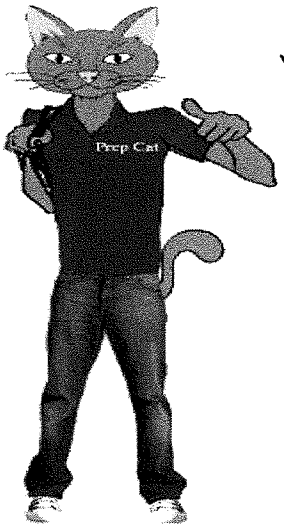
CHAPTER 3 LIFE SCIENCE



All through science the presence of "patterns" often appears. Learning to recognize patterns in nature will make the study of science more interconnected and easier to understand. Connections are everywhere. In this chapter you will study the patterns that help maintain the life of every organism in the biosphere. We'll begin by introducing ecosystems and then move on to a review of the human body. If you look closely you will see that ecosystems and the human body function in very similar ways. You will also see that you can better understand the natural world through careful observation.

PART I: INTERDEPENDENCE (INTERACTIONS BETWEEN LIVING THINGS AND THEIR ENVIRONMENT)

Standards: SC.5.L.15.1, SC.5.L.17.1, SC.6.L.14.1, SC.6.L.14.2, SC.7.L.17.1, SC.7.L.17.2, SC.7.L.17.3

Ecosystems

An ecosystem describes the interaction between ***biotic*** (living)and ***abiotic*** (nonliving) things in an environment. Don't let the terms biotic and abiotic confuse you. Remember, "***bio***" means *life*. The prefix "**a**-" means *not*. So ***a-biotic*** *means "not-life" or nonliving.*

Examples of *biotic* factors

1. animals
2. plants
3. humans
4. bacteria
5. fungi

Examples of *abiotic* factors

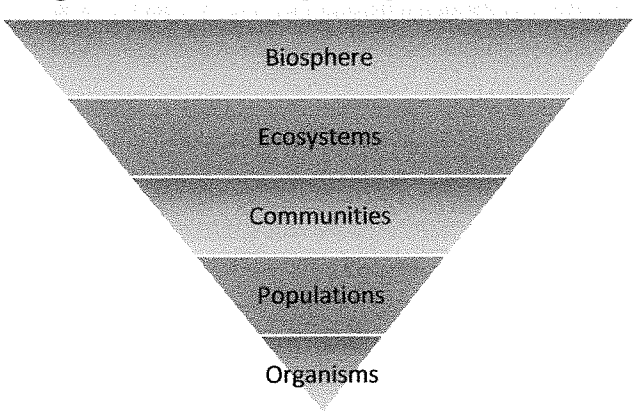
1. air

2. water
3. light
4. temperature
5. soil

Important terms

1. ***population***-- group of organisms of the same species (able to reproduce together) living in a given location. For example, all the brown bears in a forest make up a population of brown bears.
2. ***community***-- all the different interacting populations living in the same area. For example, the different populations of animals in a park make up a community.
3. ***biosphere***-- the location on Earth where all life exists. It is made up of many complex ecosystems. It includes water, air, and soil.
4. ***competition***--when two or more organisms seek the same resources for survival at the same time. These organisms share a habitat and will struggle for these resources. Plants in a forest compete for sunlight. Without sunlight they could not survive. Taller growing plants will out-compete their shorter growing plants for sunlight. Organisms compete for mates, food, shelter, etc.
5. ***niche***-- the role an organism plays in the environment. This includes the type of nutrients it requires, how it lives, how it reproduces and its relationships with other individuals in its environment.
6. ***habitat***--an organism's home.

Organization of Life (from greater to lesser)



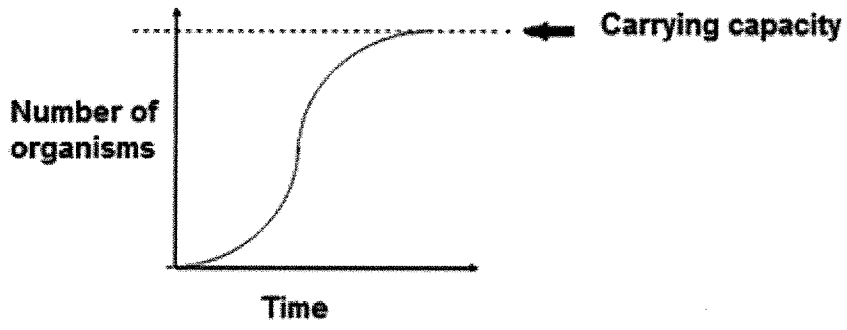
Factors That Determine the Characteristics of Populations

Standards: SC.7.L.17.3

A ***limiting factor*** (or limiting resource) is anything that determines the size or distribution of a population in an ecosystem. They include the things that make it possible or impossible for a population to survive in an area. For example, climate is a limiting factor. Polar bears can survive in cold climates because of their ***adaptations*** (i.e., fur and fat storage beneath their skin). On the other hand, cows could not survive in the same cold climate. The climate limits the types of organisms that can survive in the area. It is therefore a limiting factor.

Other limiting factors include type of food (vegetation and organisms), presence and amount of water, shelter, disease, predator-prey relationships, parasitism, etc. Any changes in a limited resource could affect the size of a population and could lead to the elimination of those populations from Earth. For example, when humans cut down trees (***deforestation***) it limits the amount of shelter available for animals that make their homes in trees. Without shelter these animals may be more vulnerable to predators. The long-term effect of this could lead to ***extinction*** (the dying out) of that species.

Living things compete with each other to get the things they need to live in their local environment. However, there are limited amounts of resources in an ecosystem. Food, water, and minerals for example may not keep up with the demand for these resources. The amount of resources limit the number of organisms an environment can support. The total amount of organisms an environment can support is called its ***carrying capacity***. If a population increases above its carrying capacity many individuals will die off as the competition for limited resources increases.

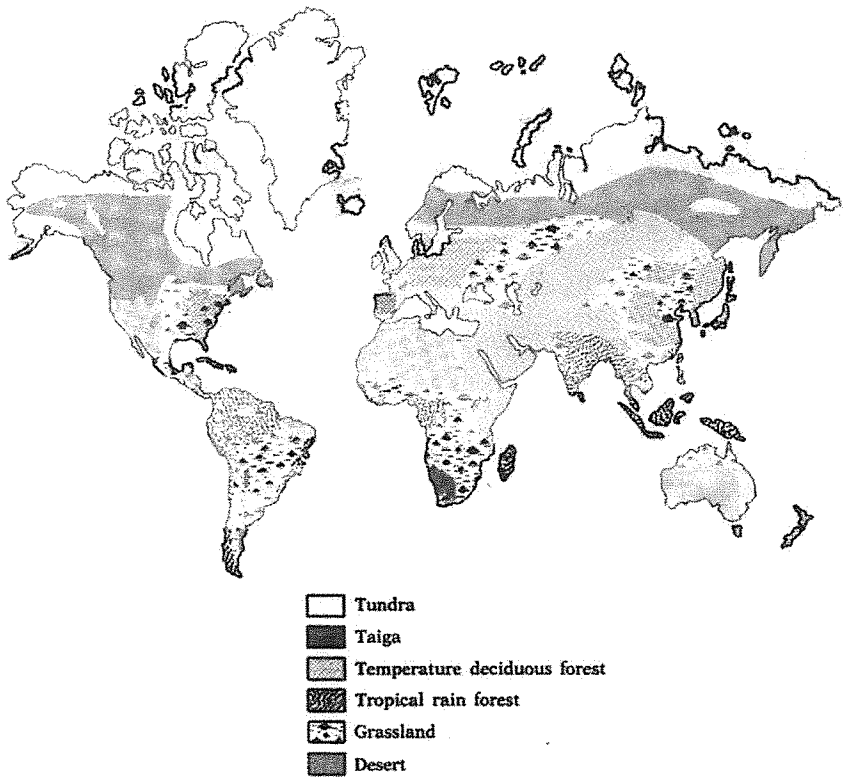


Biomes

Biomes are large ecosystems. They are complex communities characterized by a particular climate, plant life, and animal life. These broad habitats can be divided into six major land (terrestrial) biomes and two aquatic (water) biomes. Refer to the chart below.

Table 3-1 Major Land Biomes on Earth

BIOME	CHARACTERISTICS	ANIMAL LIFE	PLANT LIFE
tundra	extremely cold temperatures; permafrost (permanently frozen subsoil)	musk oxen, lemmings, reindeer, and caribou	treeless; short shrubs and grasses
taiga	long, severe winters; plenty of snowfall; summers with thawing subsoil	beavers, grizzly bears, and wolverines	forests of dense evergreen trees
temperate deciduous forest	moderate precipitation; cold winters; warm summers	wolves, birds, squirrels, and foxes	deciduous trees (maple, oak, beech), plants and shrubs
tropical rainforest	dense vegetation; heavy rainfall; seasonally warm temperatures;	monkeys, bats, frogs, and insects	many broad-leaved plant species
grassland (savannas)	little rainfall; dry climate; strong winds; large open grassy areas	lions, elephants, zebras, and antelope	grasses, very few trees
desert	dry areas; extremely small rainfall; extreme daily temperature fluctuations (can be either cold or hot)	lizards, snakes, birds, and rodents	shrubs and cactus plants



Aquatic biomes make up the largest ecosystems on Earth. These biomes are the most stable because of less variation in water temperature. However, they are affected more so by abiotic factors such as light intensity, amounts of dissolved oxygen and carbon dioxide and the mineral content of the water. The two aquatic biomes are marine and freshwater biomes.

1. ***marine biomes*** – salt water biomes include all the oceans of the world. They serve as large habitats for a wide variety of organisms since the majority of all living things on Earth live there. Marine biomes absorb a lot of solar energy and help determine Earth's climate. They contain a constant supply of nutrients and are the source of much of the oxygen produced by photosynthesis.

2. ***freshwater biomes***—fresh water biomes include all the rivers, streams, ponds, lakes and wetlands on Earth. Fresh water biomes have a very low concentration of salt. As such they have plant and animal life that are adapted for living in low salt conditions. Some fresh water biomes are still bodies, such as ponds and lakes and others are rapidly moving bodies such as streams and rivers. Wetlands, such as swamps, marshes, and bogs are areas of standing water that support aquatic plants specially adapted for moist, humid conditions. The Florida Everglades is an example of a wetland.

Organisms Have Adaptations That Enable Them to Survive in Their Environment

Standards: SC.5.L.17.1

A lack of food, water, shelter, and other needed resources affect plants and animals in their habitats. ***Adaptations*** increase an organism's rate of survival in an ecosystem. They are characteristics that help organisms compete in their habitats. For example, colors that camouflage (blend) animals with their environment help them to hide from their predators. Skin or fur color is therefore an adaptation. Adaptations become even more important when an ecosystem changes. When this happens, organisms that are better adapted to compete for limited resources (i.e., food and water) will have a better chance for survival.

Two types of adaptations are ***behavioral*** and ***structural*** . Behavioral adaptations are things organisms do to survive. Some behaviors are inherited (i.e., instincts) and some are learned. Bird migration is an example of a behavioral adaptation, as is animals moving in large groups. Structural adaptations are physical characteristics that help an organism to survive (i.e., coloration, speed, sharp teeth, beak shape and size, etc). **Table 3-2** compares the adaptations of plants and animals living in a desert habitat. Desert habitats are characterized by harsh conditions such as extreme temperature variations (extremely hot in the daytime and extremely cold at night), water scarcity, and nutrient-poor soil.

Table 3-2 Adaptations of Desert Plants and Animals

Desert Plants (i.e., cactus, bitterroot, night-blooming cereus)	Desert Animals (i.e., bats, elk, rodents, coyote)
Behavioral Adaptations Night Blooming Many desert plants are night bloomers. They have flowers that open at night when it is cooler as opposed to the day when it is hotter. Because many animals and pollinating insects are nocturnal (they sleep or are inactive during the day and are active at night) night bloomers expose their pollen when it has the best chance of being spread. Tumbling Some desert plants adapt to dry conditions by tumbling. This allows the plant to remove itself form environments that grow too dry to support it. During tumbling the plant breaks away from their roots, dry out and roll with the wind. As the tumbleweed rolls it spreads its seeds to the new places that the wind takes it. Some tumbling plants reverse the process when water is available. They unroll, put down roots and germinate. This turns them from a dry bundle of twigs to a flowering green bush. Structural Adaptations Roots Desert plants have developed a very effective	Behavioral Adaptations Burrowing Many desert animals strive to stay out of the Sun during the hottest times of the day. Some animals burrow underground during the day where it is much cooler. Many desert animals are also nocturnal. They sleep during the day when it is hot and actively hunt for food at night. Desert animals are adapted for water scarcity by obtaining water from the foods they eat. Herbivores obtain water from the plants they eat and carnivores from the blood and fluid inside the organisms they eat. Migration Many desert animals such as the pronghorn migrate to cooler, higher elevations during the summer and back to warmer, lower elevations in the winter. Structural Adaptations Many desert animals have evolved structural adaptations that help them minimize water loss and

transport system to deal with dry desert conditions. They grow long and wide root systems to gather water from deep under the surface. Xylem and Stomates Desert plants also have a water absorption system that is effective in absorbing, storing, and utilizing water. This system involves ***xylem*** located in the roots, stem, and leaves that transport water from the roots to the leaves. They also have ***stomates*** which are little pores in the leaves and stems of a plant that permits water evaporation via transpiration. Desert plants are adapted for less transpiration (and thus less water loss) by having smaller and fewer stomates than non-desert plants. Also, many desert plants open their stomates only at night when temperatures are cooler and there is less water loss.	hot desert temperatures. Many have no sweat glands to prevent loss of water through sweating. Some can further conserve water by passing very concentrated urine or no urine at all. The long ears of jack rabbits are adapted to release body heat so as to cool the body. Other types of structural adaptations include thick coats that insulate against cold temperatures and pale skin that absorbs less heat and provides protection from predators.

Trophic (Feeding) Levels

Organisms are classified by how they obtain nutrients (**trophic levels**).

1. ***autotroph*** -- organisms (plants and certain types of bacteria) that can synthesize their own food from substances in the environment, such as sunlight and water. (**Auto** = *self* **troph**= *feeder* **auto+troph** = *self feeder)*.

2. ***heterotroph*** -- organisms, like humans or tigers for example, that cannot synthesize their own food and must eat other organisms for nutrients. (**Hetero**= different **troph** = feeder **hetero+troph**= different feeder).

3. ***producer***-- autotrophic organisms. Examples: plants, grass, and algae.

4. ***consumer***-- organisms that eat other organisms. Examples: bears, humans and skunks. Types of consumers are shown on the next page.

a. **carnivore**- eats animals (meat). (Secondary consumers)
b. **herbivore**- eats plants only. (Primary consumers)
c. **omnivore**- eats plants and animals.
d. **prey**- the animal that is hunted and eaten.
e. **predator**- animals that kill and eat their prey.
f. **scavenger**- feeds on the remains of animals they have not killed.

5. ***decomposer (saprophytes)***--obtain nutrients from the remains of dead organisms. They help to recycle nutrients back into the soil. Examples: bacteria and fungi (i.e., mushrooms).

Whether predator or prey, autotroph or heterotroph, all organisms contribute to the cycle of life on Earth. Organisms are born, grow, die, and decay as new ones are being produced daily. Another pattern!

