Content Domain IV: Ecology

A LOOK AT CONTENT DOMAIN IV

Test questions in this content domain will measure your ability to explain the interrelationships between organisms and their environments. Your answers to the questions will help show your knowledge of the following elements:

- Investigate the relationships among organisms, populations, communities, ecosystems, and biomes
- Explain the flow of matter and energy through ecosystems
- Relate environmental conditions to successional changes in ecosystems
- Assess human activities that influence and modify the environment: global warming, population growth, pesticide use, water and power consumption
- Relate plant adaptations, including tropisms, to the ability to survive stressful environmental conditions
- Relate animal adaptations, including behaviors, to the ability to survive stressful environmental conditions

Spotlight on the Standards

★ ***Investigate the 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 Nino," "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 comes from the Greek word *oikos,* which means "house." It is the study of our house, our planet — Earth. Ecology is the scientific study of the interactions between different kinds of living things and their environment. An **ecologist** is a scientist who studies ecology.

The **biosphere** is the portion of Earth that supports life. Organisms are adapted to survive in a particular environment. Penguins are adapted to live in cold water and ostriches are adapted to live on dry savannahs. They have adaptations for obtaining food, for

protection, and for reproducing. Let's take a look at two important biological factors affecting living organisms.

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

SOME EXAMPLES OF ENVIRONMENTAL FACTORS

Biotic	Abiotic
Plants	Climate
Animals	Light
Bacteria	Soil
	Water

► Organization of Life ◄

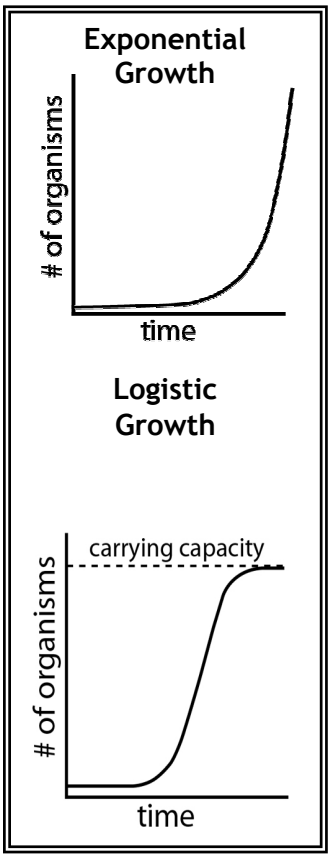
Ecologists study the interactions of organisms at five main levels of organization. Yet all the levels are interdependent on one another. To study only one level would not give the ecologist the whole picture.

Organisms — Ecologists will study the daily movements, feeding, and the general behavior of an individual organism. An example would the Arctic fox.
Populations — An ecologist will study the relationships between populations and the environment, focusing on population size, density and rate of growth.
Communities — Ecologists will be concerned with the interactions between the different populations in a community and the impacts of additions to or losses of species within communities.
Ecosystems — All biotic and abiotic factors make up the ecosystem. Ecologists will study interactions of the biotic and abiotic factors of an ecosystem with emphasis on factors that may disrupt an ecosystem.
Biosphere — This is the highest level of organization. It is here where ecologists study the entire planet and the interaction of biotic and abiotic factors on a global level. Examples of biosphere issues would be global warming and human population growth.

Population interactions

A **population** is a group of organisms of one species that live in the same place at the same time. They 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 would be the frog. The first stage of a frog is a tadpole. Tadpoles are completely different than an adult frog. Their food source is different. They have gills and live in the water. Many insects have juvenile stages that require very different resources than their adult counterparts. This minimizes competition.

A population of organisms of one species 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 impact 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. 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*** **EOCT,** you may be given a chart or graph and be asked to identify different types of growth.

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	**Density-Independent Limiting Factors**
Competition Predation Parasitism Crowding/Stress	Weather Fires Droughts/Floods Human activities

Ecologists also study the interactions between populations and their physical surroundings. An **ecosystem** is the interactions among the populations in a community and the physical surroundings of the community (also known as abiotic factors). **Terrestrial ecosystems** are those found on land. **Aquatic ecosystems** can be fresh or salt water. **Salt water ecosystems** are also called **marine** ecosystems. Marine ecosystems occupy 75% of the Earth's surface!

Within each community, particular species have particular jobs to help maintain balance. An example would be a forest community. On the forest floor, there is a decaying log. Fungi have the job of breaking down the organic material from the log. If the log is turned over, you will find 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 impacts 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.
Have you ever heard of blueberries growing in south Texas? Or avocados growing in Maine? Probably not. Blueberries like a cooler environment whereas avocados grow well in the warm valley of South Texas. Each of these plants is adapted to a particular ecosystem where they will grow and thrive. 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. These are known as **biomes**. Biomes are the Earth's major ecosystems. The six terrestrial biomes are listed below:

1. The tundra biome is found north of the Arctic Circle.
2. The taiga biome is found in a wide band south of the tundra.
3. The tropical rain forests are found in abundance in the Earth's equatorial zone.
4. Temperate deciduous forests are found in abundance throughout Europe and the eastern United States, between the taiga and the tropical biomes.
5. Desert biomes occur largely in parts of Africa, and the southwestern United States and in parts of Australia, South America, and Asia.
6. Grasslands cover most of South America, Africa, and Australia. Temperate grasslands can be found in central United States, western Canada and across southern Asia.

There are also aquatic biomes, divided into fresh water and marine ecosystems. An interesting fact is that only three percent of the water on Earth is fresh water! Ninety-eight percent of the fresh water is found in frozen icecaps! (98% of 3%) Fresh water biomes are the lakes, rivers, streams and ponds.

Marine biomes include the open ocean, the rocky intertidal zones, and the estuaries.

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 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 25 to 75cm

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 30 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 75 to 125 cm

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

Marine Biomes

Open Ocean
Abiotic Factors: temperature range is slight, varying with latitude and water depth
Biotic Factors: phytoplankton, fish, dolphins, whales, seals, sea birds

Rocky Intertidal
Abiotic Factors: alternating exposure to sunlight and submergence
Biotic Factors: algae, sea urchins, clams, mussels, starfish

Estuaries
Abiotic Factors: temperature change is extreme
Biotic Factors: algae, mosses, aquatic plants, insects, shrimp, crabs, amphibians, birds

Spotlight on the Standards

★Explain the Flow of Matter and Energy through Ecosystems★

- Arranging components of a food chain according to energy flow

Matter and energy are constantly flowing through a stable ecosystem. The primary source of this energy is the sun. Plants and some bacteria harness the energy of the Sun through the process of photosynthesis. Plants are **primary producers**. They use the energy they harness from the sun to change simple nonliving chemical nutrients in their environment into living tissues. Plants are also called **autotrophs**, meaning "self-feeding."
Because animals cannot harness energy from the sun, they need to eat other organisms to obtain their energy and nutrients. Animals are called **consumers**. They are also known as **heterotrophs**, meaning they need to feed on other organisms. Animals store this energy in their body in the forms of complex carbohydrates, fats, or 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 (Sun, plants, other organisms) are on the same trophic level.

Consumer	Energy Source	Example
Herbivore	eat plants	deer
Carnivore	eat other animals	lions
Omnivore	eat both plants and animals	raccoon
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 the Earth, the energy flows first to the tissues of primary producers, then to the tissues of consumers, and finally to the decomposers. This is called a *food chain.*

A food chain shows how energy and matter flow through an ecosystem. A food chain is usually four or five links.

