is caused by contaminants from sewers, industries, farms, and homes, which enter water sources such as lakes, rivers, groundwater, and oceans. Sewage, chemical wastes, fertilizer, and dirty wash water can enter lakes, streams, rivers, and eventually oceans. Pollutants that trickle down through the soil can make their way to the underlying groundwater, which is the source of drinking water for some people.

Humans are, however, becoming more aware of the possible negative effects they have had on the environment and are trying to offset past damage. As a result, greater efforts are being made to conserve energy resources, to protect and conserve material resources, and to control pollution. For example, wildlife conservation efforts protect species from habitat loss, overhunting, and pollution.

People are making an effort to conserve energy by limiting the use of energy resources, such as fossil fuels, through the increased use of public transportation and carpooling. Another way energy resources are being conserved is by reducing energy waste by making homes and buildings more energy efficient. Using alternative forms of energy can also conserve energy resources. For example, solar energy and wind energy provide an unlimited supply of energy with minimal impact on the environment.

You've probably heard of the "three Rs" of conservation: reduce, reuse, and recycle. Reducing, reusing, and recycling resources can decrease the amount of new material taken from Earth. For example, buying products in recyclable packages or products that can be recycled helps conserve material resources. Another way to conserve material resources is to reuse materials instead of throwing them away.

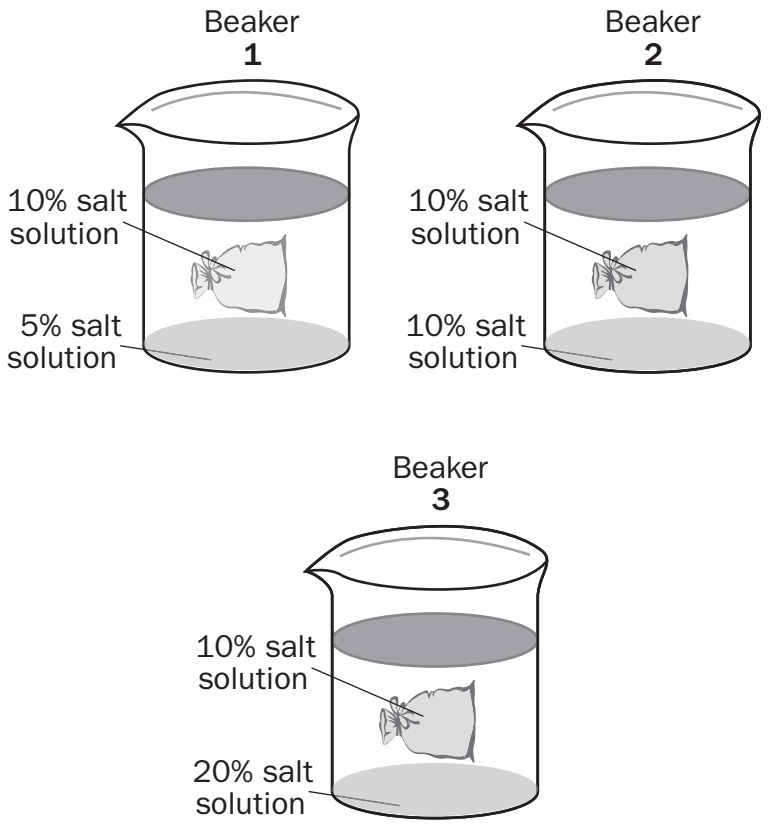
What happens to the materials that are not recycled or cannot be recycled or reused? They probably end up in the garbage, which is hauled to a landfill to be buried underground. In a sanitary landfill, layers of compacted garbage are spread between layers of soil and eventually covered with grass and other plants. New techniques of sanitation and waste disposal are also being developed.

SAMPLE ITEMS

Item 13

Selected-Response

A student is demonstrating how water moves across cell membranes to maintain homeostasis. The student uses dialysis bags, which are semipermeable and model cell membranes. The student fills each of the three bags with 100 mL of a 10% salt solution and ties the end of each bag. In Beaker 1, the student places 200 mL of a 5% salt solution. In Beaker 2, the student places 200 mL of a 10% salt solution. In Beaker 3, the student places 200 mL of a 20% salt solution.



