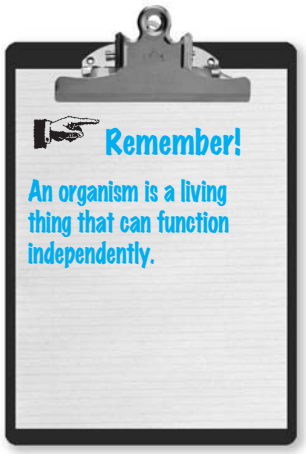
# Objective 2

**The student will demonstrate an understanding of living systems and environment.**

My Notes

## From your studies in science, you should be able to show an understanding of living systems and their environments.




### What are "living systems"?

That's a good question. A system is made up of different parts. An example of a living system is an ecosystem or a single organism made up of many parts—such as a human being. We have bones, muscles, and nerves, as well as many other parts. These parts all work together to help us live. All these parts are made up of cells, the smallest unit of a living system.

### I know something about cells. They are very small, right?

Yes, you're right. We need a microscope to see most cells. Tell me what else you know about cells.

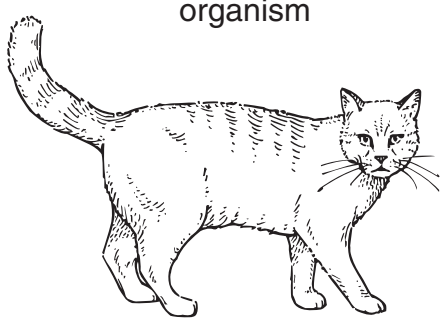
### All living things are made up of cells, aren't they?

Correct. Some organisms are made up of only one cell. These organisms are called single-celled (unicellular). Other organisms are made up of many cells. Larger organisms, such as humans, have billions of cells. Organisms with many cells are called multicellular.

Single-celled organism

(magnified view)

Multicellular organism



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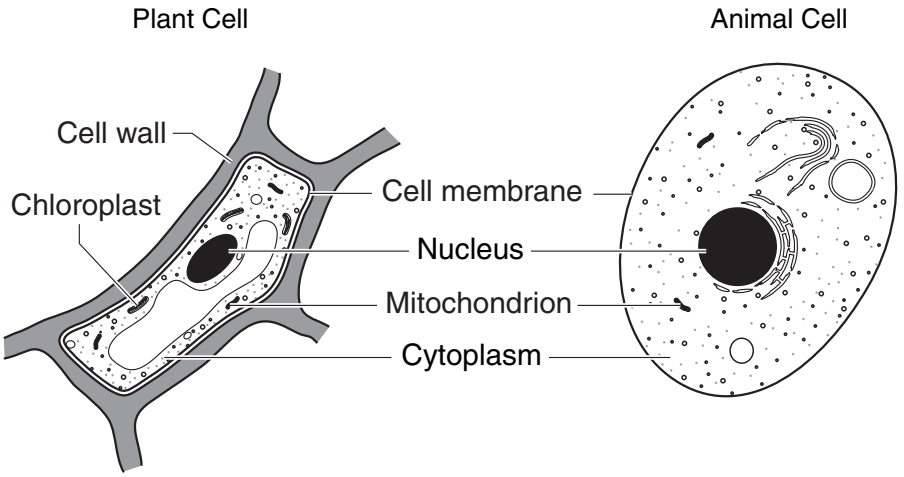
## So all cells are the same?

No, not really. All cells have many of the same basic structures. Look at the diagram below of a plant cell and an animal cell. Do you see any structures that are the same?




## They both have a cell membrane, a nucleus, and cytoplasm, right?

Yes. Both plant and animal cells have these parts. But plant cells also have cell walls for support and chloroplasts to carry out photosynthesis. Plant and animal cells both have mitochondria to provide the energy needed for cell activities.

## Do all plant and animal cells look like the ones shown above?

No. These two cells just give us an idea of the basic structure of cells. Plant and animal cells actually have many different shapes and sizes, depending on their function.

In a single-celled organism, one cell must perform all the functions of that organism. In multicellular organisms, different cells perform different functions. In the human body, for example, nerve cells transmit signals and muscle cells aid in movement. There are many different types of *cells* that make up the *tissues*, *organs*, and *organ systems* in the human body. Tissues are made up of many similar cells doing a single job. Organs are made up of different kinds of tissues that work together. An organ system is a group of organs working together.