A FOOD CHAIN

Sun → grass → mice → hawk

On the ***Biology*** **EOCT**, you may be given a diagram of a food chain or web and be asked to describe the role of different organisms. A question for this standard might look like this:

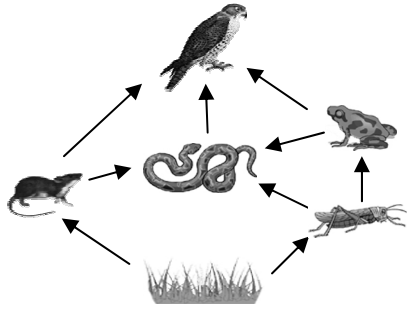
In the food chain below, which population will most likely decrease if snakes are removed from the food chain?

grass → grasshopper → frog → snake → hawk

A grass
B grasshopper
C frog
D hawk

The correct answer is **D**. The food chain indicates that hawks feed on snakes. If snakes are removed from the food chain, hawks would be negatively affected because they would have to depend more on other food sources. Frogs would most likely increase in numbers for a short time in response to not being eaten by hawks.

A FOOD WEB

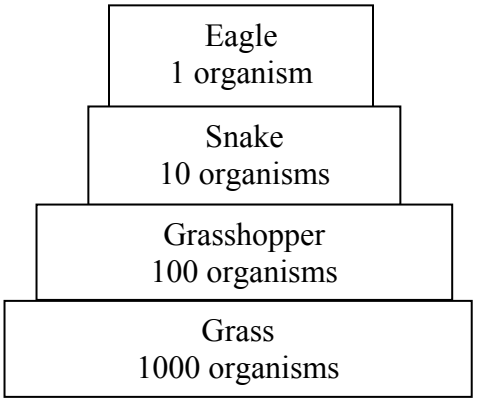


- Comparing the quantity of energy in the steps of an energy pyramid

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. Ecologists call this more complex interconnected system a **food web**.

Ecologists use energy pyramids to show how energy decreases at each succeeding trophic level. The total energy transfer from one trophic level to the next is only about 10%. Not all the food that is captured is actually eaten and digested. Some of the digested food is used by that organism as a source of energy. Every time an organism eats another, much of the energy is used up rather than being stored. Some of the energy is lost as heat. Also, ecologists construct energy pyramids based on the population size at each trophic level. This shows how some populations will decrease at each increasing level.



- Explain the need for cycling of major nutrients (C, O, H, N, P).

Unlike energy, matter is recycled in an ecosystem. Matter cycles from one organism to another. Matter cannot be replenished in an ecosystem, like the energy from the sun. For example, in the water cycle, water passes from the atmosphere to the land or water surfaces through precipitation and then eventually returns to the atmosphere. Carbon is found in the environment as carbon dioxide gas. From the atmosphere, CO_2 is used in 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. Atmospheric nitrogen makes up 78% of our air, but it is in a nonusable form. Lightning and some bacteria are able to convert atmospheric nitrogen into usable nitrogen-containing compounds. Plants use these nitrates and ammonium compounds in their growth. Herbivores eat the plants and convert nitrogen-containing plant proteins into nitrogen-containing animal proteins. Organisms return nitrogen to the atmosphere when they die and decay. Phosphorus cycles through the environment in two ways. Plants get phosphorus from the soil. Animals get phosphorus from the plants they eat. When the animals die, they decompose and the phosphorus is returned to the soil. The other way that phosphorus is cycled is a long term cycle. Phosphates that are washed out to sea become incorporated into sediments as insoluble compounds. When the sediments become exposed, the phosphorus can be recycled again into the environment.

Refer to your textbook for diagrams and additional information about each of these cycles. On the ***Biology*** **EOCT**, you may be asked to describe the interactions of biotic and abiotic factors in the various cycles.

A sample question on the ***Biology*** **EOCT** may look like this:

One essential element that has two different cycles is

A water
B carbon
C nitrogen
D phosphorus

The correct answer is **D**, phosphorus. It cycles two ways in the environment, one short-term and one long-term cycle.

Spotlight on the Standards

★ ***Relate environmental conditions to successional changes in ecosystems*** ★

Succession

Ecosystems are alive and constantly changing. Some changes happen quickly, such as a forest fire or flood or even when a volcano erupts. Some happen slowly over a period of time as new saplings grow 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 happens when one community is completely destroyed and a new one emerges. An example is the changes that take place after a volcano erupts and the lava flow stops and cools. 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 they were airborne or came as "hitch-hikers" on the feathers of the birds, or from the ocean tides, 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 and later, seals used Surtsey's beaches to have their young. However, over time, Surtesy has lost about one-fourth of its mass, due to erosion. One day the island may completely disappear. It has given scientists an in-depth look at how a community is developed and then destroyed.

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 destroys a community. It is like primary succession, in that 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 different. It also takes less time to reach a climax community.

In Yellowstone National Park, thousands of acres burned as a result of a lightning strike. This was another opportunity for scientists to study secondary succession first hand. It was surprising to see wildflowers pop up first. They were not able to grow under the forest shade. Within three years, flowers, grasses, ferns, and saplings began to take hold and grow. Once the saplings begin to grow, they once again will shade the forest floor and a mature forest will develop.

Spotlight on the Standard

★Assess and explain human activities that influence and modify the environment★

In today's world there is a high demand for resources in order for living things to survive. There are natural resources that we use everyday, without realizing it. 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 over long periods of time. Humans use them faster than they can be replaced.

Extinction is the complete disappearance of a species. The list of extinct species grows longer every year. Within the last twenty years, it is estimated that 30 species of plants and animals have become extinct in the United States alone. Some extinctions happen because of natural disasters but many, if not most, are due to human activity. Species that are declining rapidly are considered to be a **threatened** species. An example is the African elephant, pursued for its ivory tusks. A species is considered **endangered** when its numbers drop so low that extinction is almost inevitable. In the Florida Keys, the manatee is endangered because of boating and loss of habitat. In California, the condors are endangered due to several human-caused factors.

One of the major ways humans impact the environment is pollution, which is probably one of the greatest threats to living things. **Pollution** is the contamination of soil, water, or air and is a result of human activity. Any substance that is harmful or is a waste product is a **pollutant**. A pollutant can be a substance in the wrong place or in the wrong concentration. Although pollution has been around for many years, it has increased worldwide as more countries have become 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 these 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, flying planes, and generating electricity 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 their 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 amount of living things that can grow (plants, trees, ferns). It also has a great effect on lake ecosystems 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, like 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 the Earth. The surface of the Earth heats up and radiates 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 happen, the Earth would be too cold for any living things to survive. All the Sun's energy would be radiated back into space. The **ozone layer** that surrounds the Earth prevents lethal doses of ultraviolet radiation coming in from the sun from reaching organisms here on the Earth. Scientists have discovered that the ozone layer is thinning due to the release of CFC's (chlorofluorocarbons) into the atmosphere. CFC's are manufactured for coolants in refrigerators and air conditioners, and used in making Styrofoam.

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 the 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 effect 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, protect and conserve material resources, and to control pollution. For example, wildlife conservation efforts protect species from habitat loss, over-hunting, and pollution.

People are making an effort to conserve energy by limiting the use of energy resources like fossil fuels through the increased use of public transportation and carpooling. Another way energy resources are being conserved is to reduce 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 R's" of conservation: reduce, reuse, and recycle. Reducing, reusing, and recycling resources can decrease the amount of new material taken from the 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.

Learning about the possible causes and solutions to certain ecological problems will help you answer a question like the following:

The theory of global warming suggests that a trend toward warmer temperatures on Earth will cause glaciers to lose mass. A major consequence of glacial melting is

A flooding coastal regions
B destruction of fossil records
C increased saltiness of the ocean
D increase in atmospheric carbon dioxide

The correct answer is **A**. Glaciers contain more fresh water (2.15%) than any other fresh water source on Earth. If glaciers and other bodies of fresh water ice melted, low coastal regions would be flooded by the rising ocean water. Some fossil records might be destroyed, but this would not be a major consequence. The ocean would become less salty, not more salty, as it was diluted with fresh water. The melting of glaciers would not cause an increase in atmospheric carbon dioxide, but increasing atmospheric carbon dioxide could contribute to further warming.