Food Chains and Food Webs

Standards: SC.7.L.17.1, SC.8.L.18.4

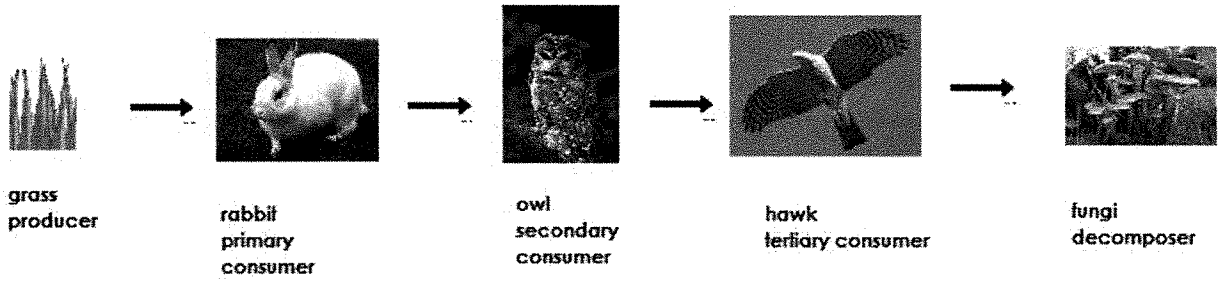
Trophic relationships are all connected by a pattern of energy flow. This shows how energy (nutrients) moves through an ecosystem. The easiest way to demonstrate this flow of energy is with a ***food chain***. In a simple food chain energy transfers from the Sun to plants (producers), to animals (consumers), and finally to decomposers (fungi and bacteria) which decays organisms and recycle nutrients back into the soil for plants to utilize. A food chain is a pattern of eating and being eaten.

The majority of all food chains begin with the Sun. We say the *majority* due to the existence of organisms that are capable of using inorganic and organic compounds found in their environment as their primary energy source. These organisms are chemotrophic as opposed to photosynthetic. Some are found in the depths of the ocean where sunlight does not penetrate.

Autotrophic organisms, such as plants (producers) use the energy source of sunlight along with other materials to make food (energy). This energy is transferred to animals that eat the plants.

These herbivores (1st level consumers) eat the plants to obtain its energy. Carnivores (2nd level consumers) and omnivores (consumers) eat the animals that eat plants as well as other animals. Scavengers eat the remains of dead organisms. Decomposers (fungi and bacteria) transfer energy back into the ground and recycle nutrients into the soil for plants to use. This continuous pattern or cycle is a food chain. The arrows of the food chain mean "eaten by". So, in the food chain below the grass is "eaten by" the rabbit, who in turn is "eaten by the owl" and so on and so forth. You may not realize how you participate in a food chain but when you eat vegetables and fruits you are eating plants. When you eat meat you are eating animals that may have eaten other animals and plants.

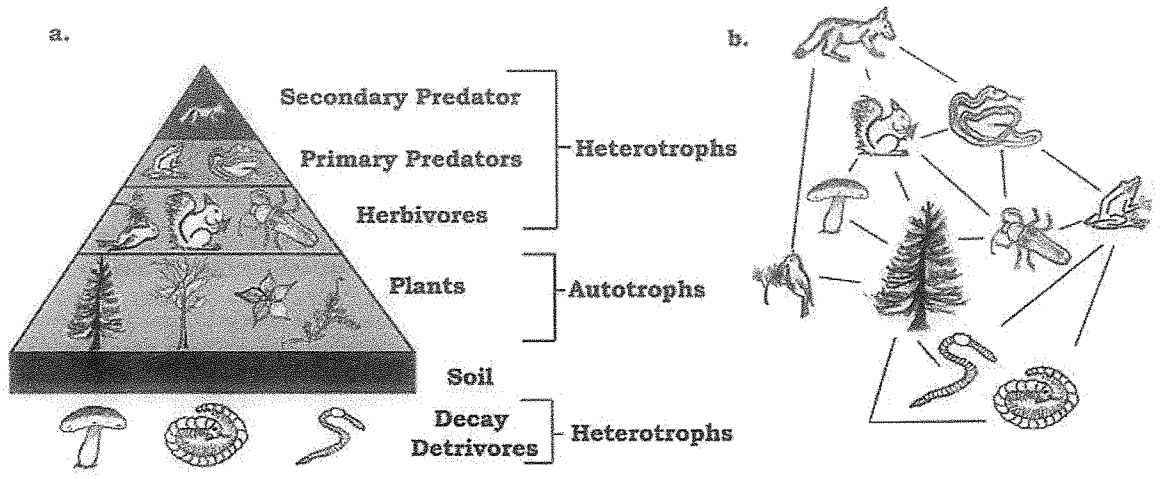
FOOD CHAIN



The energy in one organism is never transferred 100% to another organism when it is eaten. You learned in chapter 2 that energy transfer is never 100% efficient. Some energy is converted to heat and lost to the environment. In the case of food chains, the animal being eaten uses some of its energy for its own metabolism (digestion, reproduction, etc). The animal doing the eating only gets a fraction of that energy.

Keep in mind, that because science is interconnected that the Laws of Conservation of Mass and Energy applies to ecosystems as well. Remember from chapter 2 that energy is neither created nor destroyed. It is just transformed from one form to another. This is the Law of Conservation of Energy. The energy from the Sun that was transferred to the plant was used to create food for the plant through the process of photosynthesis. Whatever amount of energy that was not lost to heat or the environment was transferred to the organism that ate the plant. Likewise, this energy will be transferred to the organism that eats this one (and so on and so on). The Law of Conservation of Mass also applies here. Matter is simply recycled from one organism to another and the total amount of matter doesn't change.

Because no animal typically eats only one type of organism, ***food webs*** are used to more accurately describe feeding relationships. A food web is a group of connected food chains. It demonstrates the flow of energy from one organism to another as one is eaten by the other. Below is an example of a food web.



Source: Author, Mark David Thompson

Biodiversity

Plants and animals, including humans, interact with and depend upon each other and their environment to satisfy their basic needs. ***Biodiversity*** refers to the presence of a wide range of different organisms in an ecosystem and how they interact with abiotic factors and with each other. It is variety. Each organism, carrying out its own niche, helps to promote better interactions and overall stability of an ecosystem. Because individuals do not eat only one type of organism, the reduction in one species has less of an effect where variety of other food choices exists than where there is no variety. Biodiversity also insures that some organisms will survive in the event of a devastating environmental event such as disease, drought, famine, or volcanic eruption. Tropical rainforests are the most diverse ecosystems on Earth. Here, there are a wide variety of plants that are used to make medicines and useful products.

Ecological Relationships

Standards: SC.7.L.17.2

Ecological relationships can be described based on who benefits and who is harmed by the relationship. ***Symbiosis*** is the term used to describe when two different organisms live together in close association. Examples of symbiotic relationships include:

1. ***commensalism***-- when one organism benefits from the relationship and the other one is neither helped nor harmed. For example, the remora are tiny fish that attach themselves to sharks as a quick mode of transportation and for protection. The shark isn't helped by the remora but it isn't hurt either.

2. ***mutualism***-- when both organisms benefit from the relationship. For example, the bacteria that live in the intestines of cows provide them with an enzyme that allows them to digest the plants they eat. In turn the cows provide the bacteria with a stable supply of nutrients.

3. ***parasitism***-- when one organism (the ***parasite***) benefits from the relationship and the other one (the ***host***) is harmed. For example, eating undercooked meat can cause tapeworms to grow in the digestive tract of humans. The tapeworm get a steady supply of nutrients from the human. In return the human may develop a disease and become very sick from the tapeworm infection.

Photosynthesis, Cellular Respiration and Other Patterns in Nature

Standards: SC.5.E.7.1, SC.5.E.7.2, SC.8.L.18.1, SC.8.L.18.2, SC.8.L.18.3, SC.8.L.18.4

Common examples of patterns in nature are listed on the next page. The exchange of energy and matter by the living and nonliving parts of the environment sets up a pattern of recycling that allows materials to be used over and over again by living things. Energy and matter are continuously exchanged between organisms and their physical environment. In all the examples below, the Law of Conservation of Mass applies in that the total mass of the system

never changes. The amount of material present at the beginning of the reaction is accounted for at the end. No material is ever wasted.

1. ***carbon-hydrogen-oxygen cycle***-- the elements carbon, hydrogen, and oxygen are recycled in the environment by the process of ***photosynthesis*** and ***cellular respiration***. In the process of photosynthesis green plants use ***chlorophyll*** (the green pigment found in ***chloroplasts***) to capture sunlight. Sunlight is used to split water (H_2O) molecules (***photolysis***) to release hydrogen molecules. Hydrogen combines with carbon dioxide (CO_2) from the environment to make the sugar, ***glucose*** ($C_6H_{12}O_6$). Oxygen is released into the environment as a by-product (waste product).

Organisms (including green plants and animals that eat the plants) break down glucose to release the energy (***ATPs***) present inside through the process of cellular respiration (***aerobic respiration***). Oxygen is used in this reaction. It is the same oxygen the plants released into the environment from photosynthesis. Cellular respiration occurs in the ***mitochondria*** of the cell. The glucose made by plants is combined with the oxygen to make energy. A waste product of cellular respiration is carbon dioxide. Plants use the carbon dioxide that animals breathe out. This carbon dioxide is used by plants for photosynthesis as the process begins over again. Notice that no form of matter (carbon, oxygen and hydrogen) is wasted in these two processes. They are recycled over and over again.
The diagram below demonstrates that in the chemical reaction of photosynthesis and respiration the same quantities of reactants are present in the same amounts as products. No matter is wasted; it is all conserved. The Law of Conservation of Mass applies here. We should mention that carbon dioxide is also released into the air by other processes, such as the ***combustion*** (burning) of ***fossil fuels*** (natural gas, oil, and coal). The ***decomposition*** (rotting) of dead organisms also returns carbon, oxygen and hydrogen (and other matter)to the soil for plants to use for growth and photosynthesis.

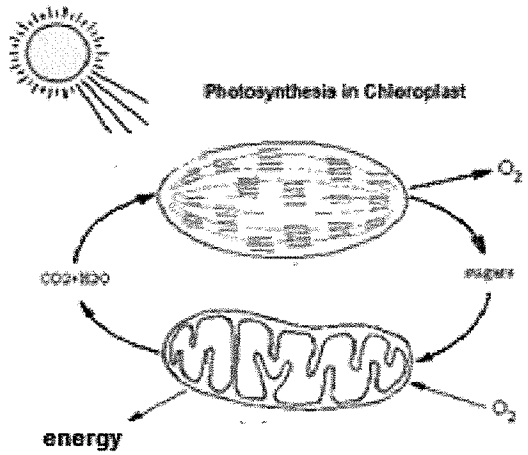
Photosynthesis Reaction

$6CO_2 + 6H_2O + ENERGY \rightarrow C_6H_{12}O_6 + 6O_2$

WATER

CARBON DIOXIDE

GLUCOSE



Cellular Respiration Reaction

OXYGEN

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + ENERGY$

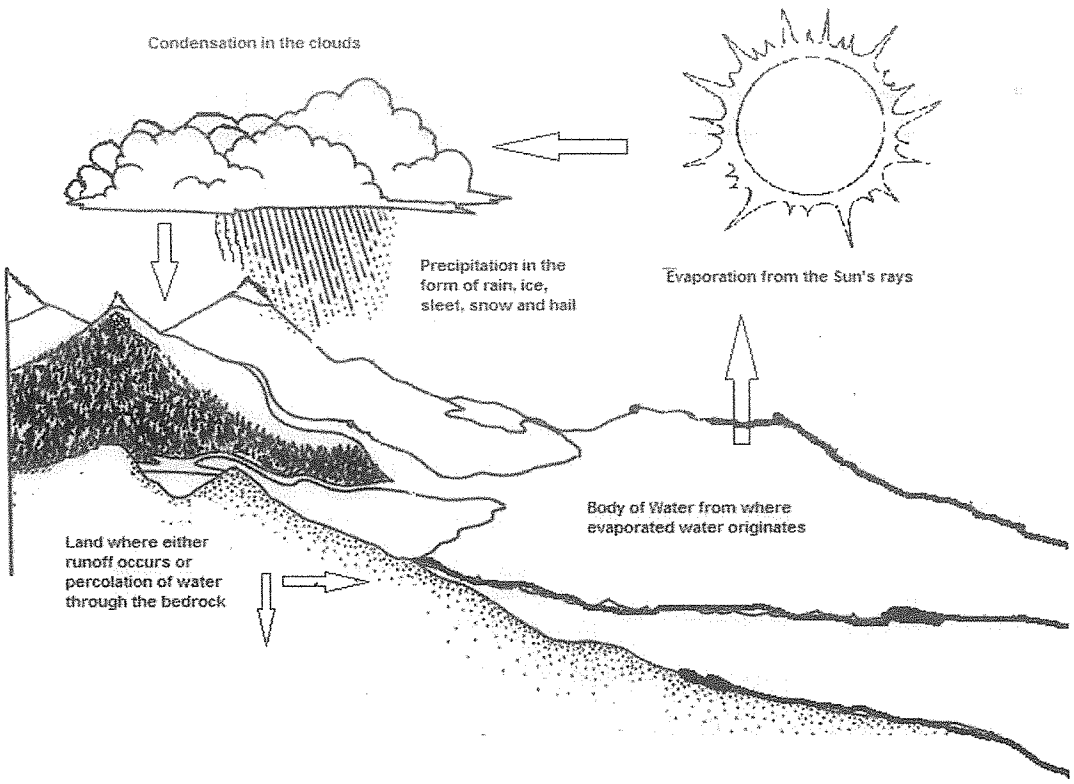
GLUCOSE

WATER

CARBON DIOXIDE

ATP

2. ***water cycle***- (See the diagram on the next page). The water cycle demonstrates the movement of water through the Earth as it changes from the liquid form in oceans, ponds, etc., to a gas (water vapor) by ***evaporation*** and ***transpiration*** (evaporation of water from the leaves of plants). Water vapor cools and condenses to form clouds (***condensation***) which become heavy and release the liquid water as ***precipitation*** (any form of water that falls from the sky, i.e., snow, rain, hail, etc). That water then returns to the oceans and other bodies of water as ***runoff*** or seeps into the ground as ***groundwater***.



Water cycle diagram

Human Impact on the Environment

Standards: SC.7.E.6.6

Like natural events, human activities can have a major impact on the environment. Humans are a part of ecosystems and have the greatest capacity to change them–in both positive and negative ways. Sometimes their activities can be destructive and alter the balance in an ecosystem. This affects other organisms.

Deforestation is the cutting down of forest. This destroys animal habitats and can lead to their extinction as well as the extinction of medicinal plant species. Deforestation leads to ***erosion*** of topsoil since trees that anchor the soil and keep it moist and firm, are removed. Poor agricultural practices and over-grazing (feeding on too much grass, for example) depletes (reduces) nutrients in soil and erodes topsoil.

Desertification is the process by which an area becomes a desert. This may occur in areas bordering desert areas when excessive plant life and soil depletion occurs.

Urbanization is the physical growth of urban or city areas. Urbanization also has a negative effect on ecosystems. Land is cleared, which removes necessary vegetation and soil. Without trees and ground cover, which absorbs solar radiation, local temperatures will increase. Urban areas tend to have higher temperatures than rural areas. They also tend to have higher concentrations of carbon dioxide emissions since there is less vegetation to absorb this greenhouse gas.

As human populations continue to grow the increase in urbanization occurs. More than half of the world's population now lives in urban areas. We can attribute advances in medicine and technology as major reasons for people living longer and increases in human population growth. Around the world human populations are growing at such an alarming rate and exceeding the carrying capacity of the environment. In these countries populations are growing faster than the ability to produce food, leading to hunger and starvation.

Over-hunting, fishing, and trapping leads to extinction of some species and the endangerment of others. Importing of ***invasive*** and ***exotic*** species (species that are not natural inhabitants of an area and have no natural enemies or competitors) disrupt ecosystems. Because they have no natural enemies, these species out-compete native plant and animal species for resources, resulting in a loss of biodiversity.