What kind of environments are in Beakers 1, 2, and 3?

A. Beaker 1: hypertonic, Beaker 2: hypotonic, Beaker 3: isotonic
B. Beaker 1: hypertonic, Beaker 2: isotonic, Beaker 3: hypotonic
C. Beaker 1: isotonic, Beaker 2: hypertonic, Beaker 3: hypotonic
D. Beaker 1: hypotonic, Beaker 2: isotonic, Beaker 3: hypertonic

Item 14

Selected-Response

In 1976, the enzyme DNA helicase was discovered. DNA helicase breaks bonds between nitrogenous bases. Which statement BEST describes how the discovery of DNA helicase furthered the understanding of DNA replication?

A. It revealed the mechanism by which two DNA strands are “unzipped” from each other.

B. It resulted in the development of laboratory methods of replicating RNA.

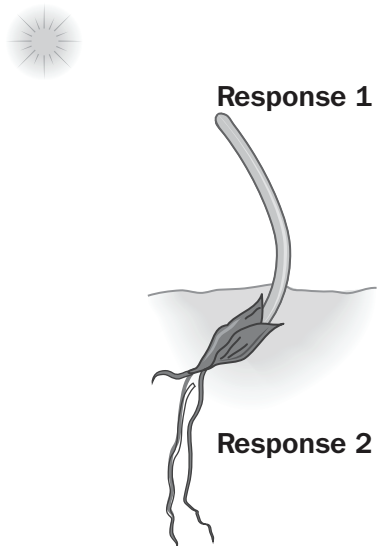
C. It led scientists to discover that DNA is made up of nucleotides.

D. It helped uncover the double-helix structure of DNA.

Item 15

Selected-Response

The diagram shows a plant's responses to stimuli.



Which table presents explanations for the plant's responses?

A.

Response	Explanation
1	In response to light, a plant hormone causes the shoot to lengthen more on one side, and the stem bends toward the light.
2	In response to gravity, a plant hormone accumulates in certain areas, and the roots grow downward.

B.

Response	Explanation
1	In response to light, the chloroplasts begin to photosynthesize, and the shoot leans toward the light.
2	In response to water, the vacuoles on one side of the roots swell, and the roots grow downward.

C.

Response	Explanation
1	In response to the heat, sensors in the shoot are activated, and the shoot bends toward the Sun.
2	In response to touching the soil, sensors in the root are activated, and the roots grow downward.

D.

Response	Explanation
1	In response to gravity, a plant hormone causes cell replication, and the shoot grows upward.
2	In response to light, a plant hormone causes cells to move away from the Sun, and the roots grow downward.

Item 16

Selected-Response

Scientists noted that each of several anole lizard species in the Caribbean islands has a body type that seems to be well suited for its own habitat. For example, the anole species that live mainly on tree trunks have stocky bodies and long legs. Anoles that live in grassy areas are slender and have very long legs. Scientists also noted that distinct anole species with the same body types can be found on several different islands. These findings are consistent with the mechanism of natural selection, which favors adaptations that allow a species to survive in its environment.

The scientists developed a few hypotheses for the finding that the twig-dwelling anole species found on several of the islands have thin bodies, large toe pads, and short legs and tails. They then performed DNA analysis on each of these twig-dwelling species. This analysis revealed that the twig-dwelling species on different islands did not share a recent common ancestor.

Which of these hypotheses is supported by the findings?

A. A species of twig-dwelling anoles developed on one island, and then descendents spread out to other islands.

B. The twig-dwelling anoles are much better adapted to living in the Caribbean islands than the trunk-dwelling and grass-dwelling anoles.

C. Each twig-dwelling species came from distant ancestors but evolved in similar ways despite separated habitats.

D. Twig-dwelling anoles, trunk-dwelling anoles, and grass-dwelling anoles all evolved from the same ancestor.

ACTIVITY

Molecular Movement Across a Membrane Activity

Standards: SB1a, SB1d

Note: Clear non-resealable plastic bags or clear plastic wrap can be substituted if used with twist ties to securely close the bags.