Spotlight on the Standard

★Relate plant adaptations, including tropisms, to the ability to survive stressful environmental conditions★

Even though plants don't have a nervous system, they do possess mechanisms that enable them to respond to their environment. These responses are known as tropisms. It is a Greek word, which 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 may be 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 their environment
Geotropism—a plant's response to gravity
Phototropism—a plant's response to light
Thigmotropism—a plant's response to touch

So how do plants control their growth in response to environmental stimuli? Most plants do this by way of 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 the 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.

There are also hormones that do the opposite; they inhibit plant growth and cell division. **Abscisic acid** is one of these. It inhibits plant growth during times of stress, such as cold temperatures or drought. In studying these hormones, scientists have found that it is the balance of different hormones that determines the plant growth, rather than one hormone by itself.

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 underground. Tulips, daffodils, and crocuses are a few examples. Many trees drop their leaves and go dormant for the winter. Conifers have needles instead of leaves. The leaves have a waxy coating over them to reduce the amount of evaporation that takes place and to conserve water. The bark on the conifers is thick, helping to insulate the tissues inside. These adaptations help the conifers to continue their life processes even in below freezing temperatures. The branches of the conifers are flexible, allowing for them to bend instead of break under the weight of ice and snow.

Flowers can be pollinated in a number of ways, by the wind, insects, birds, and animals, even bats. Maple trees produce seeds that are shaped like a wing. They have the nickname of "helicopters." They can be 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 of "hitchhikers." Many flowers that depend on insects for pollination are brightly colored and fragrant, to draw attention to them. Pollen will rub off on the insect and they will carry it to another flower. The coconuts from palm trees float. They will travel from one beach to the next or even from one island to another.

A question for this standard may look like this:

What characteristic of some pine trees allows the species to survive disasters?

A modified leaves form needle bundles
B seeds that germinate after fires
C pollen that is easily carried by wind
D bark that is lightly colored

The correct answer is **B**. Several species of pine have seeds that are resistant to fire. They are in cones that must be exposed to fire to open and release the seeds. The modified leaves conserve moisture. The pollen blows easily, therefore insect and bird activity isn't necessary to spread the pollen from tree to tree. The color of the bark does not make the tree resistant to disaster. Bark thickness is a more important characteristic.

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

Spotlight on the Standard

★ ***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 a stimuli in its environment. Squirrels gathering nuts and acorns in the autumn is a behavior that is stimulated by shorter days and colder weather. Animals have a busy life! Gathering food for themselves and their young, caring for their young, avoiding predators, seeking shelter, and finding a mate, are important to the survival of animals. How do they know what to do and where to go?

Inheritance plays an important role in an animal's behavior. An animal's genetic makeup determines how it will respond to certain stimuli. Scientists have found that an animal's hormonal balance, in combination with its nervous system, affects how sensitive an animal is to certain stimuli. Inherited behavior of animals is known as **innate behavior**. It includes both automatic responses and instinctive behaviors. When you touch a hot surface, you automatically draw your hand away from the source of heat. When something flashes in your face, you automatically blink. These behaviors are known as **reflexes**. They are the simple, automatic responses that require no thinking at all. You just respond.

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. An animal's courtship behavior is instinctive. Animals will recognize certain behaviors exhibited by members of the same species. Each species has its own 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

A **territory** is a physical space that contains the breeding grounds, feeding area, shelter or potential mates of an animal. Animals that have territories will defend their space, whether it is against an animal of the same species or a different one. Setting up

territories is a way to reduce conflict, control populations, and decrease competition. It also is 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. Fighting is often more symbolic than anything else. Usually it will be the stronger animal that will stop the fighting and the weaker animal will show 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 will fly north in the spring to breed. Some species of whales do the same. Arctic terns migrate between the Arctic Circle and Antarctic. This trip calls for great endurance and strength in the little birds. How do they know where they are going? Animals migrate in a variety of ways. Scientists believe that some use geographical clues such as mountain ranges. Others may use the 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. Yet, not all animals migrate. How do these other animals cope with a changing environment?

Many animals undergo physiological changes that reduce their need for energy. Some animals and birds go into **hibernation** during the cold winter months. Hibernation is a state in which the body temperature drops, oxygen consumption decreases, and breathing rates decrease to just a few breaths per minute. **Estivation** is a state 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. It has survival value because it allows animals to change their behavior in a changing environment. It allows the animal to adapt in order to increase its 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. An example is when an animal returns to the place of its birth to lay its eggs or when an animal imprints on its mother or other organism in its environment. Kemp 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. Out of a herd of zebras, a young zebra can find its mother with no problem.

Adaptations for Defense

Most species of plants and animals have adaptations that serve as a defense against a predator or as a means of escape. They fall into two categories: mechanical defense and chemical defense.
Mechanical defense is incorporated into the physical structure of the organism.
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 have liquid ink that they squirt out as a curtain to escape behind. Sometimes it's just an animal's size that is enough to deter a predator from attacking. Plants also have their own mechanical defenses. Many have thorns, spines and stiff hairs that repel a predator. Some grasses in the African savannahs have a thick deposit of silica that wears away the teeth of grazing animals. However, some of these animals have counteradapted and have developed large, hard molars that resist the abrasive action of the mineral.

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 combination of hydrogen peroxide and a boiling solution of quinines. 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 a great example. As larva, monarchs feed on milkweed plants, which contain cardiac glycosides, which are poisonous to vertebrates and many insects. After pupation, the tissues of the adult monarch are saturated with the chemicals. Birds that eat the monarch will vomit violently. This is a way of ensuring the monarch's survival.

Chemical defenses in plants come in a number of ways. 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.

Another defense is **camouflage**. It involves colors and patterns that enable the organism to blend into its environment or appear to be something they are not. **Cryptic coloration** is when an organism has the same color or pattern as its background. Gecko lizards, tree frogs and leafhoppers are a few examples. **Disruptive coloration** is another example

where an organism's silhouette is broken up by color patterns. **Countershading** is when an organism is two toned. Light and dark colors reduce the 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.

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

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

Sample Questions For Content Domain IV: Ecology

1 A group of organisms of a certain species that is in one area at a given time is know as a (an)

A ecosystem
B community
C population
D trophic level

2 As energy flows through an ecosystem, at each trophic level it

A increases
B decreases
C fluctuates
D remains the same

3 Predators often feed on weak or sick animals in an ecosystem. The role of the predator is described as its

A community
B habitat
C niche
D population

4 The dodder is a land plant that parasitizes other plants. It grows in long thin strands that penetrate the host plant and absorb water, minerals and carbohydrates. Unlike other land plants, the mature dodder does not require

A nutrients
B water
C air
D sunlight

5 The state of California has several large cities and very productive croplands that divert and use large amounts of water from rivers. What is one damaging effect of this use of water from the rivers?

A increased amounts of solid waste pollution in the oceans
B decreased amounts of fresh water in marshes and estuaries
C changes in local rainfall amounts
D changes in upstream water tables

6 Plants that live in the rainforest have many adaptations to their environment. Some plants such as vines have adaptations which allow them to attach themselves to the trunks of trees. These adaptations allow vines to successfully compete for which of the following limiting resources in the rainforest?

A sunlight
B water
C carbon dioxide
D oxygen

7 Lightning causes a fire that destroys all the plants in a forest community. Which of the following is most likely to be the first to occupy the burned area?

A oak seedlings
B pine trees
C grasses and annual plants
D woody shrubs

8 Pilot fish and sharks have a relationship where the pilot fish eats bits of food that the shark drops or leaves behind. The shark is unaffected by the pilot fish behavior. Which of the following best roles describes the pilot fish?

A predator
B herbivore
C scavenger
D parasite

9 Birds have been observed puffing up their feathers under certain conditions. By trapping air between feathers, this behavior helps the bird

A hide from enemies
B expend less energy during flight
C shelter offspring
D trap body heat

Answers to Sample Questions in Content Domain IV

1. Answer: **C** Standard SB4.a: *Investigate the relationships among organisms, populations, communities, ecosystems, and biomes*

The correct answer is **C,** population. An ecosystem consists of all biotic and abiotic factors. A community consists of several populations living in an area. Trophic levels have to do with energy pyramids. One trophic level can include many species.