The quality of the air, water, and land is compromised by harmful chemicals, sewage, solid wastes, thermal pollution, and by other human means. These forms of pollution not only harm wildlife but they harm humans as well. We are not immune from the harmful effects of our own destructive practices. The burning of fossil fuels contributes to air pollution and increases the ***greenhouse effect*** (the natural heating of the planet by the absorption of solar radiation by the atmosphere). This leads to ***global warming*** (the increase in temperature of Earth's climates).

Climate change caused by global warming will begin to affect the weather. As the Earth's climates heat up it will cause the melting of polar ice caps. Water that was trapped in the ice of glaciers will be released more and more into the water cycle. This inundation of water is expected to affect the frequency of extreme weather events such as drought, extreme temperatures, flooding, high winds and severe storms.

The depletion of the ***ozone layer*** (the natural shield in the Earth's atmosphere that blocks the

Sun's harmful UV rays from reaching the surface) allows more UV rays to penetrate the atmosphere and increase the rate of skin cancers in humans and harm to plants as well.

Solutions to Environmental Problems

A mutual relationship exists between humans and other living things. We rely on plants, animals and other organisms for food, shelter, medicines, clothing, etc. We therefore have a responsibility to correct and learn from our mistakes by taking positive steps in preserving the environment. There are many ways humans have sought solutions for environmental problems. For one, humans have adopted legislation to protect the Earth from harmful activities. For example, there are laws in place that regulate hunting and fishing. Endangered species are being protected by the creation of national parks and wildlife refuges. Other environmental solutions are outlined below.

Recycling paper, glass, metals and plastics allows products to be reused over and over. It reduces the loss of trees and other natural resources used to make these products. It also reduces the amounts of these materials in landfills.

Conservation (saving) of energy by turning off lights and plugging out appliances and electronics is being practiced. Humans also practice energy conservation by finding more energy saving ways of getting around. They are commuting more and more by walking, riding bikes and carpooling. This reduces the burning of fossil fuels and conserves the limited amounts we have left on Earth. Remember, fossil fuels are ***nonrenewable*** resources (they cannot easily be replaced). It took millions of years for them to be formed and would take millions of years more to recreate them. ***Renewable*** resources are more readily available. These include water, wind, and solar power.

Reforestation prevents further loss of trees by replanting. This helps to prevent erosion of topsoil and reduction in carbon dioxide emissions. Reforestation also creates habitats for organisms that rely on trees for shelter and food.

In countries such as China, population control laws have been created to limit population growth by reducing the number of children per family. Individuals in other countries have also made personal choices to limit family size by the use of biological birth control methods. Controlling population size takes a strain off of limited resources and frees some up for reserves.

Biological control is a method that replaces chemical pesticides as a way of controlling insects and pests. It is the use of living organisms to control the population of these pests. Natural parasites are used to kill harmful insects. Sex hormones are also used to attract and trap environmental pests. Biological control is a better option over toxic pesticides because it doesn't contaminate the land and water or disrupt food webs.

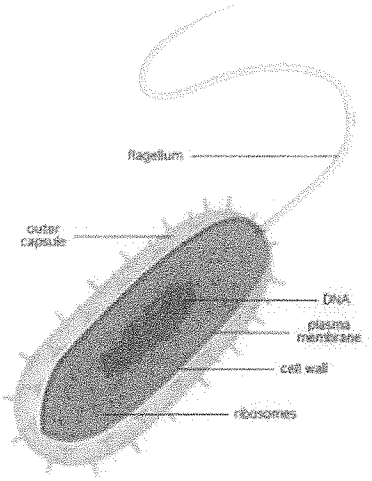
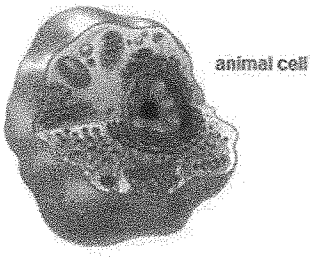
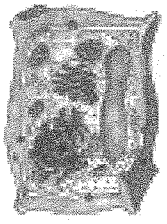
PART II: ORGANIZATION AND DEVELOPMENT OF LIVING ORGANISM

Cells

Standards: SC.6.L.14.1, SC.6.L.14.2, SC.6.L.14.3, SC.6.L.14.4

All living things share certain characteristics. A major similarity among all organisms is that they are all made of ***cells***. Cells are the smaller parts in all living things, too small to be seen without magnification. The cell is the smallest basic unit of structure and function in living things. It carries out all the processes necessary for life. Some organisms are made up of only one cell. We call them ***unicellular*** (uni = one) or single-celled. These are the simplest cells. Other organisms are more complex and are made up of many cells. We call them ***multi-cellular*** (multi = many). Most organisms are multi-cellular. Living things are also classified as either ***prokaryotic*** or ***eukaryotic***. **Table 3-3** on the following page shows a comparison between prokaryotic and eukaryotic cells.

Table 3-3 Comparison of Prokaryotic and Eukaryotic Cells

PROKARYOTIC CELLS	EUKARYOTIC CELLS
Bacteria 	Cells of plant, animal, protist and fungi (Eurkaryotes include some single-celled and all multi-cellular organisms)   plant cell
cell membrane, cell wall, cytoplasm, ribosomes, but no membrane bound organelles present	cell membrane, cytoplasm, ribosomes, organelles, and membrane bound organelles
one circular DNA. no nucleus present	DNA found within the nucleus of the cell

Inside the cell are small structures called ***organelles*** that perform specific life functions for the cell. These include such functions as getting energy from food (respiration), growth, maintenance, regulation and reproduction. These physiological functions maintain life and are determined by what occurs within the cell. The chart below summarizes the names of the organelles and their functions. Note which structures can be found in plant cells only and which can be found in animal (humans, dogs, rabbits, insects, etc.,) only.

Table 3-4 Cell Organelles and Their Functions

Name of Organelle	Function
nucleus	The "brain" of the cell. The cell's command center. Contains DNA that caries information needed for cells to live, grow, and reproduce. All eukaryotic cells have a nucleus.
cell membrane	The "bodyguard" for the cell. Protection for the cell. Controls what goes into and out of the cell (selective permeability). Allows nutrients to enter the cell and wastes to exit. Separates the cell from its environment. All cells have a cell membrane.
nuclear membrane	Surrounds the nucleus and allows materials to pass into and out of the nucleus.
cytoskeleton	The "skeleton" for the cell. Supports the cell's shape and helps the cell move just as the human skeleton gives us support and helps us to move.
ribosomes	Make proteins.
endoplasmic reticulum (ER)	The "highway" of the cell. A system of channels that transports proteins and other materials made inside the cell.
smooth ER	No ribosomes attached. Makes lipids. Breaks down toxic substances that could damage the cell.
rough ER	Has ribosomes attached. Packages the proteins made by ribosomes.
golgi complex (or golgi bodies)	Modifies and enhances proteins made by ribosomes (e.g., adds a sugar or phosphate group to the protein).
lysosomes	The "garbage disposal" of the cell. It gets rid of wastes. Found in animal cells only.
mitochondria	The "powerhouse of the cell". Breaks down glucose in cell to make energy (ATP) for the cell.
vacuole (small)	The "refrigerator" of the cell. Stores water and nutrients. Found in animal cells only.
central vacuole (large)	Found in plants only. Stores water for plants. Breaks down wastes in plants (just like the lysosomes in animal cells). When water levels here are low, plants wilt (become shriveled up).
cell wall	Found in plants and some prokaryotic cells only. Rigid and tough for support of plant to help it stand upright. Surrounds the plant cell outside of its cell membrane.
chloroplast	Found in plant cells only. Helps the plant to create its own food by the process of photosynthesis. Contains the green pigment chlorophyll that captures the energy from the sun necessary for photosynthesis.
nucleolus	Make ribosomes

The cells of all organisms undergo similar processes to maintain ***homeostasis***. Homeostasis is maintaining a stable internal environment in spite of internal or external changes. "Homeo" = ***same*** + "stasis"= ***staying*** so, homeostasis is the process of staying the same. Organisms become sick or die when they fail to maintain homeostasis. Each cell of the human body has organelles that are adapted/and or specialized to perform its own life functions. All of these processes serve to maintain homeostasis.

Metabolism is the term given to all the chemical activities an organism must carry on in order to remain alive. To be considered living, all organisms must perform the following eight life functions (metabolic activities):

1. **respiration** --making energy for the cell
2. **growth**--increasing in cell size or cell number
3. **synthesis**-- combing small molecules to make larger ones. example: photosynthesis
4. **regulation**--maintaining a stable internal environment
5. **nutrition**--obtaining and processing nutrients
6. **transport**-- circulation of materials throughout the organism
7. **excretion**-- removing metabolic wastes. example: carbon dioxide, water, and ammonia.
8. **reproduction**--producing new individuals

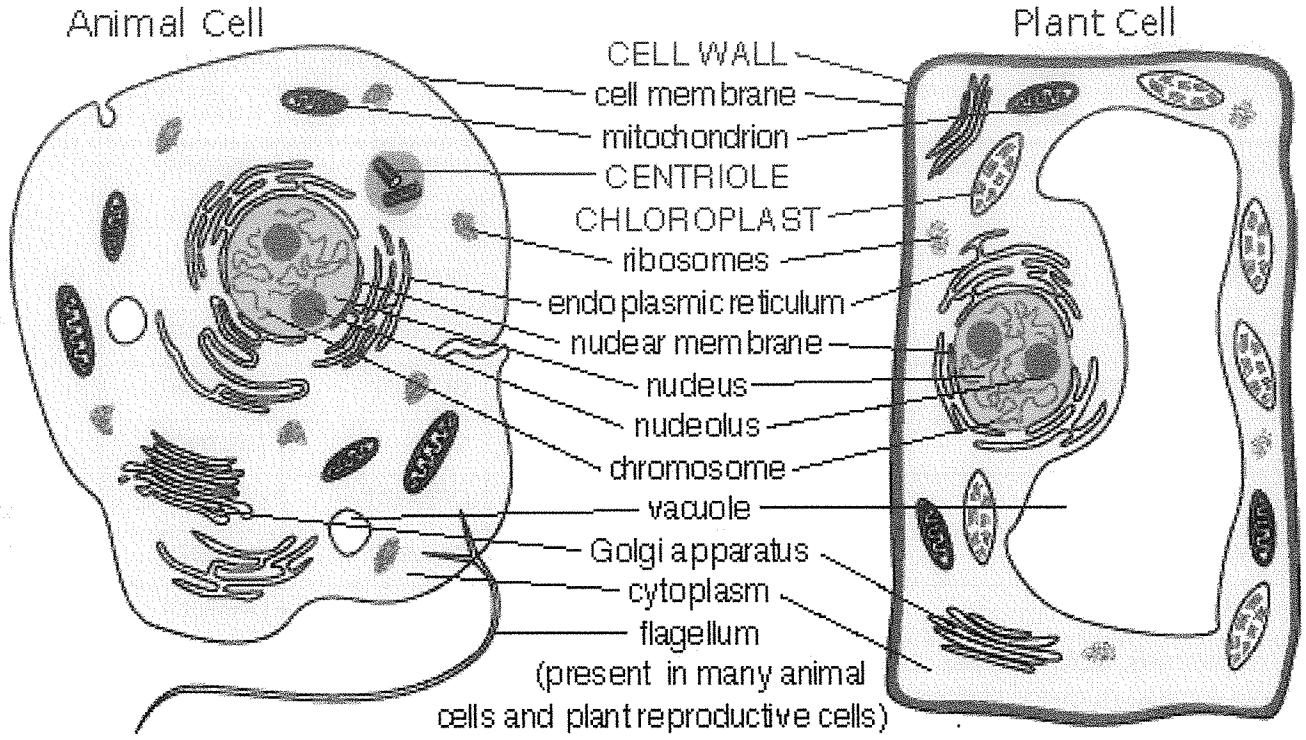


Table 3-5 Organelles of Human Cells and Their Life Functions

Life Function	Cell Organelle Responsible for Carrying out Life Function
1. respiration	mitochondria
2. growth	nucleus, cytoskeleton
3. synthesis	chloroplast, ribosomes, nucleolus, golgi bodies
4. regulation	nucleus, cell membrane and all organelles
5. nutrition	vacuoles, lysosomes
6. transport	cell membrane, endoplasmic reticulum (ER)
7. excretion	cell membrane, smooth ER
8. reproduction	nucleus, centrioles, cytoskeleton

Plant and animal cells share many similarities. For one, both plant cells and animal cells are eukaryotic. This means they have a nucleus and other membrane bound organelles. They even have many of the same organelles in common. However, although they do share many similarities, there are some differences between plant cells and animal cells. **Table 3-6** below will help you differentiate between the two. Keep in mind that the term animal cell includes everything from tiny eukaryotic microorganisms to humans. Students tend to forget this.

Table 3-6 Plant Cells vs. Animal Cells

Characteristics	**Plant Cells**	**Animal cells**
cell Wall	present	absent
chloroplast	present	absent
chlorophyll	present	absent
large central vacuole	present	absent
small vacuole	absent	present
lysosome	absent	present
cell membrane	present	present
cytoplasm	present	present
centrioles	absent	present
ribosomes, golgi bodies, endoplasmic reticulum, nucleolus, nuclear membrane, mitochondria	present	present
shape	rectangular	round
ability to make own food through photosynthesis	yes	no

The Cell Theory (The Scientific Theory of Cells)

Standards: SC.6.L.14.2

The ***Cell Theory*** is a major theory that governs the classification of living organisms. It is a fundamental organizing principle of life on Earth. The cell theory has three parts:

1. All living things are made of cells (single-celled or multi-cellular)
2. The cell is the basic unit of structure and function (basic unit of life)

3. All cells come from preexisting cells (i.e., new cells form when parent cells divide).

As with any other theory, there are a few exceptions to the Cell Theory:

1. Viruses are not living cells. They are made up of a core of DNA or RNA surrounded by a protein coat. They do not have organelles, yet viruses can reproduce themselves inside a living host cell. A virus is like a parasite. It lives off of living organisms. Outside the organism it shows no sign of life.

2. Mitochondria and chloroplasts, which are organelles found inside of cells, have their own DNA and can reproduce themselves.

3. The very first living cells on Earth could not have come from a preexisting cell. They must have been formed from non-cellular materials in their environment.

Similarities Between the Organization of Complex Organisms and Ecosystems

Standards: SC.6.L.14.1

We have mentioned the concept of patterns many times in this book. When it comes to living things more patterns can be seen when close observations occur. There is a pattern in the hierarchical organization of organisms that is very similar to that of ecosystems. Remember in an ecosystem, the smallest level of organization is a ***species***. A group of species inhabiting an area is called a ***population***. A group of populations inhabiting an area is called a **community**. A group of various communities inhabiting an area (along with the abiotic factors) is called an ***ecosystem***. The largest ecosystem on Earth is called the ***biosphere***.

Complex organisms are organized in a similar fashion. The smallest functional unit of life is the ***cell***. A group of similar cells that perform a specific function is called a ***tissue***. A group of tissues that work together to carry out a specific function is called an ***organ***. A group of organs that work together to perform a bodily function is called an ***organ system*** and all the organ systems make up the total ***organism***.

Example: cells— form tissues—which forms the organs of breathing (lungs, trachea, bronchi,

bronchioles, alveoli)—which are collectively known as the respiratory system (an organ system) and can all be found in an organism (i.e. , a human)

Our pattern of hierarchical organization can even be expanded to include atoms, molecules and organelles. ***Atoms*** (the smallest units of matter) make up ***molecules***. Molecules form organelles, which are the structural and functional parts of cells. The rest of this you already know: cells form tissues, which form organs, which form organ systems, which form the organism. [**Note**: Cells with similar functions have similar structures. Those with different structures have different functions].