Duration: 1 hour

Materials*:*

- 2 eggs
- container of syrup
- container of tap water

Procedure*:*

1. Submerge two eggs in a bowl of vinegar for two days.
2. Carefully rinse the shells off the eggs.
3. Submerge one egg in a bowl of syrup.
4. Submerge the second egg in a bowl of tap water.
5. Allow the eggs to sit for 24 hours.
6. Record observations.

Discuss the following with a family member or a friend:

How did the eggs change during the experiment? Why?

Describe the solutions as hypertonic, hypotonic, or isotonic.

Relate the results of this activity to cell membranes.

Which way did the water move in each condition?

ADDITIONAL SAMPLE ITEM KEYS

Item	Standard/ Element	Characteristics of Science Standard/ Element	DOK Level	Correct Answer	Explanation
1	SB1a	SCSh3e	1	B	The correct answer is choice (B) the production of proteins. Choice (A) is incorrect because mitochondria produce energy for the cell. Choice (C) is incorrect because the cell membrane controls the removal of substances from a cell. Choice (D) is incorrect because lysosomes break down chemicals.
2	SB4a	SCSh3e	2	B	The correct answer is choice (B) Species 2 is a predator of Species 1. Choice (A) is incorrect because the prey population is usually larger in size than the predator population. Choice (C) is incorrect because the species in a mutualistic relationship would show similar population patterns. Choice (D) is incorrect because in commensalism, one species would be unaffected by a change in the other species.
3	SB5c	SCSh3e	2	C	The correct answer is choice (C) Humans and rhesus monkeys are more similar than chickens and frogs. They have fewer differences in amino acids than the other organisms. Choice (A) is incorrect because the biochemical data is evidence that there is likely a common ancestor shared by all organisms on the chart. Choice (B) is incorrect because, although hemoglobin may be important, the graph concerns amino acid differences. Choice (D) is incorrect because the graph shows the number of differences in amino acids between humans and other organisms.
4	SB3b	SCSh3d	1	D	The correct answer is choice (D) Plantae because it has chloroplasts and is multi-cellular. Choices (A) and (C) are incorrect because animals and fungi do not have chloroplasts. Choice (B) is incorrect because archaebacteria are unicellular and microscopic.

Item	Standard/ Element	Characteristics of Science Standard/ Element	DOK Level	Correct Answer	Explanation
5	SB1b	SCSh3d	2	D	The correct answer is choice (D) as it shows that there is less activation energy required for the biochemical reaction to occur. Choice (A) is incorrect because the graph shows an exaggerated decrease in energy that would not be effective to produce the products. Choice (B) is incorrect because the graph shows an increase in activation energy with the enzyme. Choice (C) is incorrect because there is little decrease in activation energy.
6	SB3a	SCSh3a	2	A	The correct answer is choice (A) If leaves are uncovered, then their chloroplasts will produce more oxygen than the leaves that are covered in green plastic. Chloroplasts are the site of photosynthesis and release oxygen during the process. Choice (B) is incorrect because mitochondria do not absorb carbon dioxide. Choice (C) is incorrect because chloroplasts do not release carbon dioxide. Choice (D) is incorrect because mitochondria do not produce oxygen.
7	SB4b	SCSh5e	2	B	The correct answer is choice (B) 1,500 joules. Roughly 10% of energy is retained as it moves from one trophic level to the next. The primary producers possess 150,000 joules which is converted to 15,000 joules when the plants are eaten by the primary consumers. The secondary consumers eat the primary consumers and the energy passed along is reduced to 1,500 joules. Choice (A) is incorrect because that energy value would be transferred to the tertiary consumers. Choice (C) is incorrect because this energy level is available to primary consumers. Choice (D) is incorrect because energy is lost, not conserved, as it moves from each trophic level.