2. Answer: **B** Standard SB4.b: *Explain the flow of matter and energy through ecosystems by*

- *Arranging components of a food chain according to energy flow*
- *Comparing the quantity of energy in the steps of energy pyramids*
- *Explaining the need for cycling of major nutrients (C, O, H, N, P)*

The correct answer is **B**. As energy is transferred up the energy pyramid, remember that only about 10% of the energy moves to each successive level. The rest of the energy is used by the organisms themselves or is given off as heat.

3. Answer: **C** Standard SB4.a: *Investigate the relationships among organisms, populations, communities, ecosystems, and biomes*
The correct answer is **C**. The community describes the different populations in an ecosystem while population describes all individuals of the same species. The niche of any organism is the functional role within the ecosystem. A habitat is the physical environment of an organism.

4. Answer: **D** Standard SB4.e *Relate plant adaptations, including tropisms, to the ability to survive stressful environmental conditions*
The correct answer is **D**. Since the dodder is able to get water, minerals and carbohydrates from other plants, it can survive without sunlight for photosynthesis. The dodder does require air for cellular respiration.

5. Answer: **B** Standard SB4.d *Assess and explain human activities that influence and modify the environment such as global warming, population growth, pesticide use, and water and power consumption*
The correct answer is **B**. The rivers flow into marshes and estuaries and excessive water use results in a decreased amount of fresh water and increased salinity in the marshes and estuaries. The primary cause of solid waste pollution in oceans is dumping of garbage. The use of water from rivers has not been found to significantly affect local climate conditions. The underground water tables in upstream watersheds are not impacted by downstream water use.

6. Answer:**B** Standard SB4.e *Relate plant adaptations, including tropisms, to the ability to survive stressful environmental conditions*
The correct answer is **A**. The tree canopy of rainforests blocks most light from reaching the ground. The vines have adapted in ways that make it possible for them to live in a part of the rainforest that has more available light.

7. Answer: **C** Standard SB4.c *Relate environmental conditions to successional changes in ecosystems*
In most ecosystems, secondary succession begins with grasses and annual plants, whose seeds either are fire-resistant or carried easily on the wind or by animals. These plants are then followed by shrubs and perennial plants, then by trees.

8. Answer: **C** Standard SB4.a *Investigate the relationships among organisms, populations, communities, ecosystems, and biomes*
The correct answer is **C**. Since pilot fish eat what the shark leaves behind, it is best described as a scavenger. Pilot fish do not obtain food by hunting, meaning it is not a predator. Since the pilot fish eats only pieces of food left by the shark, it does not eat plants. The pilot fish is not a parasite since the shark is unharmed in the relationship.

9. Answer: **D** Standard SB4.f *Relate animal adaptations, including behaviors, to the ability to survive stressful environmental conditions*
Rationale: The correct answer is **D**. Air trapped between feathers acts as an insulator. Puffing up will not help the bird become less visible, fly faster, or act more protectively.

Content Domain V: Evolution

A LOOK AT CONTENT DOMAIN V

Test questions in this content domain will measure your knowledge and understanding of the role of natural selection in the development of the theory of evolution. The questions will assess your understanding of and ability to:

- Trace the history of the theory
- Explain the history of life in terms of biodiversity, ancestry, and the rates of evolution
- Explain how fossil and biochemical evidence support the theory
- Relate natural selection to changes in organisms
- Recognize the role of evolution to biological resistance

Spotlight on the Standards

★*Trace the History of the Theory*★

The Origins of the Theory

When we think of evolution, our minds often relate that thought to the name of Darwin. But the concept of evolution began much earlier than Darwin. In fact in 1809, the year that Darwin was born, a French zoologist named Jean Baptiste de Lamarck presented a new evolutionary theory. Lamarck believed that all life forms evolved and that the driving force of evolution was the inheritance of acquired characteristics. He believed that organisms changed due to the demands of their environment. This "passing on of acquired characteristics" helped lower life forms climb the ladder of life to become more complex organisms. The example that he used in explaining his theory is that of a giraffe's neck. He believed that in order for the giraffe to reach its food, it had to stretch its neck. So, over many generations, an elongated neck became part of the giraffe's makeup. He also believed that if a body part of an organism wasn't used, that body part would be lost. We know today that his theory was a little off. But it does have an important relationship to Darwin's theory, that is, that evolution of living things proceeds according to natural laws.

Geologists were also discovering ancient bones, shells, and fossilized plants in England in the late eighteen hundreds. They were finding these remains on hillsides and in riverbeds. These findings caused people to look for an explanation for the existence of the fossils.

This new revolutionary concept of evolution would soon become a fundamental theory, explaining the diversity of organisms.

Darwin

Before Darwin ever set sail on the HMS *Beagle*, he was already preparing himself by reading Charles Lyell's *Principles of Geology.* Lyell proposed that plant and animal species had arisen, developed variations, and then became extinct over time. He also believed that the Earth's physical landscape changed over a long period of time. Darwin read an essay written fifty years before his time by a man named Thomas Malthus called *The Principles of Population.* In it, 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*. What an adventure it must have been for this naturalist! 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. But when Darwin reached the Galapagos archipelago, the world burst open before him with an amazing variety of life.

It was here that he found large iguanas swimming in the ocean and eating seaweed! Lizards have always been terrestrial reptiles in warm environments. What were they doing in the ocean? He also found giant tortoises with carvings on their backs from whalers that had passed through a hundred years before. He saw different variations of mockingbirds and other bird species.

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. The organisms that lack these adaptations will not reproduce as successfully.

Secondly, the organisms on the Galapagos 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 with finches of the same species on another island. He theorized that within a population of a species, adaptations would arise due to reproductive isolation. The organisms would develop adaptations to their environment

over time that would result in significant differences between the same species on different islands.

But while Darwin was composing his theories of evolution, another man by the name of 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 evolutionary theory.

What is even more interesting is the fact that Darwin knew nothing about genes or genetics. He was missing the connection between heredity and differences in the characteristics of organisms. 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.

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 these variations on to the next generation.

A question for this standard on the *Biology* **EOCT** may look like this:

Ancestors of the koala lived on the ground, but modern koalas live in trees and eat eucalyptus leaves, which are poisonous to most other animals. The difference between the ancestor and modern koalas was caused by

A the presence of homologous structures
B the presence of vestigal organs
C selective breeding
D natural selection

The correct answer is **D**. Koalas changed gradually over time through the process of natural selection to fit a niche in which there was little competition for food or habitat. Homologous structures and vestigal organs are a result of evolution, not a cause. Koalas were not selectively bred by humans to have the traits they have today.

Spotlight on the Standard

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

Ever since Darwin and his theory of evolution and Mendel with his genetics, scientists have come to the conclusion that all organisms on Earth are somehow related. Some animal relationships are easier to observe than others. Scientists have coined the term **adaptive radiation** when diversity seems to have occurred in a newly evolved species in a relatively short time. They also believe it occurs when an organism colonizes a new area in which there is another organism that is lacking in survival skills. Researchers use the example of the finches Darwin observed on the Galapagos Islands. He counted over a dozen different kinds of finches that he believed evolved from a single founding species.