Reproduction (Cell Division and Growth)

Standards: SC.7.L.16.3

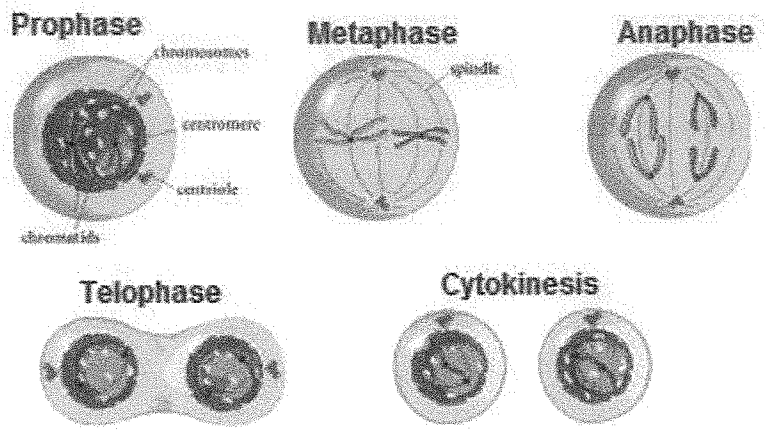
Body cells grow and divide to make more cells. This process is called ***cell division*** or ***mitosis*** and is a part of reproduction. Reproduction is characteristic of all living things and is essential for the survival of the species. Cell division allows organisms to reproduce, grow and repair damaged tissues. This is the reason why broken bones and cuts heal.

For cells to grow and divide successfully, they must pass on their DNA, which contains the genetic information (more on DNA later). In mitosis, the new cell formed, the ***daughter cell,*** is genetically identical to the original cell (the ***parent cell***) therefore, they are clones. All cells divide at least once in their life time. The cycle that describes the repetitive process of cell reproduction is called the ***cell cycle***. The steps of the cell cycle, which includes mitosis, are outlined in **Table 3-7** on the following page.

Table 3-7 Mitosis and the Cell Cycle

Cell Cycle Stage	Description
Interphase	Cell appears to be at rest. Most of its time is spent here. Nucleus is visible but the DNA is not. It appears as chromatin which looks like a plate of spaghetti. DNA is duplicated during interphase. Cell makes more organelles and materials needed to ensure each new cell will have all of the necessary structures to function properly.
Mitosis	This stage occurs after interphase. It is the actual cell division. Mitosis is divided into four stages: prophase, metaphase, anaphase and telophase.
Prophase	Nuclear membrane disappears. Chromatin coils into chromosomes and become visible. Spindle fibers form that help to split chromosomes apart. Sister chromatids form.
Metaphase	Chromosomes attached to spindles line up in the middle of the cell
Anaphase	Sister chromatids separate.
Telophase	Final stage of mitosis. New cell is formed. The nuclear membrane and nucleolus re-form. Chromosomes unwind to form chromatin again. Cytokinesis usually occurs after telophase which causes the actual separation of the cells in animal cells.

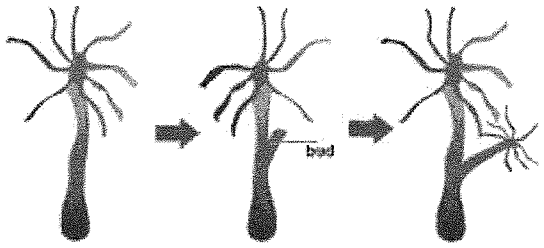
Mitosis



Having knowledge of mitosis is helpful in understanding disorders like cancer. Cancer cells no longer respond to natural signals of mitosis that tell a cell when to start and stop dividing, so they keep dividing. This leads to an overproduction of cells. Eventually a lump of cells form called a ***tumor***. Tumors cause problems in the body because they take up space within the body and prevent normal metabolic functioning. Sometimes they also press against nerves or blood vessels, restricting their functioning. Exposure to sunlight over a period of time increases the likelihood of developing skin cancer.

Mitosis is a form of ***asexual reproduction***. Asexual reproduction does not involve ***sex cells***

(***sperm*** and ***egg cells***) and it makes genetically identical cells (clones). Only one parent cell is needed. Most of the cells in your body divide by mitosis. Some multi-cellular organisms asexually reproduce by a process called ***budding***. In budding, a part of the parent organism pinches off and forms a new organism which is genetically identical to the parent cell. The bud stays attached to the parent cell while it grows. When it is fully grown it detaches.



budding in hydra

Advantages of Asexual Reproduction
1. Asexually reproducing animals do not have to use energy to find a mate, resulting in a more efficient usage of their energy.
2. Organisms can produce many offspring in a short period of time. This improves their survival rate.
3. Organisms do not have to depend on other organisms in order to reproduce.

Another form of cell division that occurs in multi-cellular organisms is called ***meiosis***. Meiosis is a form of ***sexual reproduction.*** It forms sex cells (***gametes***) that are ***NOT*** genetically identical to the parent cell although they will share some similarities. These cells have half the number of chromosomes or DNA of their parent cell. Offspring receive half their genes from each parent in sexual reproduction. Animals, including humans, inherit some characteristics from one parent and some from the other. Examples of a characteristics or traits that are passed from parent to child are hair color and eye color.

Gametes are ***haploid***. On the other hand, cells produced by mitosis are ***diploid***. They have the full chromosome number. In humans, the diploid number of chromosomes is 46 and the haploid number is 23. When a haploid egg joins a haploid sperm, the combining of their genetic information (***fertilization***) makes a cell with a full set of chromosomes (diploid). Meiosis only occurs in sex cells. Plants use asexual reproduction or ***vegetative propagation*** to grow, as well as sexual reproduction to form fruit and increase the species.

Sexual reproduction creates ***variations*** (variety) in organisms because each cell is not genetically identical to the parent cell. A process called ***crossing over*** occurs during prophase of meiosis which results in an exchange of genetic information between similar chromosomes

(***homologous chromosomes***). This creates new genetic combinations. The steps of meiosis are outlined below. Notice they are very similar to the steps of mitosis with the exception of meiosis having two cellular divisions (meiosis I and II). Both involve PMAT (prophase, metaphase, anaphase, telophase) and cytokinesis. The second division in meiosis is identical to mitosis.

Table 3-8 Stages of Meiosis

Stages of Meiosis	
Interphase I	DNA is copied (replicated). Cell prepares to enter meiosis.
Meiosis I	The first division
Prophase I	Chromosomes condense. Nuclear membrane disappears. Spindles form. Homologous chromosomes pair up (***synapsis***). Crossing over occurs.
Metaphase I	Homologous chromosomes move to center of cell.
Anaphase I	Homologues separate.
Telophase I	Nuclear membrane usually does not re-form.
Cytokinesis	May or may not occur. Two cells form that are diploid.
Interphase II	No DNA replication occurs. Cell may immediately enter into meiosis II.
Meiosis II	Proceeds just like mitosis
Prophase II	Spindle fibers form. Nuclear membrane disappears. ***Chromatin*** coils up to form chromosomes.
Metaphase II	Sister chromatids line up in the middle of the cell.
Anaphase II	Sister chromatids separate.
Telophase II	Spindle fibers disappear. Nuclear membrane and nucleolus re-form. New cell forms.
Cytokinesis II	Cell divides into two cells each having half the number of chromosomes (***haploid***). A total of four cells form after meiosis II.

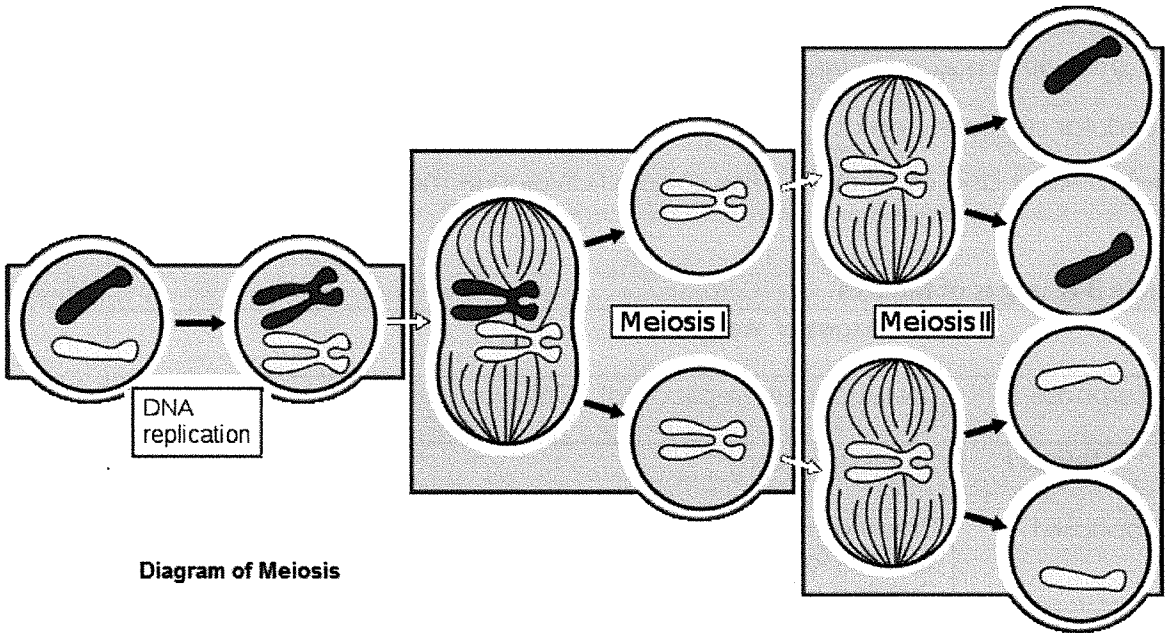
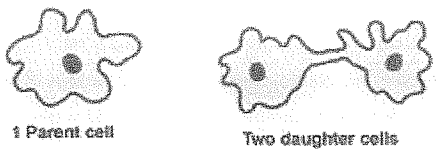


Diagram of Meiosis

Advantages of Sexual Reproduction
1. The genetic recombination that occurs during crossing over of prophase I of meiosis creates cells which are not genetically identical to their parent cell. This results in variations (differences) in populations. 2. Differences in organism's genes allows populations to adapt to changes in their environment which increases their survival rate.

Comparison of Cell Division in Eukaryotic and Prokaryotic Cells

When prokaryotes reproduce they simply divide in half. This is called ***binary fission***. Each half becomes a separate organism. The new daughter cell is genetically identical to the parent cell. Before the cell splits in half the DNA is copied and each cell gets a copy. They are clones. This whole process can take as little as 30 minutes, which is the reason bacteria can reproduce quickly. This is also the reason you become very ill when you have a bacterial infection because the bacteria can multiply so quickly.



binary fission—parent cell spits to form two daughter cells

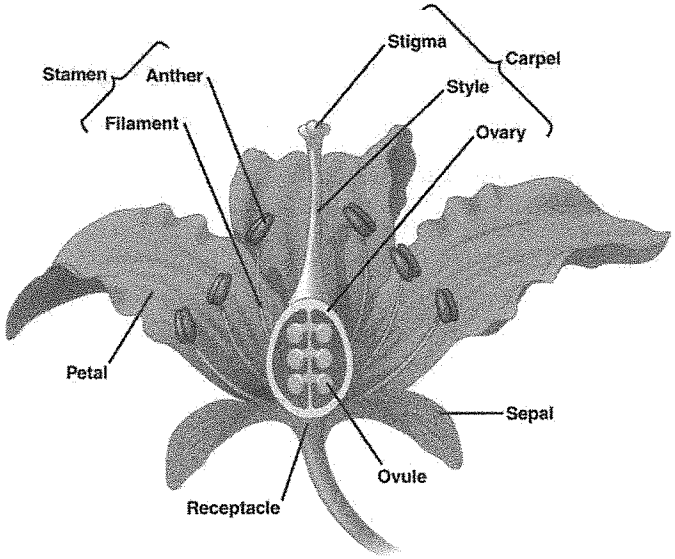
Comparison of Cell Division in Plant and Animal Cells

Standards: SC.7.L.16.3

Table 3-9 Comparison of Animal and Plant Cell Division

Animal Cell Division	Plant Cell Division
1. Have centrioles (structures involved in cell division). 2. Spindle fibers help chromosomes to separate and move. 3. Cytokinesis splits the cell to form two completely separate cells.	1. No centrioles present. 2. Spindle fibers help chromosomes to separate and move. 3. Cytokinesis does not form two completely separate cells. Plant cells remain attached after cell division. A ***cell plate*** is formed after cytokinesis. This cell plate eventually becomes the cell wall.

Sexual Reproduction in Plants



The Flower is the reproductive structure of flowering plants (angiosperms). It consists of various parts. The male reproductive structure is the ***stamen***, which consists of the ***anther*** and the ***filament***. The female reproductive structure is the ***carpel*** (***pistal***) which consists of the ***stigma***, ***style*** and ***ovary***.

Pollination begins the reproductive process. It is the transfer of pollen grains from the anther to the stigma of the same flower (self-pollination) or of a different flower (cross-pollination). Pollen is produced by the anther. It contains the male reproductive cell, the sperm cell. Pollen must fertilize an ovule to produce a viable seed. Pollinators include bees, other insects and animals that unknowingly transport pollen grains in their fur.

Once the pollen grain makes contact with the stigma a pollen tube begins to grow down the style on its way to the ovary. The sperm cell travels in the pollen tube and fertilizes the female reproductive cell, the egg cells, located and produced by the ovules in the ovary. After fertilization the ovule becomes the seed. The ovary becomes the fruit.

Organ and Organ Systems

Standards: SC.5.L.14.1, SC.6.L.14.5

Your cells depend on other cells in your body. They all work together to carry out their specialized functions. On a higher level, the human body contains many organs and organ systems to perform different functions. The major organ systems are listed in **Table 3-10** on the following page. A breakdown of each body system follows **Table 3-10**.