Item	Standard/ Element	Characteristics of Science Standard/ Element	DOK Level	Correct Answer	Explanation
8	SB4a	SCSh3e	2	B	The correct answer is choice (B) Stage 4 occurred because energy input and output within populations remained balanced. Equilibrium has been achieved. Choice (A) is incorrect because it describes what happens at Stage 1. Choice (C) is incorrect because it describes what happens at Stage 2. Choice (D) is incorrect because it describes what happens at Stage 3.
9	SB4c	SCSh3e	2	D	The correct answer is choice (D) secondary succession because the first organisms to grow were grasses. Secondary succession occurs in areas where soil is present. Choice (A) is incorrect because primary succession occurs when a population of organisms develops in an area that had not supported life previously. Choice (B) is incorrect because secondary succession is not defined by two changes in population. Choice (C) is incorrect because primary succession occurs when a population of organisms develops in an area that had not supported life previously. So primary succession actually results in an increase in the number of species.
10	SB2a	SCSh3e	1	B	The correct answer is choice (B) The nucleic acid is RNA because RNA is the only nucleic acid with uracil. Choice (A) is not correct because DNA is double-stranded and the base adenine pairs with the base thymine. Choice (C) is not correct because proteins are composed of amino acids, not nucelotiodes, and proteins are not a type of nucleic acid. Choice (D) is incorrect because two key distinctions between DNA and RNA are present: number of strands and bases present.

Item	Standard/ Element	Characteristics of Science Standard/ Element	DOK Level	Correct Answer	Explanation
11	SB2d	SCSh3a	2	D	The correct answer is choice (D) Mice that live near steel mills will have higher rates of abnormalities due to mutations than mice in rural areas because they have a higher percentage of gene mutations. Choice (A) is incorrect because the same number of genes will be expressed. Choice (B) is incorrect because the same number of genes will be expressed. Choice (C) is incorrect because rural mice will have lower mutation rates.
12	SB5e	SCSh3e	2	C	The correct answer is choice (C) Some insects passed a beneficial mutation to offspring because Insect B's population decreases less after the second application. Choice (A) is incorrect because the insecticide did reduce both populations of insects. Choice (B) is incorrect because the insecticide continued to reduce Insect A populations more than Insect B populations. Choice (D) is incorrect because not spraying insecticide on some plants wouldn't likely cause more resistant insects to live.
13	SB1d	SCSh3e	2	D	The correct answer is choice (D) Beaker 1: hypotonic, Beaker 2: isotonic, Beaker 3: hypertonic. Per the given solutions, Beaker 1 is hypotonic because the solute concentration is lower in solution compared to the bag; Beaker 2 is isotonic because the solution concentration is the same in the solution and bag; and Beaker 3 is hypertonic because the solute concentration is higher in the solution compared to the bag. Choices (A), (B), and (C) are incorrect because the environments listed do not match the conditions shown for each beaker.

Item	Standard/ Element	Characteristics of Science Standard/ Element	DOK Level	Correct Answer	Explanation
14	SB2B	SCSh3e	2	A	The correct answer is choice (A) It revealed the mechanism by which two DNA strands are "unzipped" from each other. DNA helicase breaks the bonds that hold two DNA strands together. Choice (B) is incorrect because DNA helicase is not found in RNA. Choice (C) is incorrect because the role of nucleotides was determined when the structure of DNA was discovered. Choice (D) is incorrect because the double-helix structure of DNA had to be known before the function of DNA helicase could be determined.
15	SB4e	SCSh3e	2	A	The correct answer is choice (A) as this table accurately identifies the plant's responses to two stimuli. Phototropism causes plants to grow toward light, and geotropism causes roots to grow in the direction of gravity. Choice (B) is incorrect because the chloroplasts are not involved in the directional response caused by light stimuli that causes the plant to lean toward the light. Choice (C) is incorrect because the plant bends to the left because of light stimuli, not heat. Choice (D) is incorrect because gravity causes roots to grow downward, not shoots to grow upward. Also, light stimuli cause cells to move toward the sun, as shown in the diagram.
16	SB5d	SCSh3e	3	C	The correct answer is choice (C) Each twig-dwelling species came from distant ancestors but evolved in similar ways despite separated habitats. This is supported by the DNA findings that the anoles did not share a common ancestor. Choice (A) is incorrect because the DNA findings revealed that the species had different ancestors. Choice (B) is incorrect because the scientists were not studying which species of anoles are better adapted. Choice (D) is incorrect because the scientists were hypothesizing only about twig-dwelling anoles.

Study/Resource
Guide for Students
and Parents
Biology
End-of-Course