A similar, but opposite concept is that of **convergent evolution**. This is where unrelated species may independently evolve superficial similarities, because of their adaptations to the same environment. These connections are valid in their own way but they still have their limitations as to tying together the relationships that organisms have with one another. It wasn't until molecular biologists developed new techniques for analyzing DNA that a major connection was made. As more and more data were gathered, evolutionary biologists became intrigued with DNA and the information that it provided about the relationships between 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. One structure in particular that is of great interest is the ribosome. Molecular biologists have found that the DNA sequences that build bacterial ribosomes are similar to the genes that direct the assembly of human ribosomes. Another interesting connection they found was myosin. **Myosin** is a protein found in muscle cells of humans and other multicellular organisms. Myosin reacts with other proteins to cause muscles to contract, causing movement. The interesting point is that myosin is also found in yeast cells. Do yeast cells have muscles that make them move? No, not really. But they do have parts within the cell that require movement. This is accomplished when the myosin interacts with other proteins to make that movement possible. So, how can these similarities be explained? The original form of myosin made it possible for parts of the cells to move. As life diversified, the original myosin genes evolved into forms that help our bodies move. This similarity between genes and DNA shows that once life began, it diversified by evolving, combining, and mixing up the makeup of living organisms. This has culminated in what scientists call **biodiversity**.

Biodiversity is the variety of organisms, their genetic information, and the biological communities in which they live. Researchers use three different terms when talking about biodiversity:

Ecosystem diversity includes the variety of habitats, living communities, and ecological processes in the living world.
Species diversity includes the vast number of different organisms on Earth.
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.

Is it possible, then, to determine how long ago genes branched off from a common ancestor? 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. It seems that different branches on the evolutionary tree 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.

Speciation is the evolution of a new species that occurs when interbreeding happens, or when the production of fertile offspring is prevented. In the physical world, natural barriers form and cause the breakup of populations to form smaller populations. Volcanoes, sea-level changes, and earthquakes are a few examples of natural occurrences that affect populations. This is known as **geographical isolation**. Geographical isolation prevents interbreeding, so gene exchange will cease. 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 it can be concluded that there is a new species formed.

Gradualism is the concept that evolution occurs over a long period of time and that adaptive changes accumulated 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 in between.

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 change as new evidence becomes available.

For the ***Biology*** **EOCT**, 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. A question may look like this:

Horses and tapirs have a common ancestor, but now look very different. Horses now are grassland animals adapted for grazing on grass and shrubs. Tapirs are jungle animals that live in dense forests and eat fruit, leaves, and aquatic vegetation. Which of the following led to the development of such differences in the two species?

A selective breeding
B convergent evolution
C DNA hybridization
D natural selection

The correct answer is **D**. The animals with traits that contributed to success in a particular environment reproduced and passed on those traits. Horses and tapirs were not developed by selective breeding. DNA hybridization is a laboratory technique used to evaluate DNA similarities and differences. Convergent evolution is a process by which unrelated organisms develop similar attributes due to living in similar environments.

You may also be asked to describe historical ideas that lead 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 are discovering gigantic tubeworms near the deep sea vents in the Marianas Trench. Paleontologists are uncovering fossils never before seen in Montana. It does not mean that these are newly-developed species. We just were not able to observe them before. Not everybody will agree with any one theory. Biologists turn to the fossil record. That is where we will look too!

Spotlight on the Standard

★Explain How Fossil and Biochemical Evidence Support the Theory★

Have you ever tried putting together a jigsaw puzzle but find that there are missing pieces and you just can't quite get the picture together? That's what faces biologists in trying to put together the fossil record. The fossil record provides biologists with an incomplete picture of the evolution of the Earth's plants and animals. Many fossils are the remains of the hard parts of an organism after they have died. Many are from shells, bones or the remains of plants with thick cell walls. There are also impressions left behind in sediments along rivers and lakes. One problem with the fossil record is that there are no remains of any "intermediate" or transition forms. That "missing link" is still missing. There are several reasons that paleontologists have for this theory. They estimate that

approximately two-thirds of all the organisms that ever lived were soft bodied. They didn't have rigid skeletons or teeth that could be left behind. It also depended on where and how an organism died as to whether their remains could be fossilized. Fossils also could have been destroyed by erosion or pressure from overlaying rocks. Exposure to wind, rain, and soil erosion in certain landscapes could have prevented fossils from ever forming. There are many environmental factors that must be taken into account when you look at the fossil record. One final problem is that of **time-averaging**. That is how paleontologists determine the length of time represented in a given fossil sample. They take into account the death, the burial, and any movement of the remains of the fossil. This makes it very difficult to determine when one organism lived relative to another. When a scientist finds two different fossils in the same area (for example, a type of bone found among clamshells) it doesn't necessarily mean that they lived in the same time period or even in the same area.

Biologists have found a way to determine the relative ages of fossils within a semi-precise time limit. It is called **radioisotope dating**. These isotopes act as a clock for measuring time. To use this method, scientists must know:

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

Carbon 14 (^{14}C) is the primary isotope that is 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, 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 the 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.

So, biologists will utilize 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**.

Once the ages have been established, they will use that information to build a **phylogeny**. A phylogeny is a description of the lines of descent of plants and animals as they lived from one era to the next. The most complete line that has been discovered is of the horse. Paleontologists have been able to trace similar forms of the horse and also show a sequence of changes that have taken place over a long period of time. But for most organisms, it's not that easy. Fossil collections are not complete enough to determine any evolutionary patterns or traits. It makes it hard to determine on a phylogenic tree which organism is descended from which. In this case, a biologist will infer likely phylogenies

by comparing morphological features and chromosomal characteristics and insert the organism that is compatible.

For the ***Biology*** **EOCT**, it is important that you are able to explain the concepts of how the fossil record and biochemical evidence support the theory of evolution. A question on the test may look like this:

Fossils of Archeopteryx show that this animal had feathers, like a bird. It also had a bony tail, teeth, and claws on its wings, like a reptile. This fossil is evidence that supports the idea that

A birds and reptiles have a common ancestor
B birds have changed very little over 150 million years
C reptile species are more advanced than bird species
D reptiles are warm-blooded like birds

The correct answer is **A**. The fossil is a transition fossil, showing the gradual loss of some unnecessary physical structures and the gradual development of those characteristics that were beneficial to survival. Most birds are very different from the fossil Archeopteryx and have changed a great deal in the past 150 million years. There is no evidence in this fossil to show that reptiles are more advanced than birds. Reptiles are not warm-blooded like birds.

Extinction

Extinction is the permanent loss of a species. We know that extinctions have occurred over time. The great red elk and the saber tooth tiger are two examples of extinct species. Scientists can only speculate about the forces that have driven certain species and even whole lineages of organisms to become extinct. Paleontologists have come to the conclusion that there have been five mass extinctions, resulting in a great number of species being completely wiped out. They believe one of these mass extinctions to have occurred at the end of the Permian period, when 96% of marine invertebrates became extinct. The other one they believe to have occurred is at the end of the Cretaceous period, when they believe 60-75% of marine species died. What would cause such a catastrophic event that would lead to this extinction?

Researchers must take caution in interpreting data on these mass extinctions. We have learned that the fossil record is not a complete way to determine all the species that once lived. There are missing pieces to the puzzle. Where are these missing pieces, and did they ever exist? Also, if there were catastrophic events that were the cause of these extinctions, did they happen quickly or did they occur over a long period of time? If they occurred over a long period of time, why did the species not adapt to their changing environment in order to survive? Questions like these spark an interest and inspire people like Darwin, Wallace, Lamarck, and others to search the world around us to understand where life began.

Spotlight on the Standards

★Relate Natural Selection to Changes in Organisms★

Remember that the key to Darwin's theory of organisms struggling for existence came from the concept that some organisms have an advantage over others. This advantage increases the organism's survival rate. If the physical appearance (phenotype) of an organism changes to improve the reproductive success of the organism, then it makes sense that the genes involved have also changed.

Well, let's take a look. If you look around your classroom, you notice a great variety of sizes, shapes, and colors among your classmates. The same is true for just about every species. Within each species is a vast array of morphological (structural) differences. This presents a problem for evolutionary biologists. It is impossible to determine the exact number of gene loci and alleles that are responsible for variation. Remember that one gene can affect a number of traits and, conversely, two or more genes can affect one single trait. Is there an easy genetic explanation? Mendel was on the right track in working with genes that controlled physical traits. It was in the 1950s and '60s that new techniques allowed molecular biologists to discover the genetic code and protein structure. This enabled them to explore genotypes and phenotypes at a deeper level, making the connection between genetics and adaptation by the process of natural selection.