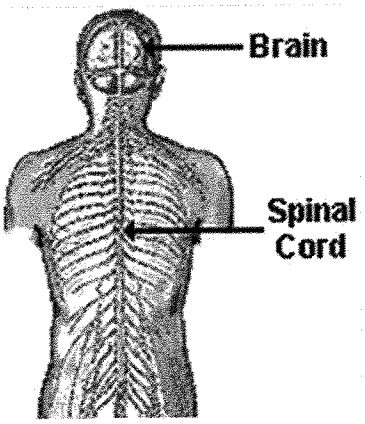
Table 3-10 Organ Systems and Their Functions

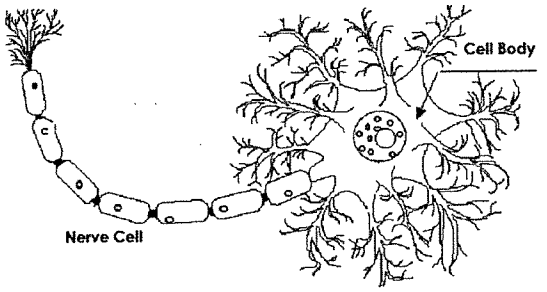
Organ System	Function
1. respiratory system	removes carbon dioxide from blood and exchanges it for oxygen
2. immune system	made up of the white blood cells and lymph nodes and fights disease and infections in the body
3. reproductive system	produces eggs and sperm cells and provides mechanisms to increase the species number
4. excretory system	removes wastes from the bloodstream
5. nervous system	detects stimuli, secretes chemical and electric signals, and controls all other organ systems
6. endocrine system	releases hormones into the blood to communicate with target cells
7. digestive system	uses enzymes to break down food and release nutrients into the blood stream. removes solid wastes from the body (feces).
8. muscular and skeletal system	works together to move the body
9. circulatory system	delivers nutrients and oxygen to cells and carries metabolic waste and carbon dioxide away from cells

Human Body Systems

NERVOUS SYSTEM (REGULATION)

ORGANS OF THE NERVOUS SYSTEM AND THEIR FUNCTIONS	
ORGAN	FUNCTION
nerve cells (neurons)	Cells that process and transmit information
nerves	Carries signals or nerve impulses that transmit information
brain	Controls the different functions of the body. Functions in learning, memory, movement, etc.
spinal cord	Coordinates activities between the brain and other body structures



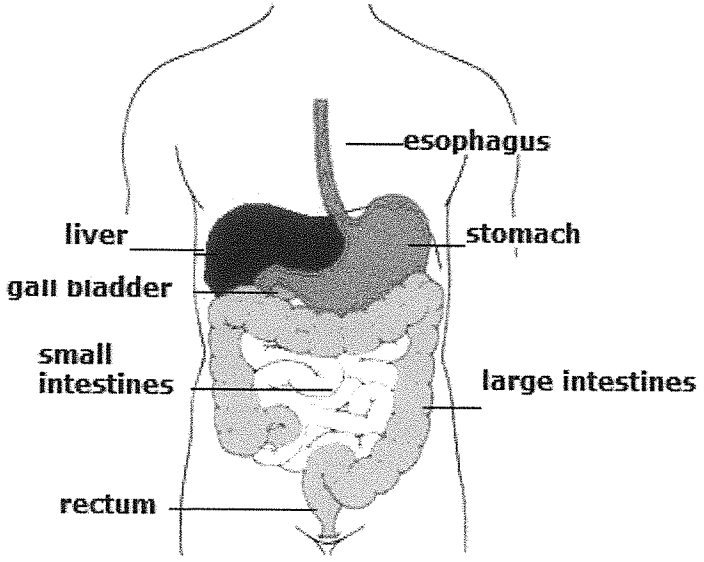


HOW THIS SYSTEM MAINTAINS HOMEOSTASIS

Since the nervous system does not store nutrients it must receive a continuous supply of blood from the circulatory system. Any interruption to the flow of blood may bring about brain damage or death. The nervous system maintains homeostasis by controlling and regulating the other parts of the body.

DISORDERS OF THE NERVOUS SYSTEM		
NAME OF DISORDER	**HOW CAUSED**	**EFFECT ON THE SYSTEM**
CEREBRAL PALSY	Damage or abnormal development in the parts of the brain that control muscle tone and movement	Affects body movement, balance, and posture
MENINGITIS	Viral or bacterial infection	Can lead to seizures, unconsciousness, headaches, etc.
STROKE	Damage to brain by cerebral hemorrhage or blood clot	Loss of bodily functions (i.e., talking, walking, etc.)
POLIO	Virus	May cause paralysis
ALZHEIMER'S DISEASE	Genetic or environmental causes. Degenerative disease in which neurons in brain gradually become destroyed	Fatal. Causes loss of memory, mood swings, unusual behavior, and overall loss of functioning

ORGANS OF THE DIGESTIVE SYSTEM AND THEIR FUNCTIONS	
ORGAN	**FUNCTION**
stomach	Stores food. Mechanical and chemical digestion. Protein digestion begins here
mouth	Mechanical and chemical digestion. Carbohydrate digestion begins here. Ingestion occurs here (food enters the body).
esophagus	Moves food to stomach by peristalsis
gallbladder	"Stores" bile which is used to digest fats
small intestine	Chemical digestion and nutrient absorption
liver (accessory organ)	"Makes" bile for fat digestion
large intestine	Absorbs water and minerals from undigested food and forms feces
anus	Feces leaves the body through the anus
rectum	Temporarily stores feces
pancreas (accessory organ)	Produces enzymes that are used by the small intestine to digest foods

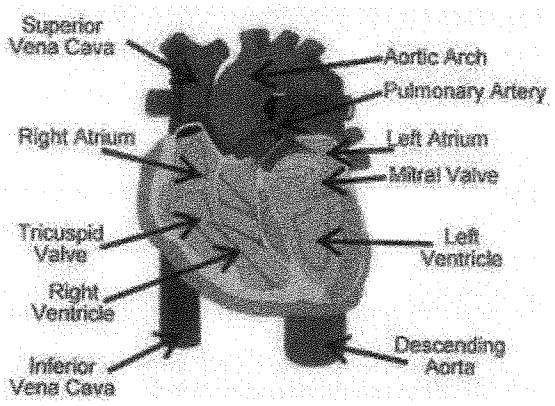


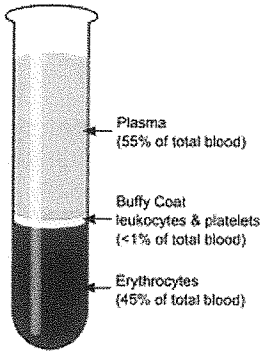
HOW THIS SYSTEM MAINTAINS HOMEOSTASIS

The digestive system breaks down carbohydrates, fats, and proteins before they are absorbed by the body as nutrients and used by the cells. Once the digestive system breaks down the nutrients, the circulatory system works with it to distribute the nutrients to each cell. The digestive system also helps to eliminate wastes (feces) to prevent a toxic buildup in the body. The liver, which monitors the blood, is a very important organ of homeostasis. The liver breaks down toxic substances like alcohol and other drugs and destroys old blood cells.

DISORDERS OF THE DIGESTIVE SYSTEM		
NAME OF DISORDER	**HOW CAUSED**	**EFFECT ON THE SYSTEM**
ULCER	Bacterial infection	Causes bleeding (loss of blood) and pain
DIARRHEA	Decreased water absorption in large intestine	Dehydration (loss of vital water)
CONSTIPATION	Increased water absorption in large intestine	Difficulty in eliminating feces
GALLSTONES	Caused by a combination of factors, including inherited body chemistry, body weight, gallbladder motility (movement), and perhaps diet. Gallstones develop when bile contains too much cholesterol and not enough bile salts.	Severe pain, blockage of bile ducts (vessels), and prevention of flow of bile.

ORGANS OF THE CIRCULATORY SYSTEM AND THEIR FUNCTIONS	
ORGAN	**FUNCTION**
arteries	Carry blood away from the heart
veins	Carry blood to the heart
capillaries	Where nutrients and gases are exchanged
red blood cells	Carry oxygen and carbon dioxide and give blood its red color because they contain hemoglobin (an iron-containing protein that binds oxygen in the lungs and transports it to tissues in the body).
white blood cells	Fights diseases (pathogens)
plasma	The liquid portion of blood
blood	Supply oxygen and nutrients to tissue. Removes wastes such as carbon dioxide, urea and lactic acid. Circulates white blood cells and detect foreign material by antibodies. Transports hormones. Regulates body pH levels and core body temperature.
platelets	Cell fragments which play an important part in the clotting of the blood
heart	Pumps blood through the body





HOW THIS SYSTEM MAINTAINS HOMEOSTASIS

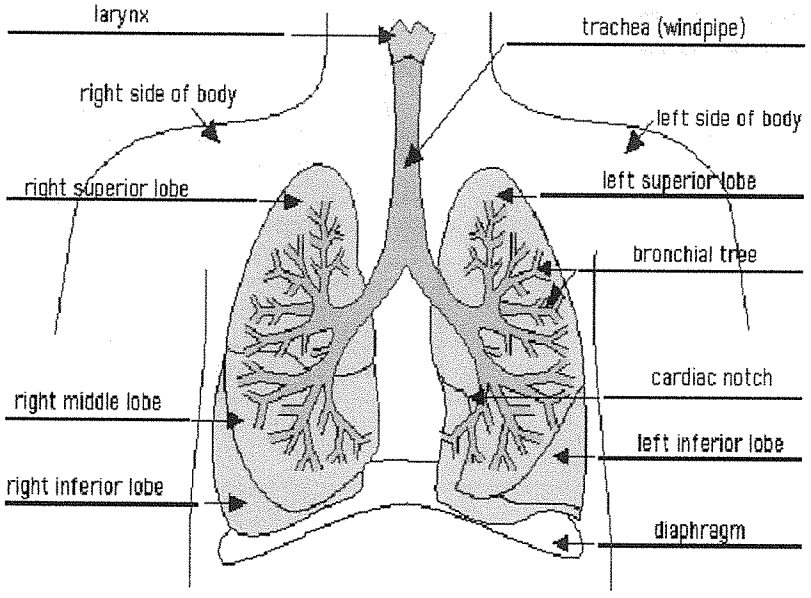
Stabilizes body temperature and pH. Nutrient molecules leave the capillaries to be taken up by the cells and waste molecules given off by the cells are received by the capillaries to be transported away. Blood contributes to homeostasis by transporting oxygen (red blood cells), fighting infection (white blood cells) and clotting blood when necessary (platelets). The circulatory system works with the respiratory system to maintain homeostasis by distributing the oxygen molecules needed for respiration and also by circulating the carbon dioxide waste of respiration as well. The excretory system works with these systems to remove the waste products of respiration (carbon dioxide and water) from the body. Oxygen is utilized during cellular respiration. Fighting infection keeps the body intact and prevents it from succumbing to disease caused by viruses and bacteria. Clotting of blood when a vessel has been cut prevents the loss of this vital fluid. Plasma, too, contributes to homeostasis. The nutrients needed and wastes given off by cells are carried in plasma. Plasma also helps to maintain blood pressure.

DISORDERS OF THE CIRCULATORY SYSTEM

(CARDIOVASCULAR DISEASES)

NAME OF DISORDER	HOW CAUSED	EFFECT ON THE SYSTEM
HYPERTENSION (HIGH BLOOD PRESSURE)	Dietary, genetic, or unknown medical cause. Can be caused by diseases of other body systems i.e., kidney disease.	Can result in heart attack, stroke or death
HEART ATTACK	Clot inside a blood vessel that blocks the flow of blood. Usually caused by an injury to the vessel's wall, both by trauma or infection and by the slowing of blood flow past the point of injury.	Blockage deprives portions of the heart of needed nutrients and oxygen resulting in destruction of heart tissue
ANEMIA	Genetic or dietary causes. Low red cell count or some abnormality of the red blood cells or the hemoglobin. Dietary (Iron Deficiency Anemia) or genetic (Sickle Cell Anemia).	Low oxygen transport capacity of the blood
LEUKEMIA	Cancer of the blood or bone marrow due to genetic or environmental causes	Damage to the bone marrow. This means people with leukemia may become bruised, bleed excessively, or develop pinprick bleeds and anemia

ORGANS OF THE RESPIRATORY SYSTEM AND THEIR FUNCTIONS	
ORGAN	**FUNCTION**
pharynx	Part of the digestive and respiratory system of many organisms. Because both food and air pass through the pharynx, special adaptations are necessary to prevent choking when food or liquid is swallowed.
trachea	Lets air move from the throat to the lungs
bronchi	Carries air to the lungs
bronchioles	Smaller part of bronchi which lets air move from the bronchi to the alveoli
alveoli	Where gas exchange takes place (carbon dioxide is exchanged for oxygen)
lungs	Its principal function is to transport oxygen from the atmosphere into the bloodstream, and to excrete carbon dioxide from the bloodstream into the atmosphere

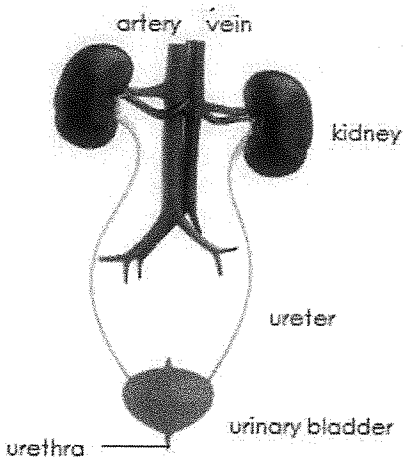


HOW THIS SYSTEM MAINTAINS HOMEOSTASIS

The respiratory system helps to maintain homeostasis by maintaining the carbon dioxide and oxygen balance in the body. When the carbon dioxide concentration rises or when the pH lowers, the respiratory center of the brain is stimulated and the breathing rate increases. The excretory system removes the wastes of respiration.

DISORDERS OF THE RESPIRATORY SYSTEM		
NAME OF DISORDER	**HOW CAUSED**	**EFFECT ON THE SYSTEM**
BRONCHITIS	Usually by bacterial or viral infection in the bronchi.	Persistent cough or sputum production. Obstructed airways. Inflamed airways. Shortness of breath and wheezing.
ASTHMA	These episodes may be triggered by such things as exposure to an environmental stimulant (or allergen), cold air, exercise or exertion, or emotional stress. In children, the most common triggers are viruses such as those that cause the common cold.	The airway sometimes tightens and becomes inflamed and is lined with excessive amounts of mucus. This airway narrowing causes symptoms such as wheezing, shortness of breath, chest tightness, and coughing.
EMPHYSEMA	Exposure to toxic chemicals or long-term exposure to tobacco smoke.	Emphysema is characterized by loss of elasticity of the lung tissue, destruction of structures supporting the alveoli, and destruction of capillaries feeding the alveoli. Symptoms include shortness of breath, hypoventilation, and an expanded chest. As emphysema progresses, clubbing of the fingers may be observed, a feature of tissue being deprived of oxygen.

ORGANS OF THE EXCRETORY SYSTEM AND THEIR FUNCTIONS	
ORGAN	**FUNCTION**
lungs	Excrete carbon dioxide and water vapor
liver	Detoxify drugs
skin	Excrete sweat (water and salts) through sweat glands.
kidneys	Filter wastes (such as urea) from the blood and excrete them, along with water, as urine
ureters	Carry urine from the kidneys to the urinary bladder
urinary bladder	Store urine until it can be excreted from the body
urethra	Carry urine from the bladder to outside of the body

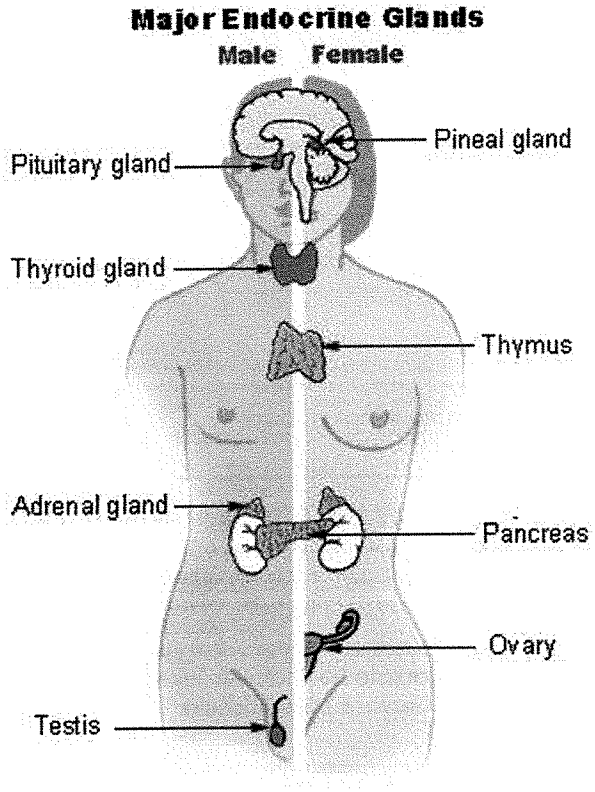


HOW THIS SYSTEM MAINTAINS HOMEOSTASIS

The excretory system helps to maintain homeostasis by removing the wastes of metabolism (ammonia, urea, salts, water, etc) from the body. The skin removes wastes from the body by way of sweating. This also helps to maintain body temperature. The kidneys and the urinary system also help to remove wastes. As blood passes through the kidneys, urine is made and excreted. Urine is composed of substances not needed by cells, end-products of metabolism (i.e., urea) and excess salts and water.