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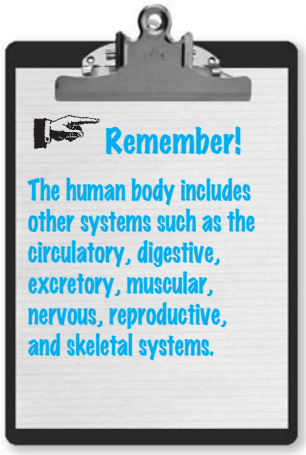
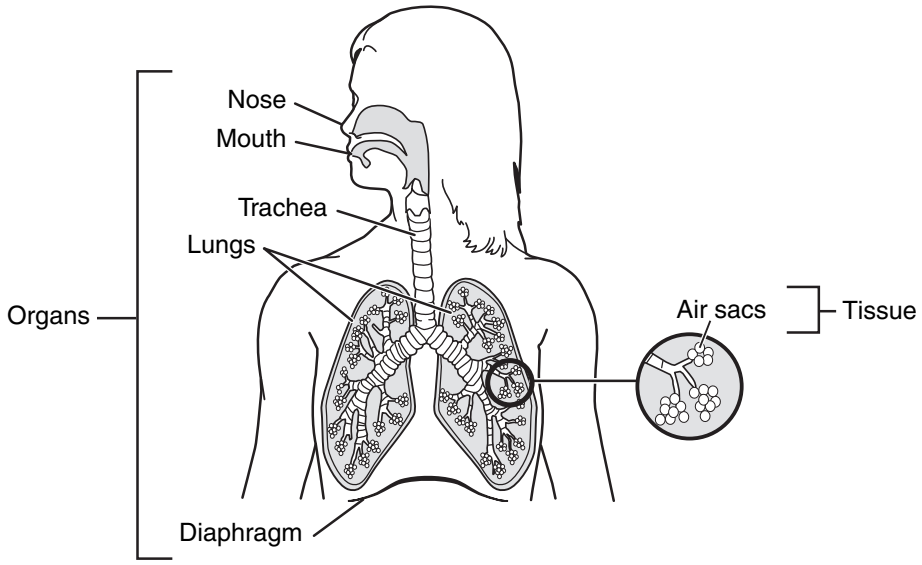
**I don't quite understand the difference between tissues, organs, and organ systems. Can you give me an example?**

Sure! Let's look at the respiratory system. Here's a diagram of the human respiratory system.



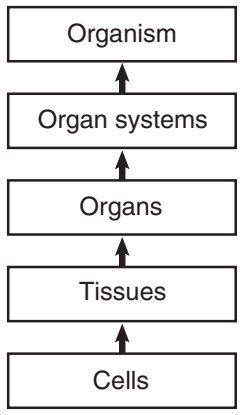




When you breathe, cells in your lungs help move oxygen into your bloodstream. Many of these cells together form an air sac, which is a kind of lung tissue. These and other tissues together form a lung, which is an organ. The mouth, nose, and trachea are other organs that work together with the lungs to help you breathe. These are some of the organs that make up the respiratory system. The respiratory system is just one of many organ systems in the whole human organism.

**So cells make up tissues, tissues make up organs, organs make up organ systems, and organ systems make up an organism?**

You've got it! Here's a diagram to help you remember the levels of organization within your body.

Levels of Organization



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**O.K., I get it. The human body is one big organism with lots of smaller systems that function together, right?**

That's exactly right.

**So what keeps all those parts working together?**

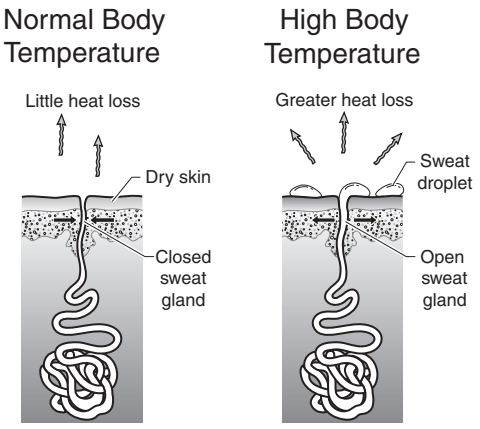
Systems must work together to carry out various life functions. For example, when a runner runs around a track, different systems have to work together. Muscles move the runner's arms and legs. This uses up oxygen, which must be provided through the bloodstream. The heart starts beating faster to move more blood to the muscle cells that need oxygen. As the breathing rate increases, the lungs have to take in oxygen and get rid of carbon dioxide more quickly. The brain sends signals to the lungs, heart, and muscles to coordinate all these activities. It's really amazing how well the parts of the human body work together.

**What about conditions that need to stay constant, such as body temperature?**

The body has ways of adjusting to different conditions. Keeping conditions such as body temperature constant is called *equilibrium* (homeostasis). Equilibrium occurs when a system is balanced.

**When we exercise, isn't sweating somehow involved in keeping our body temperature from getting too high?**

Yes, that's part of the story. If the body temperature gets too high, sweat glands open up, causing a person to sweat. The sweat then evaporates, carrying heat energy away from the body. This cools the skin. When the body temperature returns to normal, another nerve signal is sent out to close the sweat glands. Sweating is one type of *feedback mechanism*. A feedback mechanism is a response of an organism to a given change, such as temperature or the amount of light.