Natural selection acts on an organism's phenotype and indirectly on its genotype. Gene pools change over time due to nonrandom mating, genetic drift, mutation, migration and natural selection. Natural selection is credited with the vast number of 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. What does this mean? The fitness of an individual depends on the probability that the one individual will contribute its genetic information to the next generation. It depends on that organism's ability to survive and reproduce successfully. It is not necessarily the strongest, biggest, or most aggressive animal that has the highest fitness rating. It is a combination of structure, physiology, biochemistry, and behavior that determines an animal's fitness. When an organism has a set of alleles and proteins with a variety of phenotypes and biological capabilities, it enables the individual to survive under a wide range of environmental factors.

Biologists use two rules to tie together geography with fitness of allelic variations in warm-blooded animals.

Environment plays an important role in determining which of several alleles is optimum for a population's survival. Selective processes will lead to an increase in adaptations of populations in their environment. Let's look at some types of selective processes in natural selection. Keep in mind that natural selection doesn't always increase the complexity of an organism's structures or behaviors. Also, natural selection doesn't produce new genotypes and phenotypes, but it rather eliminates the less fit, enabling the more fit to reproduce and ensuring the species survival.

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 change from one phenotypic property to a new one. 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. Directional doesn't mean that something is directing change. It may be that the variant arose by chance or was already part of the allele, and selective pressure opted for the preservation of it. Many insects have become resistant to pesticides. Those with enzymes that resist the organophosphate insecticides sprayed on them survive and reproduce, passing on the genes for the enzyme.

Diversifying Selection
When a population is faced with conditions so diverse that no single phenotype is more successful that any other, genetic and phenotypic variability allow different selective pressures to operate at the same time. This results in two or more phenotypes, each adapted to some specialized feature for a particular part of the total environment. Some plants may be highly specialized for a certain environment and will not grow in any other place.

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

Balancing Selection
Balancing selection operates to counteract the loss of variant alleles in a population. There are two forms of balancing selection: **heterozygote advantage** and **frequency-dependent selection**. Heterozygote advantage exists when a heterozygote (Aa) has a higher fitness than either homozygote (AA, aa).

Heterozygote advantage is used by plant and animal breeders by breeding together two distinct parental lines in order to improve their product; a sweeter ear of corn or a line of prize dogs. There is a disadvantage to this. It is called **genetic load**. Genetic load is the sum total of those alleles that yield some advantage when they are heterozygous but that are lethal or deleterious when homozygous.

Frequency-dependent selection is a process that operates when the relative fitness of the genotypes in a population vary according to their frequency. It occurs when a predator concentrates on a particular phenotype, usually the most common and the most abundant.

Natural selection can take on many forms and produce diverse effects on organisms. 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 species or increasing a species. Increasing the diversity in genotype and phenotype may result in a new species. Whatever job natural selection takes on, it is evident to most biologists that it is the major driving force in the evolution of life.

A lot of material has been covered. It is important for you to review your textbook. On the ***Biology*** **EOCT**, you may be asked to describe the different variations of natural selection and their impact on a species. A question may look like this:

Although the Arctic fox and the kit fox are closely related, they look very different because the individuals

A acquired traits during their lifetimes that contributed to survival
B with traits most suited to their environments reproduced most successfully
C migrated long distances to environments that most suited their traits
D passed on to their offspring acquired behaviors that were helpful

The correct answer is **B.** The animals gradually evolved to have very different traits that helped them succeed in very different environments. Traits and behaviors acquired by an animal during its lifetime are not passed on to the next generation. The animals also would not have moved to a dramatically different region to try to fit their traits to their environment.

Spotlight on the Standard

★Recognize the Role of Evolution to Biological Resistance★

New techniques in molecular biology have given researchers new insight into genetic mechanisms that may be involved in some types of directional selection. Remember that directional selection involves change from one phenotypic property to a new one. It refers to a trend that happens consistently over time. When a bed of oysters in Malpeque Bay was infected with a lethal pathogen in 1915, it almost wiped out the oyster industry. But 10 years later, the oysters were making a comeback. By 1940, the Malpeque Bay was producing more oysters than it ever had. They began to repopulate other areas that had been wiped out. What brought about this drastic change for the oyster? Directional selection. Out of the 50 million or so offspring that were produced each year by the oysters, a fraction of those offspring carried an allele that was resistant to this pathogen. So when the environmental conditions were favorable for the offspring that carried this allele, the outcome was an increase in that variant in the population. This resulted in an increase in healthy oysters.

Many insects have developed a resistance to insecticides. Simple point mutations may be the process by which enzymes like acetylcholinesterase are modified so they are no longer susceptible to the insecticide. Some mosquito populations react differently when exposed to organophosphates. They have a gene coding for a detoxifying esterase enzyme. It keeps the organophosphate at a nonpoisonous level. It has been discovered that in a swamp treated with a pesticide, the surviving mosquitoes had an amplification of this gene. Over 250 copies were present in each diploid cell. With this large number, the mosquitoes can make large amounts of the esterase enzyme resulting in detoxifying the insecticide.

This gene amplification has been observed in other arthropods, in mammalian tumor cells, and during cell differentiation. Biologists are not sure what exactly triggers or signals this process but they do know that once it starts, gene amplification takes on specific characteristics that enable it to perform its particular function. Viruses are another organism that are constantly evolving in response to changes in their environment. Some don't change quickly, like smallpox or measles. This gave biologists time to create a vaccine against them. Others change very quickly, like the flu. The flu virus mutates rapidly, constantly changing its genotype and phenotype, so the flu virus changes year to year. The body does not recognize the new virus as anything harmful, so it doesn't send out anything to attack it. Another adaptation of viruses is that certain viruses can live in two or more different hosts. One virus may originally live in pigs and geese and then move on to live in humans and ducks. Viruses carry their genetic information on eight pieces of DNA. So if two strains of the virus infect the same cell, some of those genes will get mixed up, resulting in a new strain of the virus. This can cause major problems for the host.

It is very important to review your textbook and study these concepts. On the ***Biology* EOCT** you may be asked to explain the importance of evolutionary changes on organisms that are affected by biological resistance and how these come about. A question may look like this:

Some viral diseases require only one vaccination, which lasts for years. For other diseases like the flu, vaccinations last only one season. The flu vaccine lasts such a short time because the flu virus

A is more easily transmitted
B mutates much more rapidly
C is less dangerous
D is much smaller

The correct answer is **B**, the flu virus mutates much more rapidly.

Sample Questions for Content Domain V

This section has some sample questions for you to try. After you have answered all of the questions, check your answers in the "Answers to the Content Domain V Sample Questions" section that follows. This section will give you the correct answer to each question, and it will explain why the other answer choices are incorrect.

1 From the following answers, which is considered by most biologists to be the most accurate in supporting the theory of evolution?

A fossils
B embryology
C DNA sequencing
D genetic equilibrium

2 The development of radiocarbon dating allows scientists to see how many times carbon atoms have been through half-lives. Since scientists know the length of a C-14 half-life, they can gain knowledge about fossils using the C-14 dating technique. When radiocarbon dating was first introduced, it changed the way people thought about how organisms evolved because the technique showed

A how long ago some organisms were alive
B that eating habits have changed in some animals
C how different the chemical composition was long ago
D that most plants were gymnosperms

3 There are millions of species of organisms living at this time and new species are still being discovered. Based on Darwin's theory of evolution, which of the following best describes how millions of species have developed?

A Organisms passed on acquired characteristics to evolve from lower life forms to higher life forms.
B Organisms were selectively bred to create different species.
C Completely different species crossed with one another to form the many different organisms.
D Different genetic variations in organisms were selected in different environments.