DISORDERS OF THE EXCRETORY SYSTEM		
NAME OF DISORDER	**HOW CAUSED**	**EFFECT ON THE SYSTEM**
KIDNEY DISEASE	Long term use of pain killers (i.e., aspirin) and other drugs. Can be caused by other diseases, such as lupus and diabetes. Genetic component.	Increased blood pressure, buildup of waste products in the blood, damage to blood vessels, change in the composition of blood, swelling (edema), heart disease, etc.
GOUT	Caused by a buildup of uric acid in the blood that gets deposited into the joints. Diet and genetics is usually the cause.	Excruciating and sudden pain, swelling, redness, warmness and stiffness in the joint. Low-grade fever may also be present. The inflammation of the tissues around the joint causes the skin to be swollen, tender and sore if it is even slightly touched. For example, a blanket draping over the affected area could cause extreme pain.

ORGANS OF THE ENDOCRINE SYSTEM AND THEIR FUNCTIONS	
ENDOCRINE GLANDS AND THE HORMONES THEY SECRETE	**FUNCTION**
hypothalamus	The "master gland". Controls metabolism and such things as body temperature, hunger, thirst, and sleep.
pituitary gland	Secretes hormones that control homeostasis and other endocrine glands
thyroid gland	Produces hormones (i.e., thyroxin), that regulate the rate of metabolism and affect the growth and rate of function of many other body systems
parathyroid glands	The sole function of the parathyroid glands is to regulate the calcium level in our bodies within a very narrow range so that the nervous and muscular systems can function properly
adrenal glands	Chiefly responsible for regulating stress.
pancrease	Produce the hormones insulin and glucagon which regulate blood sugar
<u>gonads</u> **1. testes** **2. ovaries**	Produce male sex hormones such as testosterone which function in puberty, and secondary male sex characteristics (penis growth, facial hair, course skin, muscle mass, etc). Produce female sex hormones such as estrogen and progesterone which function in puberty, secondary sex characteristics, the menstrual cycle, and in pregnancy.



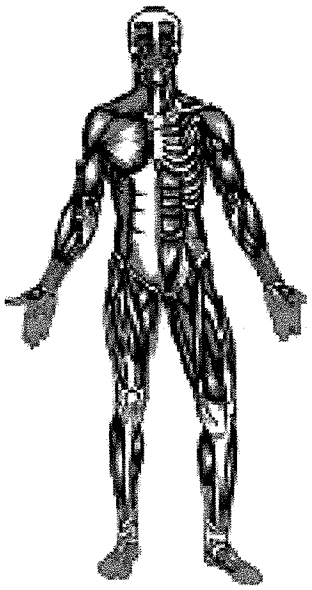
HOW THIS SYSTEM MAINTAINS HOMEOSTASIS

The hormones produced by the endocrine glands are chemical messengers that are transported throughout the body via the circulatory system by the blood. The endocrine and nervous system both coordinate the activities of body parts and help to maintain homeostasis. The nervous system reacts quickly to external and internal stimuli, whereas the endocrine system is slower to act but its effects are longer lasting. A number of different hormones are active in keeping the blood glucose level at a normal level (0.1%). The most important of these is insulin. Immediately after eating, increased glucose concentration stimulates the pancreas to release insulin. Insulin also promotes the uptake of glucose by cells including the liver. Insulin stimulates the conversion of glucose to glycogen in the liver. Between eating, when insulin is not being produced, the liver convert glycogen to glucose and therefore the blood glucose level remains constant. This conversion of glycogen is stimulated by both glucagon and, in times of emergency, also adrenalin. If the supply of glycogen should run out and the blood glucose level remains low, hormones will direct the liver to make more glucose.

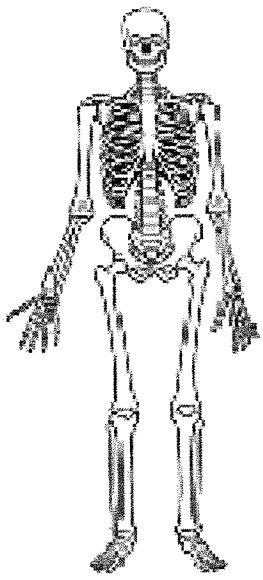
DISORDERS OF THE ENDOCRINE SYSTEM		
Name of Disorder	**How Caused**	**Effect on the system**
GOITER	Usually due to iodine deficiency. Can be caused by autoimmune disease	At times it does not negatively affect the system (except in appearance) but it could cause breathing and swallowing problems. Swelling of the neck due to an enlarged thyroid gland.
DIABETES	Physical damage to the pancreas or a deficiency in the hormone insulin (produced by the pancreas). Genetic and dietary causes.	Metabolic disorder characterized by high blood sugar. Inability to regulate blood sugar. Diabetic coma, foot amputations, blindness, stroke, death
PITUITARY GLAND DISORDERS	Damage to the pituitary gland resulting in overproduction or underproduction of growth hormone and other hormones produced by this gland. Damage can include those caused by severe head trauma, surgery, brain tumors, etc.	Growth problems in children. In adults can cause loss of strength and muscle tone, poor memory, social withdrawal, and even depression.

LOCOMOTION (MOVEMENT)

ORGANS OF LOCOMOTION AND THEIR FUNCTIONS	
ORGAN	**FUNCTION**
bones	Function to move, support, and protect the body, produce red and white blood cells and store minerals
cartilage	Helps in the formation of bones. Supplies a smooth surface for the movement of bones. Cartilage is found in many places in the body including the joints, rib cage, ear, nose, bronchial tubes and the spine.
joints	Location at which two or more bones make contact. They are constructed to allow movement and provide mechanical support.
muscles	Produce force and cause motion, either locomotion or movement within internal organs
skeletal muscles	"Voluntary" (under conscious control) muscle causes locomotion and affects posture
smooth muscle	"Involuntary" (not under conscious control) muscle found in the walls of organs such as the stomach, esophagus, bladder and small intestine
cardiac muscle	"Involuntary" muscle found in the heart only
tendons	Connects muscle to bone
ligaments	Connects bone to bone



Muscular System



Skeletal System

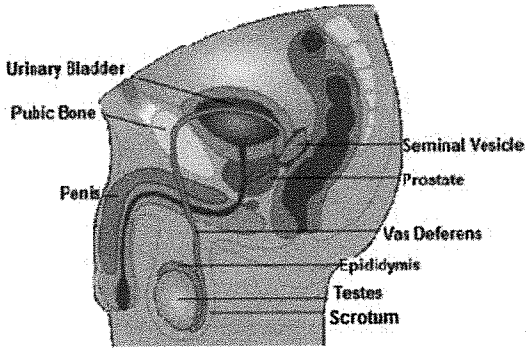
HOW THIS SYSTEM MAINTAINS HOMEOSTASIS

When the body is at rest, body heat is generated primarily by the liver, heart, brain, and endocrine glands, but when the muscles are active they generate many times the heat produced by these organs. Therefore, increased muscle activity by rubbing the hands or stamping the feet is used as a short-term measure to raise body temperature and maintain homeostasis.

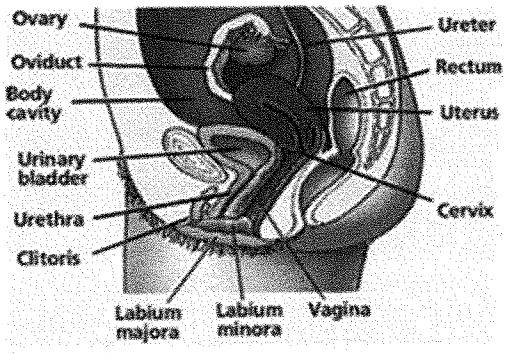
DISORDERS OF LOCOMOTION		
Name of Disorder	**How Caused**	**Effect on the system**
ARTHRITIS	Inflammation of joints caused by joint infection, autoimmune disease, or other metabolic causes	Damage to joints, pain, loss of use of affected body parts, disability
TENDONITIS	Inflammation of tendons caused by overuse of the tendon as in athletic activity or via other diseases, such as arthritis	Symptoms can vary from an ache or pain and stiffness to the local area of the tendon, or a burning that surrounds the whole joint around the inflamed tendon. With this condition, the pain is usually worse during and after activity, and the tendon and joint area can become stiffer the following day as swelling impinges on the movement of the tendon.

REPRODUCTIVE SYSTEM (REPRODUCTION)

ORGANS OF THE REPRODUCTIVE SYSTEM AND THEIR FUNCTIONS	
ORGAN	**FUNCTION**
ovary	Produces egg cells in females
oviduct (fallopian tube)	Passageway for eggs released from the ovaries or for fertilized eggs to travel to the uterus
uterus	Place where the fertilized egg (zygote) develops into an embryo, fetus, then ultimately a baby
cervix	During childbirth, contractions of the uterus will dilate the cervix up to 10 cm in diameter to allow the child to pass through
vagina	Providing a path for menstrual fluids to leave the body. Sexual activity. Giving birth.
penis	Male reproductive organ adapted for reproduction for the delivery of sperm. It also serves as the external male organ of urination.
testes	Produces sperm in males
scrotum	Keeps the testes at a temperature slightly lower than that of the rest of the body for the protection of the sperm
urethra	The urethra has an excretory function in both genders to pass urine to the outside, and also a reproductive function in the male, as a passage for sperm
vas deferens	Functions in male ejaculation to propel sperm forward in order to eject it from the penis
seminal vesicles	They secrete a significant proportion of the fluid that ultimately becomes semen. Semen is composed of sperm cells and seminal fluid.
prostate gland	The main function of the prostate is to store and secrete a clear, slightly alkaline fluid that constitutes up to one-third of the volume of semen



Male Reproductive System



Female Reproductive System

HOW THIS SYSTEM MAINTAINS HOMEOSTASIS
Reproduction does not help to maintain homeostasis!!!!!!

DISORDERS OF THE REPRODUCTIVE SYSTEM		
NAME OF DISORDER	**HOW CAUSED**	**EFFECT ON THE SYSTEM**
CERVICAL CANCER	Genetic or environmental. Most scientific studies have found that human papillomavirus (HPV) infection is responsible for virtually all cases of cervical cancer. HPV is contracted during sexual intercourse.	Symptoms of advanced cervical cancer may include: loss of appetite, weight loss, fatigue, pelvic pain, back pain, leg pain, single swollen leg, heavy bleeding from the vagina, leaking of urine or feces from the vagina, and bone fractures.
PROSTATE CANCER	Genetic or environmental	Pain, difficulty in urinating, erectile dysfunction and other symptoms
MALE INFERTILITY	Inability to produce children naturally due to problems such as low sperm count, testicular cancer, physical damage to testicles, etc.	Impairs the ability to reproduce
FEMALE INFERTILITY	Inability to conceive children or to carry a pregnancy to term due to issues such as genetics, uterine fibroids, blockage to fallopian tube due to excessive scarring from venereal disease, etc.	Impairs the ability to reproduce

Comparison of Human Organ Systems and Plant Structures

Standards: SC.5.L.14.2

All plants and animals, including humans, are alike in some ways and different in others. They all have internal parts and external structures that function to keep them alive and help them grow and reproduce. The physical structures of plants may differ from humans but the functions they carry out serve a similar purpose. Certain differences between plants and animals are quite

obvious. Animals are motile. They have legs and other structures to help them achieve movement. Plants on the other hand lack locomotion. While they lack many of the structures of animals, plants manage to accomplish the same life functions.

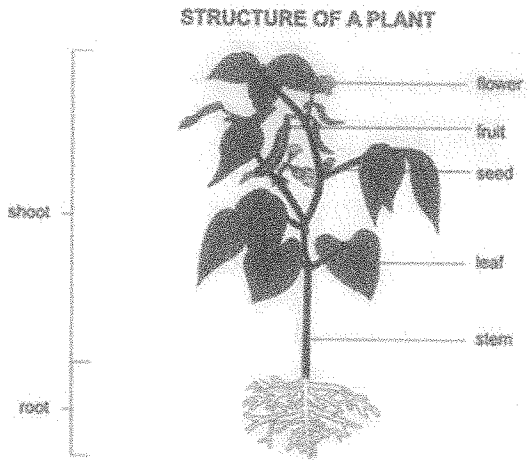
Xylem and ***phloem*** are tissues in plants that function as a circulatory system. Xylem transports water from the root to the leaves and phloem distributes food from the leaves downward. Plant stems provide structure to a plant in the same manner as a skeleton or exoskeleton provides structure to an animal.

Plants, like animals, have hormones that control such life functions as growth and development. One such hormone is ***auxin***. Auxin regulates the amount, type, and direction of plant growth. Hormones are part of the endocrine system of animals.

Plants perform sexual reproduction as do animals. They have ovaries that make egg cells. They have pollen grains that transport sperm cells inside to the ovaries for fertilization. The stamen and the pistil are the reproductive organs of the plant. Animals have a much more highly developed sensory and nervous system than plants. Plants have almost no ability to sense.

Table 3-11 Comparison of Human and Plant Organ Systems

Functions	Human Organ System	Plant Organ System
support	skeletal system (exoskeleton in some animals)	stem system (adds height and seeks light as well
transport water and nutrients	circulatory system(i.e., heart pumps blood)	stem system (vascular—xylem and phloem tissue)
reproduce	reproductive system	flower system (sexual). ***stamen*** = male reproductive organ. ***pistal*** = female reproductive organ
waste removal	excretory system	root and leaf system (***stomates*** = structures in leaves that allow gases such as carbon dioxide, water vapor and oxygen exit and enter the leaf)
energy usage or production	all systems respiratory system	all systems
provide a barrier to the outside environment	integumentary system (skin)	epidermal system
takes in water and nutrients	digestive system	root and leaf systems



Infectious Agents

Standards: SC.6.L.14.6

An ***infectious agent*** is one that causes a disease or infection that can be spread from one individual to another. These include viruses, parasites, bacteria and fungi. They are also referred to as ***pathogens***. One way to prevent infection from bacteria and viruses is by washing your hands often. Parasitic infections can be avoided by not drinking contaminated water or eating undercooked food.

Table 3-12 Infectious Agents

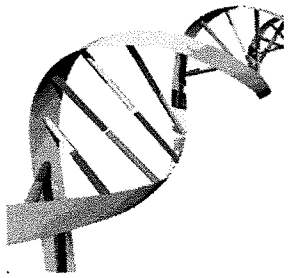
Type of Pathogen	Examples of Diseases Caused	Typical Mode of Transmission	Treatment	Size of Pathogen
Virus	Small pox, influenza (flu), mumps, measles, chickenpox, Ebola, rubella, HIV	Blood- borne	Anti-viral drugs	20-300 nanometers in length
Parasites	Malaria	Through contaminated food and water, via vectors (insects), blood - borne, air-borne	Clinical medicines	From microscopic- well over 30 feet
Bacteria	Tuberculosis, pneumonia, tetanus, syphilis, typhoid fever, and diphtheria	Airborne, water-borne, Blood-borne	Antibiotics	1-5 micrometers in length
Fungi	Most common cause of disease in plants. Apart from athletes foot fungus most life threatening fungal infections occur in humans with weak immune systems. Skin, nail or yeast infections.	Through soil	Fungi are eukaryotic organisms which create a treatment challenge when other eukaryotic cells are infected. Fungicides or anti-fungal agents disrupt the fungi's homeostasis in order to kill it.	A typical fungal cell is 1-40 micrometers in length.

PART 3: HEREDITY

Standards: SC.7.L.16.1, SC.7.L.16.2, SC.7.L.16.3, SC.7.L.16.4

How does a heart cell know that it's supposed to be a heart cell or bone tissue know that it's supposed to make red blood cells? Why do you look similar to your parents? The answer is all in your ***deoxyribonucleic acid***, or as it is more commonly known as, ***DNA***. Every organism requires a set of instructions that specifies its traits. DNA is the set of instructions that determines if an animal will have a particular fur color; whether a flower will grow to be a rose or an orchid; or whether you will be tall or short. DNA controls the traits of an organism.

DNA is the genetic material that is passed from generation to generation. Genes are sections of DNA arranged linearly. Genes are located on chromosomes. These chromosomes are located in the nucleus of the cell. ***Genetics*** is the study of DNA and how characteristics (***traits***) are passed down from parent to ***offspring*** through ***gametes*** (sex cells). The process of parents passing on genetic information to their offspring is called ***heredity***. Heredity is the passage of these instructions from one generation to the next.



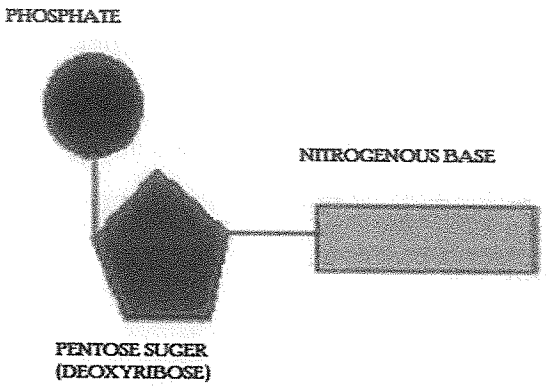
DNA Molecule

From the picture above you can see that DNA's shape resembles a twisted ladder. We call this a ***double helix***. ***James Watson & Francis Crick*** are the scientists who created the first accurate model of DNA. This is what we know about the structure of DNA:

1. DNA molecules are very long
2. DNA is made of thousands of repeating units called ***nucleotides***. A nucleotide is made up of three parts; a sugar (***deoxyribose***), a phosphate, and a nitrogenous base.
3. DNA contains four nitrogenous bases:
   - adenine (A)
   - cytosine (C)

- guanine (G)
- thymine (T)

4. The four bases in DNA bond together in only one way: guanine (G) pairs with cytosine (C) and adenine (A) pairs with thymine (T). We call this ***complementary base pairing***. This principle was first observed in the 1950's by a scientist named ***Erwin Chargaff***. We call base pairing rules in DNA, ***Chargaff's Rules*** . He observed that the amount of thymine in DNA always equals the amount of adenine. And the amount of cytosine always equals the amount of guanine.



DNA nucleotide

The study of heredity began in the 1800's with an Austrian monk named ***Gregor Mendel***. Using regular garden pea plants he performed important experiments to explore heredity. Without having the knowledge we have today of DNA and genes his discoveries helped scientists better understand how traits are passed from one generation to the next. Mendel observed traits such as seed shape, plant height, and flower color. He observed the results of pollination and fertilization of gametes from plants having same characteristics (i.e., both tall) and plants having different characteristics (i.e., one tall and one short). He observed the characteristics of the offspring (the F1 generation). Mendel then ***crossed*** (mated) these offspring (F2 generation) and observed the outcome.

Based on the characteristics observed in the offspring, Mendel developed principles of inheritance and concluded that these characteristics must have been due to certain "factors" originating from the parents. We now know these factors to be genes. It is genes that determine traits. In sexually reproducing organisms, half of inherited traits in the offspring come from the mother and the other half comes from the father. Therefore, no offspring is identical to its parents. Organisms inherit some characteristics from one parent and some form the other. This

combination creates variety. In fact, no two organisms are identical (apart from identical twins) because no two organisms have the same DNA.

The principle of ***dominance***, which helps to explain the pattern of heredity, was one that Mendel developed.

Rules of Dominance
1. The trait that is observed in the offspring is the ***dominant trait*** (represented in genetics problems with an uppercase letter). Dominance occurs when certain ***alleles*** (different genes that control a trait) mask the expression of other alleles. 2. The trait that disappears in the offspring is the ***recessive trait*** (represented in genetic problems with a lowercase letter). A recessive trait or allele is expressed only when two recessive alleles for the same characteristic are inherited.

We will tie in dominance when we introduce ***Punnett squares*** in the next section.

Important Genetics Terms

1. ***phenotype*** -- the way an organism looks (i.e., red hair or brown eyes)
2. ***genotype*** -- the gene combination of an organism (i.e., in genetics problems letters are used to represent traits. So, the gene combination could look like this: AA or Aa or aa).
3. ***heterozygous*** -- when the two alleles for a trait are different (i.e., Aa)
4. ***homozygous*** - when the two alleles for a trait are the same (i.e., AA or aa).

Punnett Squares

Standards: SC.7.L.16.2

It is possible to predict whether a person is likely to inherit a particular trait from parents. This prediction can be made using diagrams called ***Punnett squares***. Punnett squares are diagrams that show the possible offspring (children) of a genetic cross. The following example shows how they are used in genetics. Let's use one of Mendel's pea plants in our example:

Problem: ***In pea plants tallness is a dominant trait. What are the possible offspring of a cross between a homozygous tall pea plant and a short pea plant?***

Step 1— List the given information from the problem and determine which letter combinations to use to represent the parent's traits

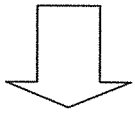
Given:

T= tall trait

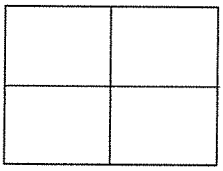
t = short trait [You have to use the same letter to represent the trait of "height"]

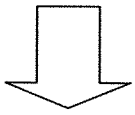
TT = gene combination of the tall parent. [Remember every trait has 2 alleles—one from the mother and the other from the father. That's why this parent has 2 T's. Both T's are capital because tallness is a dominant trait. Dominant traits are given a capital letter. Both letters are the same capital letter because this parent is homozygous, meaning both alleles are the same.]

tt = gene combination of the short parent. [Remember this parent has the recessive trait of shortness. This parent is homozygous for shortness so, they have two lower case t's]

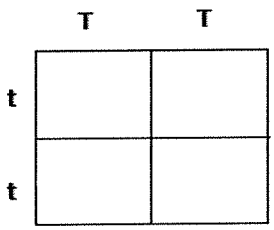


Step 2— Draw a square and divide it into 4 sections

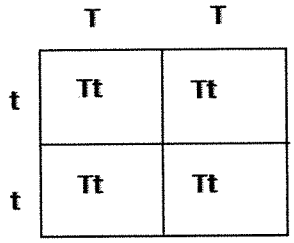




Step 3— Write the letters that represent alleles from each parent along the top and side of the square. It does not matter which parent is placed at the top or along the side. Write one letter per box.



Step 4— Fill in the squares. Each square represents one offspring of the cross. Each offspring must receive one gene from each parent since we get half our genes from our mother and the other half from our father. For each empty square distribute one letter from the top and one letter from the side. Capital letters are always written first. The letters written inside the boxes represent the gene combinations of the offspring.



Step 5— Go back and answer the original question

The possible offspring of a cross between a homozygous tall pea plant and a short pea plant are:

Tt (100%) This represents the genotype of the offspring

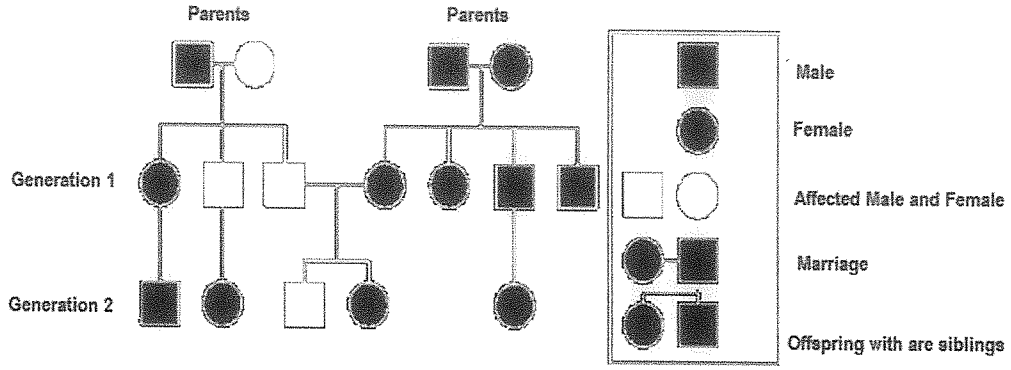
The phenotype of the offspring is they all are tall.

Remember, whenever a dominant trait is present it will be shown (expressed). Dominant traits are stronger than recessive ones (the lowercase letter).

Pedigrees

Standard: SC.7.L.16.2

Another way of representing the inheritance of traits is with the use of a chart called a ***pedigree***. A pedigree traces a gene through the family line.



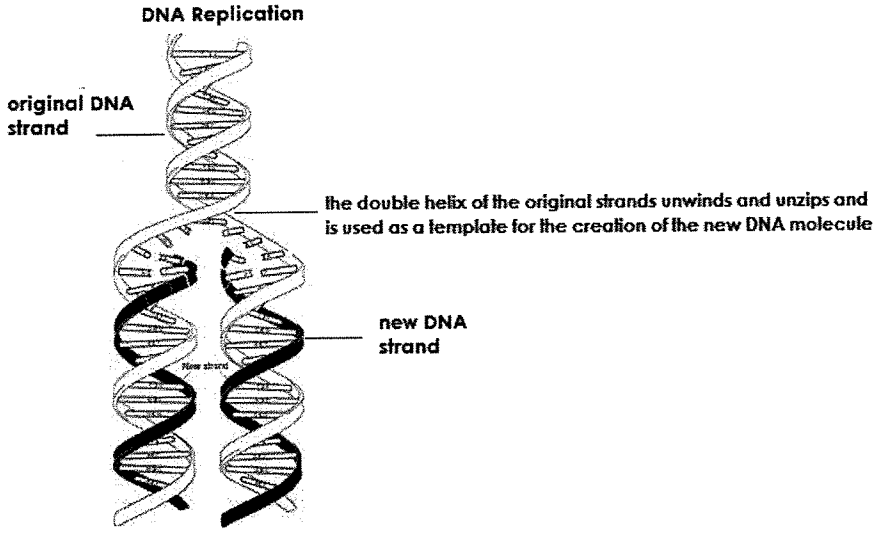
Pedigree diagram

DNA Replication

Standards: SC.7.L.16.1

We mentioned earlier that in order for cells to reproduce during mitosis and meiosis DNA must make an exact copy of itself. This is called ***DNA replication*** and it occurs during interphase. Each new cell formed gets a complete copy of the DNA. When DNA replicates the following events happen:

1. The double stranded DNA unwinds, the two strands separate and unzip by breaking the hydrogen bonds between the nitrogenous bases.
2. Free nucleotides in the nucleus bond to their complementary bases on the DNA strand. This is all controlled by enzymes.
3. A DNA molecule is produced that is identical to the original strand.



DNA and its Control of Cell Activities

Standards: SC.7.L.16.1

You already know that an organism's unique qualities are determined by the DNA located on its genes. Genes control proteins that control cell activities. This is how DNA controls cell activities.

Many of the proteins made in the cell are ***enzymes*** (molecules that speed up chemical reactions). For example, genes control the enzymes that determine eye color and height during fetal development. In fact, most of the differences you can see among organisms are due to their different types of proteins. Proteins also help cells to function. DNA's nucleotide sequence determines the sequence of ***amino acids*** (the building blocks of proteins) found in the enzyme and other proteins made. So, each gene is a set of instructions for making a protein.

DNA and Protein Synthesis

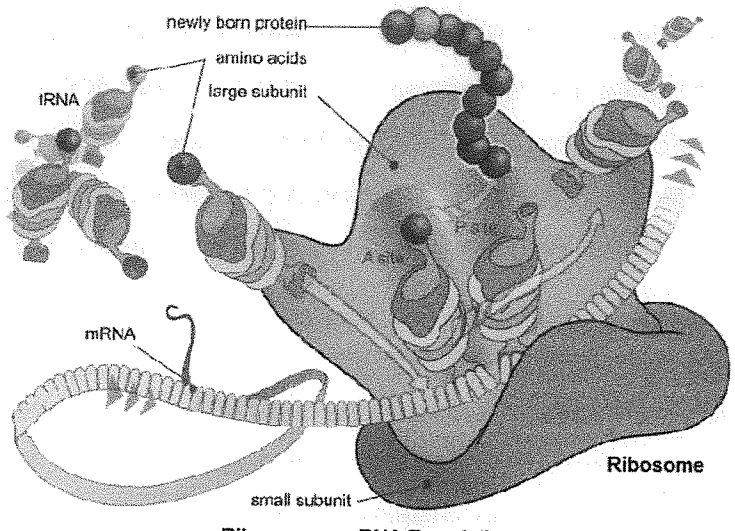
Standards: SC.7.L.16.1

1. The first step in making a protein is for DNA to unwind its double helix, open up and make a copy of one of its strands. This copy is called ***mRNA*** (messenger RNA) because it brings the message of DNA from the nucleus into the cytoplasm. This processes is called ***TRANSCRIPTION*** because DNA is being copied. The word

"transcribe" means to make a copy.

2. mRNA leaves the nucleus and attaches itself to a ribosome in the cytoplasm of the cell.
3. The ribosome becomes a protein assembly line. The mRNA is fed through the ribosome three bases (***codon***) at a time.
4. Another RNA molecule called ***tRNA*** (transfer RNA) picks up specific amino acids from the cytoplasm and brings them to the ribosome. A long string of amino acids form a protein. The amino acids become linked in a growing chain. This process is called ***TRANSLATION*** because the instructions on the original DNA strand which was copied onto the mRNA strand is interpreted; it is turned from one "language" (DNA) to another (amino acids).

Note: RNA (ribonucleic acid) is a nucleic acid similar to DNA with the exception of being single stranded, having ribose as its sugar and having uracil (U) instead of thymine (T) as one of the four bases.



Ribsomome mRNA Translation

DNA Mutations

Changes in DNA are called ***mutations***. This change can be in the amount and type of bases present or in their sequence on the DNA molecule (A, T, G, C). Mutations often occur due to random errors during DNA replication. They can lead to no damage to the organism, an improvement in the organism's traits, or to a harmful trait. Changes in the DNA of an organism

can cause changes in traits. Some mutations are beneficial, such as seedless watermelon or pink grapefruit.

Sometimes in a mutation a nitrogen base is left out. This is called a ***deletion***. On the other hand, if during a mutation an extra nitrogen base is added this would be called an ***insertion***. Sometimes the wrong base is used. This is called a ***substitution***. If a mutation occurs in the DNA of sex cells (egg and sperm), it can be inherited. Cells have proteins that can often detect and fix errors in DNA. When the mutation cannot be fixed it becomes a part of the genetic code. DNA mutations can be caused by chemicals (***mutagens***) or even UV rays from the Sun. Examples of mutagens include certain drugs, high doses of vitamin A, asbestos, and X-rays.

Biotechnology and its Impact on Individuals, Society and the Environment

Standards: SC.7.L.16.4

Biotechnology is the use of living organisms or other biological material (i.e., DNA) to develop new products for use in daily life. It has been used to develop new foods and medicines and other products. Other useful applications of biotechnology include environmental cleanup. Cloning, genetic engineering and artificial selection are some examples of biotechnology. Biotechnology can be applied to health care, agriculture and crop production, industrial, and environmental uses.