4 Which of the following best supports the idea that organisms and environments have changed over time?

A the discovery of fossilized fern plants in Antarctica
B the production of sterile hybrid animals such as the mule
C the many different species of plants in tropical areas
D the ability of many animals to learn new behaviors

5 **The cotton whitefly has become a key pest, damaging many kinds of crops. The cotton whitefly has developed resistance to a variety of pesticides. Pesticide resistance would most likely develop in insects that**

A reproduce rapidly
B feed on few types of plants
C undergo complete metamorphosis
D live in very limited regions

6 **The DNA of an organism contains information that is used to sequence amino acids to form specific proteins. The existence of different organisms with very similar amino acid sequences is evidence of**

A a common ancestor
B common adaptive behaviors
C a similar diet
D a similar environment

7 **Microorganisms such as bacteria are able to change and adapt much more quickly than other organisms. Bacterial populations, for example, are able to build a resistance to antibiotics within months, whereas compounds that are toxic to animals remain toxic to animals for many years. One reason for their rapid adaptability is that microorganisms**

A are highly motile
B have a short life span
C have specialized organelles
D are chemosynthetic

Answers to the Content Domain V Sample Questions

1. Answer: **C** Standard SB5.d: *Relate natural selection to changes in organisms*
The correct answer is **C.** DNA is the most accurate tool for determining relatedness among individuals. Remember that when Darwin developed his theory of natural selection, he did so without the benefit of the knowledge of genes. We have learned that adaptations of species are determined by the genes encoded in the DNA. Fossils are a way to determine the evolutionary process, but it is not the best way. There are a lot of missing puzzle pieces that are not accounted for. Genetic equilibrium is when there is no change in the frequency of alleles within a population. It is believed that when a population is in genetic equilibrium, it is not evolving.

2. Answer: **A** Standard SB5.c; *Explain how fossil and biochemical evidence support the theory*
The correct answer is **A**. Using the half-life value of carbon and knowing how many half-lives the carbon had experienced allowed scientists to calculate estimates of how long the organisms were alive. In many cases the time frame was much larger than originally thought. Radiocarbon dating offers no information about eating habits or chemical composition (other than carbon). C-14 dating did not provide information about the reproductive strategies of organisms.

3. Answer: **D** Standard SB5.d *Relate natural selection to changes in organisms*
The correct answer is **D**. As organisms reproduced, different combinations of traits and genetic mutations produced organisms with different characteristics. Organisms with different traits were successful in different environments. Many species evolved to fit the many different niches in the different environments. Characteristics acquired during an organism's life are not passed on to future generations. Selective breeding by humans did not take place until long after millions of different species already existed. Organisms of completely different species rarely cross successfully because of incompatibility of their DNA.

4. Answer: **A** Standard SB5.a *Trace the history of the theory*
The correct answer is **A**. The existence of fossilized ferns in Antarctica is evidence that the environment of Antarctica has changed greatly. The organisms that live in Antarctica now are adapted for a very different climate than the fossilized ferns that once lived there. The breeding of sterile hybrid animals such as the mule would not contribute to the change of organisms over time because the hybrids would not be able to reproduce to pass on their unique combination of traits. The existence of many species of tropical plants does not show that the plants have changed over time. Learned behaviors are not passed on to future generations.

5. Answer: **A** Standard SB5.e *Recognize the role of evolution to biological resistance*
The correct answer is **A**. Organisms that reproduce rapidly can fix new traits quickly because there are many generations in a short time period and mutations that help the organism survive are passed on to many more organisms in a short time. Usually, living in a limited region or eating only a few types of plant does not help organisms develop resistance because if there are significant environmental changes, these organisms are more likely to be reduced in numbers because they are not very adaptable. The process of metamorphosis does not help organisms develop pesticide resistance.

6. Answer: **A** Standard SB5.c *Explain how fossil and biochemical evidence support the theory*
The correct answer is **A**. Organisms with similar amino acid sequences are related to a common ancestor and will have similarities in their DNA. Many organisms have a similar body structure due to their environment or diet, but are not related (seals and penguins).

7. Answer: **B** Standard SB5.e *Recognize the role of evolution to biological resistance*
The correct answer is **B**. The ability to build a resistance to antibiotics is a result of the fact that many types of bacteria are able to produce thousands of generations in the same population in a matter of days. Not all bacteria are highly motile and this trait does not help the bacteria develop resistance. Chemosynthesis and specialized organelles do not contribute to the development of antibiotic resistance. Antibiotic resistance is a result of natural selection.

Co-requisite Domain: Characteristics (and Nature) of Science

A LOOK THE CO-REQUISITE DOMAIN

Test questions in this content domain will measure your ability to use scientific processes and solve problems. Your answers to the questions will help show how well you:

- Identify tools, terms and processes used in scientific inquiry, including laboratory safety and scientific research.
- Comprehend how scientific knowledge is developed.
- Recognize how scientific information is properly verified and communicated.

This part of the domain will test how well you understand the importance of ethics in science. Scientists should be curious, honest, open, and skeptical in the pursuit of knowledge. You should develop these traits during your own activities in the lab and classroom. In the lab, you might have noticed that different explanations can often be given for the same evidence. The four qualities, just mentioned, should lead you and others to find the most accurate explanation for the evidence. This requires further understanding of the scientific problem. It will require you to design and perform new experiments. These experiments will either support or weaken the opposing explanations.

Before starting the experiments, you and your classmates should use standard safety practices. These should be carefully followed in the classroom, laboratory and out in the field. These practices include:

- Always use correct procedures when working with scientific apparatus
- Always use proper techniques in the laboratory
- Immediately identify and report safety problems and violations

LABORATORY SAFETY

- Conduct and Preparation in the Laboratory
- Eye Safety
- Safety Equipment
- Dress Code and Neatness
- Working with Sharp Instruments
- Working with Chemicals
- Working with Glassware
- First Aid and Handling Emergencies
- Waste Disposal and Cleanup

Below is an example of a question on safety practices.

A student plans an experiment to separate a water solution containing borax by heating the solution over a Bunsen burner. In this way, the water is evaporated. Which piece of safety clothing or equipment is MOST appropriate for this experiment?

A cotton gloves
B dust mask
C fume hood
D safety goggles

Safety goggles (eye protection) should be worn when an experiment involves heating chemicals, so **D** is the correct answer. Since water is the substance being evaporated and borax is a dissolved solid, a fume hood is not necessary, so **C** is incorrect. Choices **A** and **B** do not represent equipment that is needed for this experiment.

By this time, you should have addressed all safety issues. Now you are ready to identify and investigate a scientific problem. First, reasonable hypotheses should be suggested for an identified problem. Then procedures should be developed to solve the problem. These procedures, when carried out, will require you and your lab group to gather, organize and record data. At the end of the experiment, the data points should be graphed so you can compare and analyze your results. Statistics should be summarized as well. Based on this work you should develop reasonable conclusions based on the data. You will evaluate whether your conclusions are reasonable by reviewing the process and checking your data against all other available information.

You will find that good data collection and organization are vital for success. As a result, you should learn to use tools and instruments for observing and measuring data. As part of this process, you should do the following:

- Develop and use orderly procedures for recording and organizing information.
- Use technology to produce tables and graphs
- Use technology to develop, test, and revise your experimental or mathematical models

STRATEGY BOX—Graphs

When working with graphs, carefully read the title and the label on each axis. Check for any other information that might be included in the graph. When you think you have the answer, double check the information given in the graph.

On the test, you will need computation and estimation skills to analyze data and create scientific explanations. Sometimes you will notice large differences between your estimates and your calculated answers. Measurement errors may have a noticeable effect on calculations. Good computation and estimation skills are needed to produce reliable results. You should know that accuracy indicates how close your measurements approach the accepted value. Precision is the agreement between two or more measurements. You should be able to express the correct number of significant figures in your calculations. Scientific notation should be used to report very large or very small values. Finally, you should be able to solve problems by substituting values into simple algebraic formulas. You might also use dimensional analysis. Below is an example of a question that assesses your computational skills in a lab activity.