Biotechnology has an environmental application when bacteria are used to clean up ocean oil spills or when biodegradable plastics, that breakdown over time to lessen pollution, are created. In many third world countries genetic engineering is being used to create bigger and stronger crops and livestock to alleviate hunger and starvation.

Genetic engineering is the transfer of genes from one organism into another. Human genes that control the synthesis of insulin hormone can be inserted into bacteria. The bacteria will then be genetically engineered to produce human insulin that can be given to diabetic patients.

Biotechnology has social benefits by the use of genetic testing to detect genetic diseases in fetuses before they are born or in paternity testing to determine the identity of a child's father.

Gene therapy, which is the use of biotechnology to treat patients with genetic disorders such as cancer improves the quality of life in these patients. Genes are inserted into the cancer patient to correct defective genes and replace them with more functional ones.

PART IV DIVERSITY AND EVOLUTION OF LIVING ORGANISMS

Evolution

Standards: SC.5.L.15.1, SC.6.L.15.1, SC.7.L.15.2, SC.7.L.15.3

When some people think of ***evolution*** they think about apes changing into humans over time. But that is not the Theory of Evolution. The Theory of Evolution suggests that existing forms of life on Earth may have evolved from earlier forms that may have been very different in looks, structure, and behavior. The Theory of Evolution is the organizing principle of life. It is an attempt to describe the change in populations over time and not individual species.

Differences in the characteristics of organisms sometimes give individuals an advantage in surviving and reproducing. These genetic variations often give organisms favorable traits that help them to better adapt to changes in their environment. Although great diversity of living things exists on Earth, changes in the environment can threaten the survival of populations.

When environmental changes occur organisms that can adapt well to these changes are said to have favorable traits. As such, these individuals will survive and reproduce over time, thus passing down favorable traits from generation to generation. Special characteristics that help an organism survive and reproduce in its environment are called ***adaptations***. Adaptations can be physical, such as fur color, or involve behaviors that give the individual an advantage in hunting, mating, or protecting itself from predators. The gills of a fish are adaptations that allow fish to breathe underwater and as such, survive in aquatic environments.

To demonstrate adaptations let's use the example of a population of leaf-eating animals (herbivores) with variations in neck length. Some individuals of the species have long necks and others have short necks. The animals with the long necks eat leaves from trees higher up. The

shorter neck animals eat leaves from low-lying bushes and shrubs. If a virus infects all the bushes and shrubs in the environment the food source of the short neck animals will decrease. As a result, they will begin to compete for what little food remains. Eventually over time, with no food, the short neck animals will begin to starve and die out. Eventually, they may become ***extinct*** (when a species has died out and no longer exist on Earth). Extinction is the end of the organism. Examples of organisms that no longer exist on Earth today (are extinct) include the Dodo, the Passenger Pigeon, the Bali Tiger, the Cuban Ruta Tree, the Tasmanian Wolf, the Caspian Tiger, and the Quagga.

The inability of the short neck animals to adapt to their changing environment would result in their extinction. The long neck animals possessed a genetic variation (long necks) that enabled them to survive the virus attack on the food source. Because of this variation they were better adapted for survival in their environment. Because they survived they would be able to reproduce and pass on this favorable trait to their offspring. In time, the long neck species would have proven to be more genetically fit than the short neck animals. Long neck animals will replace the short neck variety. It can then be said that evolution occurred in this population of animals. This is known as ***natural selection*** or survival of the fittest. The environment serves as the selecting agent for survival.

The "fittest" individual is not necessarily the biggest or the strongest. They are the ones that are more adaptable to changes in their environment. Millions of years ago when a meteor hit Earth and caused the climate change which resulted in the extinction of the dinosaurs, small mammals present at that time, survived. They were able to burrow into the ground for food and protection. Although they were much smaller than the mighty dinosaurs they proved to be more fit. They survived the catastrophic event and reproduced to increase the number of species over time.

Natural Selection is a primary mechanism leading to change over time in organisms. It is a theory that was created in the 1800's by ***Charles Darwin***, a naturalist. For this, he is given the distinction of "Father of Evolution". His theory was based on three ideas:

1. ***overpopulation***– populations produce more species than can possibly survive.
2. ***competition***– organisms compete for food, shelter, mates, etc.
3. **survival of the fittest**– variations among individuals in a population make some better suited for the environment. As such, they survive to reproduce and pass on their traits.

4. The environment is the agent of natural selection, choosing which variations are advantageous and which are not. Darwin's theory could not explain why variations occurred (the study of genetic mutations had not yet begun).

A modern example of evolution that occurs in bacteria is antibiotic resistance (the ability of bacteria to resist the harmful effects of antibiotics). When exposed to antibiotics many bacteria are killed. A genetic variation in a few would allow them to not be affected by the antibiotics and to survive the treatment. They become adaptable to the drugs. These bacteria are more genetically fit and have greater adaptation abilities for survival. Due to natural selection they would reproduce and pass on the favorable trait to their offspring. In time an entire population of bacteria is produced that carries the adaptation of antibiotic resistance.

Natural selection deals with variations in genes that occur randomly by mutations or spontaneously during crossing over of meiosis. However, humans have found ways to deliberately select which traits in plants and animals are favorable, and therefore more desirable. This practice is called ***artificial selection*** as opposed to natural selection. Humans have an impact on the genetic traits of organisms when they breed plants and animals for the inheritance of favorable traits. Deciding, for example, that red roses are more profitable than white, a gardener may breed red roses repeatedly until the population increases over white roses. Humans, as opposed to nature, now becomes the selecting agent.

Evidence for Evolution

Standards: SC.7.L.15.1

The scientific theory of evolution is supported by multiple forms of evidence. Documented evidence in support of evolution includes the ***fossil record***, the ***geologic time scale***, ***comparative anatomy***, ***comparative embryology***, ***comparative cytology***, and ***comparative biochemistry***. These pieces of evidence are described below;

The Fossil record

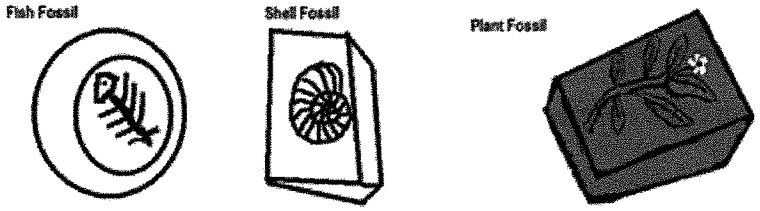
1. ***Fossils*** are the remains or imprints of organism that no longer exist. They help people learn about living things that once existed on Earth.

2. Fossil evidence is consistent with the theory of evolution that populations change over time. By studying fossils, scientists are able to develop a picture of past organisms in order to determine the changes in plant and animal life that has occurred.

3. Scientists have made a time line known as the ***fossil record*** that organizes fossils by estimated age and physical similarities.

4. Fossils found in younger layers of sedimentary rock tend to be similar to present-day organisms.

5. Relatively intact and fully preserved prehistoric organisms have been found in ice, ***amber*** (sticky plant material) and tar.



Geologic time scale

1. The geologic time scale is a scale that divides Earth's 4.6 billion year history into distinct intervals of time. The age of Earth has been estimated based on radioactive dating of the oldest known rocks from Earth's crust.

2. ***Eon*** is the largest division of geologic time (Hadean eon, Archean eon, Proterozoic eon and Phanerozoic eon).

3. ***Era*** is the second largest division of geologic time. The Phanerozoic eon is divided into three eras.

4. After era, the next largest division of time is the ***period***. The three eras are further divided into periods.

5. The smallest division of geologic time is the ***epoch***. Periods are divided into epochs.

6. The appearance and disappearance of species mark the boundaries of geologic time intervals.

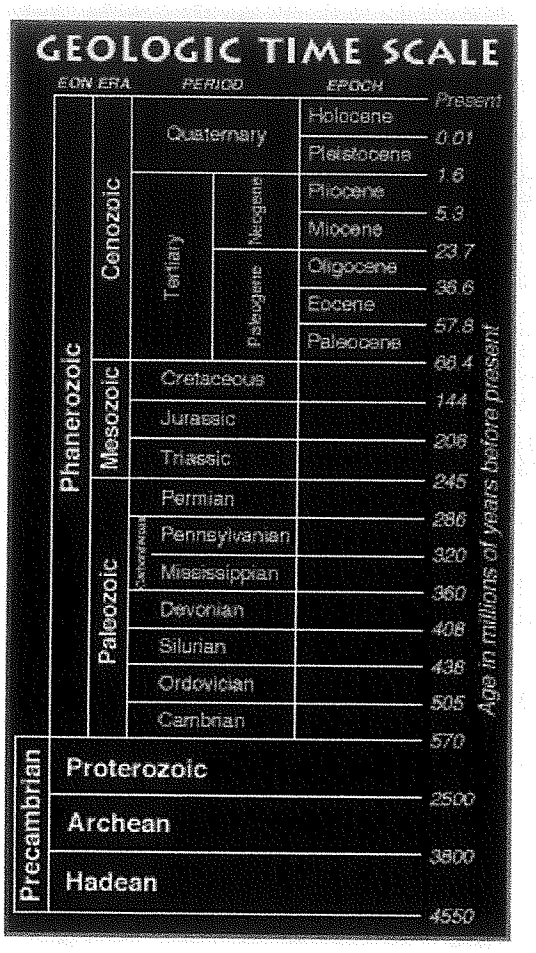
7. Mass extinctions cause the number of species to greatly decrease over a

relatively short period of time. This extinction could be due to such changes as ocean currents or global climate changes.

8. The beginning of the Paleozoic era ushered in a flourishing time for marine life. Halfway through this era land plants appeared. By the end of the Paleozoic era, insects, amphibians and reptiles populated the land.

9. The Mesozoic era was the famous age of the dinosaur. This era includes the Triassic, Jurassic and Cretaceous periods where dinosaurs and other reptiles inhabited the land. Small mammals were also present during this time. Birds appeared in the late Mesozoic era.

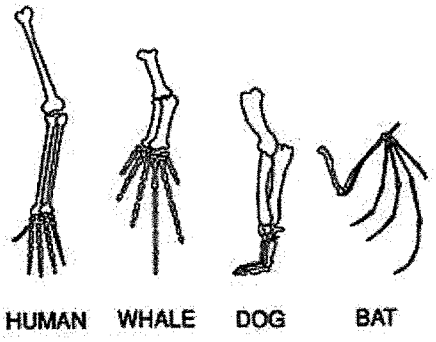
10. The Cenozoic era is the age of mammals. It is the era we currently live in.



Comparative anatomy

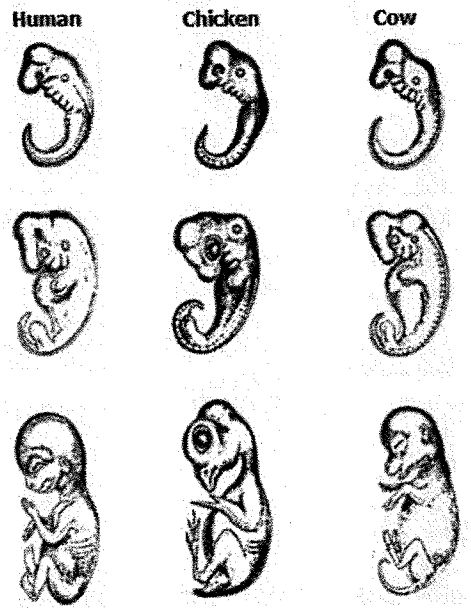
Observations of the anatomy or structure of various body parts of organisms provide evidence of similarities between various organisms. For example, there are many similarities in structure between the flipper of a whale, the wing of a bat, the arm of a human and the forelimb of a

dog. This may suggest a common ancestor.



Comparative embryology

Comparing the embryos of various organisms shows similarities in this early stage of development. It is suggestive of a common ancestor.



Comparison of embryological structures in human, chicken and cow

Comparative cytology

Most living organisms have cell organelles that are functionally and structurally similar. These include ribosomes, mitochondria and the cell membrane. Comparing these cell structures in organisms can establish an evolutionary relationship.

Comparative biochemistry

All living things contain DNA and other biochemical compounds such as enzymes. The closer

two organisms are the more similar their DNA and biochemistry. The more similar these compounds are the closer the evolutionary relationship between organisms.

Classification

Standards: SC.6.L.15.1

1. ***Classification*** -- the grouping of different types of organisms based upon similarities in structure and evolutionary relationships.

2. ***Taxonomy*** -- the branch of biology concerned with naming and classifying the diverse forms of life.

3. ***Carolus Linneaus*** devised ***binomial nomenclature*** (two names in Latin) consisting of using the genus and species of organisms to form their scientific name. It is called the LInnaean system of nomenclature.

Example: scientific name of humans = Homo sapiens

Homo is the genus name **sapiens** is the species name.

Note that scientific names have the genus name starting with a capital letter and are underlined or written in italics.

4. Taxonomic Hierarchy—groups are arranged in order from the largest, broadest group (kingdom) to the smallest, most closely related group (species).

Kingdom
Phylum
Class
Order
Family
Genus
Species

** The species is the fundamental unit of classification.

5. Organisms become more closely related and their grouping becomes smaller as you move down the taxonomic hierarchy.

6. The 6 Kingdom System is based on the following criteria:

1. Presence or absence of a nuclear membrane (cell type—simple or complex)
2. Unicellularity versus multicellularity (the # of cells in the organism)
3. Type of nutrition (organism's ability to make food)

Kingdoms of Living Things (in order from simplest to most complex)

1. **Archaebacteria**

-- Most primitive life form. These bacteria often live in extreme environments (thermal vents under conditions with no oxygen or highly acid environments).
-- Unicellular and no nucleus (prokaryotic)
--Examples: halophiles (live in extremely salty environments), methanogens (produce methane) and thermophiles (thrive in extremely hot environments)

2. **Eubacteria**

--Bacteria with primitive cell structure (prokaryotic)
--Have no organized nucleus or nuclear membrane
-- Most common type of bacteria but are classified in their own kingdom because their chemical makeup is different from archaebacteria.
--Examples: bacteria (i.e., E. coli and bacillus pneumonia) and blue green algae (cyanobacteria)

3. **Protist**

--Eukaryotic
--Unicellular. Consist of organisms that are animal-like or plant-like in their mode of nutrition
--Examples: ameba, slime mold, paramecium, euglena, and spirogyra (green alga)

4. **Fungi**

-- Eukaryotic
--Cells are usually organized into branched, multinucleate filaments which absorb digested food from the external environment (heterotrophic).

--Examples: yeasts, molds, and mushrooms

5. **Plant**

--Eukaryotic, multi-cellular

--Possess chloroplast, cell walls and are photosynthetic

--Examples: flowering plants, mosses, ferns, trees, grasses, shrubs

6. **Animal**

--Eukaryotic

-- Consist of multi-cellular organisms which ingest their food (heterotrophic)

--Examples: humans, insects, fish, reptiles, mammals, and birds

When Linnaeus developed his system of classification there were only two kingdoms, plants and animals. This two-kingdom system became obsolete with the use of microscopes. This lead to the discovery and identification of new organisms possessing distinguishing characteristics and differences. The six-kingdom system is widely used today.

The three-domain system is a classification system devised in 1990 by Carl Woese, an American microbiologist. It is based on the six-kingdom system but divides living things into three groups; ***archae domain*** (archaebacteria), ***bacteria domain*** (eubacteria), and ***eukarya domain*** (all eukaryotes). Woese based the placement of organisms into each domain based on cellular information, genetics and evolutionary lineage. The domains are divided into several kingdoms.