In a field investigation, students predicted the population density of birch trees in a temperate forest. Three groups of students gathered data by counting the number of birch trees in a 1- m^2 area. They recorded their data in the table below.

Number of Trees	11	3	7
Average diameter of trunk of the birch trees in centimeters	5	14	8

Based on the data above, what is the average number of trees that live in a 400 m^2 section of the same habitat, and what is the average diameter of the trunk of each tree?

A 2800 trees with an average trunk diameter of 9 cm
B 21 trees with an average trunk diameter of 9 cm
C 21 trees with an average trunk diameter of 27 cm
D 280 trees with an average trunk diameter of 27 cm

The correct answer is **A**. The average number of trees per square meter was multiplied by 400. The average of the measurements for trunk diameter is correctly determined. Option **B** and Option **C** are wrong because the trees for the three plots were added. Option **C** is also wrong because the trunk size was not averaged. Option **D** is wrong because the trunk diameter was not averaged.

One of the goals of scientists is to communicate scientific investigations and information clearly. With this in mind, you should be able to write clear, logical laboratory reports. You should also be able to write clear, understandable critiques of current scientific issues, including possible alternative interpretations of scientific data. When presenting data, you should use it to support scientific arguments and claims during a group discussion.

INVESTIGATING LIKE A SCIENTIST

- State the problem – ask a question
- Do background research – gather information
- Form a hypothesis – suggest an answer
- Design an investigation – perform an experiment to test the answer
- Collect data – record the results of the experiment; make a data table if necessary
- Analyze data – interpret the results of the experiment
- Draw conclusions – explain your results
- Identify new questions raised by the conclusions for further investigation
- Communicate results – share your results

To understand how science leads to new discoveries, you should be able to analyze how scientific knowledge is developed. In order for science to grow and develop, certain assumptions are required. First, scientists assume that the universe is a vast single system in which basic principles are the same everywhere.
These universal principles are discovered through observation and experimental confirmation. Science is not exact or perfect. From time to time, scientific explanations may change as new data result in changes in the scientific view of how the world works. Most of the time, small changes to previous models lead to shifts in scientific knowledge. Major changes in scientific views typically occur when a new phenomenon is observed. These changes also occur when an individual or research group gives an insightful interpretation of existing data. Hypotheses often cause scientists to develop new experiments. These experiments produce additional data. The results of these experiments are tested and revised. New and old theories may occasionally be rejected. The process of testing and fine-tuning theories never ends as scientists try to gain new insights into old problems. A question on the test might look something like this:

The development of a useable scientific model may be hindered by errors and mistaken beliefs. The scientific method, however, should eventually lead to better scientific models because

A contemporary scientists appreciate the scientific method more than ever.
B new computer technology immediately detects the scientists' errors.
C more complex scientific models lower the probability of inaccurate results.
D additional scientific research either confirms or replaces flawed theories.

Answer **D** is the correct answer. Continuing research leads to better explanations of phenomena. This leads to the revision or rejection of present-day theories. Answer **A** is incorrect because it is incorrect to assume that scientists today appreciate the scientific method more than previous scientists did.

Computers do not eliminate human error so answer **B** is incorrect. Just because a model is more complex, it does not lessen the likelihood of inaccurate results; it could make inaccurate results more likely. Answer **C** is therefore incorrect.

Finally, you should understand the important characteristics of the process of scientific inquiry. These characteristics include the following:

- The conditions of the experiment should be controlled to obtain valuable data,
- The quality of data, including possible sources of bias in hypotheses, observations, data analyses, and interpretations, should be critically examined and tested.
- Peer review and publication should be employed to increase the reliability of scientific activity and reporting.
- It should be remembered that the merit of a new theory is judged by how well scientific data are explained by the new theory.
- The ultimate goal of science should be to develop an understanding of the natural universe which is free of human bias.
- It should be remembered that scientific disciplines and traditions differ from one another. These differences include what is being studied, the techniques used, and the outcomes being sought.

If you develop a good understanding of all the concepts presented here, then you will be successful answering the questions in this co-requisite domain.

EOCT Sample Overall Study Plan Sheet

Here is a sample of what an OVERALL study plan might look like. You can use the Blank Overall Study Plan Sheet in Appendix B or create your own.

Materials/Resources I May Need When I Study:
(You can look back at page 2 for ideas.)

1. *This study guide*
2. *Pens*
3. *Highlighter*
4. *Notebook*
5. *Dictionary*

Possible Study Locations:

- First Choice: *The library*
- Second Choice: *My room*
- Third Choice: *My mom's office*

Overall Study Goals:

1. *Read and work through the entire study guide*
2. *Answer the sample questions and study the answers*
3. *Practice reading and answering the general questions*

Number of Weeks I Will Study: *6 weeks*

Number of Days a Week I Will Study: *5 days a week*

Best Study Times for Me:

- Weekdays: *7:00 p.m. – 9:00 p.m.*
- Saturday: *9:00 a.m. – 11:00 a.m.*
- Sunday: *2:00 p.m. – 4:00 p.m.*

Blank Overall Study Plan Sheet

Materials/Resources I May Need When I Study:
(You can look back at page 2 for ideas.)

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____

Possible Study Locations:

- First Choice: _____
- Second Choice: _____
- Third Choice: _____

Overall Study Goals:

1. _____
2. _____
3. _____
4. _____
5. _____

Number of Weeks I Will Study: _____

Number of Days a Week I Will Study: _____

Best Study Times for Me:

- Weekdays: _____
- Saturday: _____
- Sunday: _____

EOCT Sample Daily Study Plan Sheet

Here is a sample of what a DAILY study plan might look like. You can use the Blank Daily Study Plan Sheet in Appendix D or create your own.

Materials I May Need Today:

1. *Study Guide*
2. *Pen*
3. *Notebook*

Today's Study Location: *the desk in my room*

Study Time Today: *From 7:00 p.m. to 8:00 p.m. with a short break at 7:30 p.m.*
(Be sure to consider how long you can actively study in one sitting. Can you sit for 20 minutes? 30 minutes? An hour? If you say you will study for three hours, but get restless after 40 minutes, anything beyond 40 minutes may not be productive—you will most likely fidget and daydream your time away. "Doing time" at your desk doesn't count for real studying.)

If I start to get tired or lose focus today, I will: *do some sit-ups.*

Today's Study Goals and Accomplishments: (Be specific. Include things like number of pages, sections, or standards. The more specific you are, the better able you will be to tell if you reached your goals. Keep it REALISTIC. You will retain more if you study small "chunks" or blocks of material at a time.)

Study Task	*Completed*	*Needs more work*	*Needs more information*
1. Review what I learned last time	X		
2. Study the first standard in Content Domain I	X		
3. Study the second standard in Content Domain I		X	

What I learned today:

1. *The difference between ATP and ADP*
2. *What the questions about organisms and genetics might look like*
3. *How to tell the difference between the Calvin cycle and Krebs cycle*

Today's reward for meeting my study goals: *Eating some popcorn*

Blank Daily Study Plan Sheet

Materials I May Need Today:

1. _____
2. _____
3. _____
4. _____
5. _____

Today's Study Location:

Study Time Today: _____
(Be sure to consider how long you can actively study in one sitting. Can you sit for 20 minutes? 30 minutes? An hour? If you say you will study for three hours, but get restless after 40 minutes, anything beyond 40 minutes may not be productive—you will most likely fidget and daydream your time away. "Doing time" at your desk doesn't count for real studying.)

If I start to get tired or lose focus today, I will: _____

Today's Study Goals and Accomplishments: (Be specific. Include things like number of pages, sections, or standards. The more specific you are, the better able you will be to tell if you reached your goals. Keep it REALISTIC. You will retain more if you study small "chunks" or blocks of material at a time.)

Study Task	*Completed*	*Needs More Work*	*Needs More Information*
1.			
2.			
3.			
4.			
5.			

What I learned today:

1. _____
2. _____
3. _____

Today's reward for meeting my study goals: _____