**Are there any other types of feedback mechanisms?**

Sure. One controls the amount of water in cells. Others control chemical reactions in the body and in cells. But all feedback

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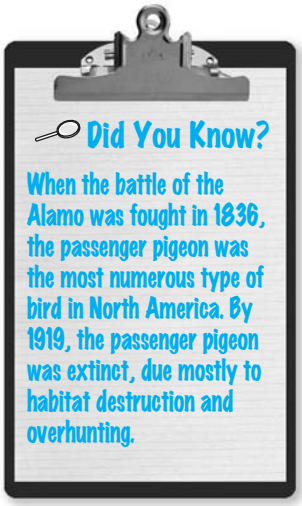
mechanisms are designed to recognize and respond to the changing needs of organisms.

**What happens when an organism can't maintain equilibrium in its environment?**

Sometimes an organism becomes sick or injured. Sometimes a temporary change in the organism's environment is too extreme (for example, extremely cold temperatures or lack of rainfall). The organism may die if it cannot maintain equilibrium. However, most organisms are *adapted* to the environment where they live. Their body systems and behaviors adjust or change to allow them to survive in the new environment.

**What happens to an organism if the environment changes permanently, such as when a warm climate becomes gradually colder?**

If an organism does not have adaptations that allow it to live in the colder climate, then it must move to a warmer environment or it will die. This can affect single organisms as well as whole populations. Occasionally, such long-term changes cause the death of every member of a species. The loss of an entire species is called *extinction*.




**You keep talking about adaptations. What are adaptations and how do organisms get them?**

Some organisms may be able to survive cold weather because they have an advantage such as thick fur. *Genes* passed from parents to offspring may cause the offspring to have thick fur. A gene is a segment of DNA on a chromosome. This type of characteristic is called a *genetic trait*. A gene is a portion of DNA that contains information for a specific trait. A genetic trait that helps an organism survive in its environment is called an adaptation. Adaptations can be either physical characteristics or behaviors.

**O.K., I get that genes control traits. But how are genes passed from parents to offspring?**

During reproduction, the parents' genes in the *sex cells* (egg and sperm) will create the new organism. This is called *sexual reproduction*. In sexual reproduction, both parents pass the genes for traits on to their offspring. Half the genes for these traits come from the male parent, and half come from the female parent. Sexual reproduction therefore results in genetic diversity due to the large number of gene combinations that may occur.

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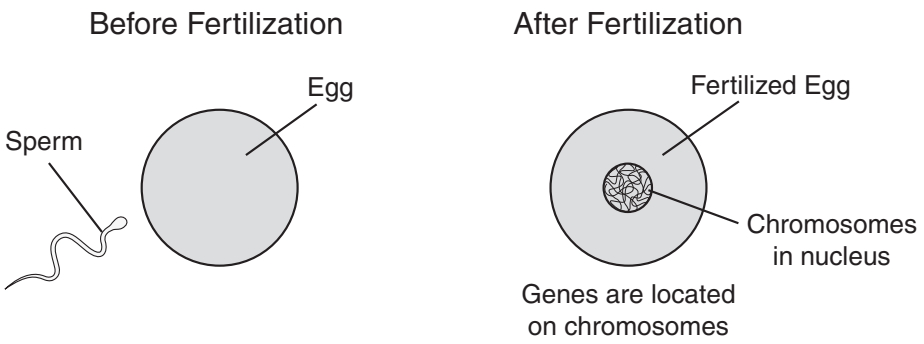
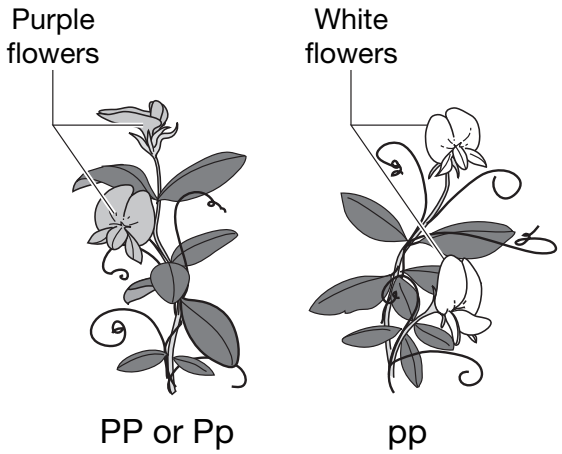



**That's interesting. I thought all the parents' traits were passed down to the offspring. How do genes combine to produce different traits?**

Each parent has genes that occur in pairs and, due to the production of the special sex cells, only one of the *alleles* of a gene pair will be in each sex cell. Alleles are forms of the same gene. So the offspring receive one allele of a gene from the mother and one from the father. They often occur in two forms called *dominant* and *recessive*. If a *dominant allele* of a gene is present, the dominant trait will appear in an organism. A capital letter is used to show a dominant allele. In order for a recessive trait to be expressed, both alleles of the gene must be recessive. A lowercase letter is used to show a recessive allele.


**This is all getting a little confusing. Can we look at an example?**

Sure. Let's look at a simple dominant-recessive trait in pea plants. A pea plant can have purple or white flowers. The dominant trait is purple flowers, which is an expression of the dominant allele (P). The recessive trait is white flowers, which is an expression of the recessive allele (p).




A pea plant will have purple flowers if it receives a dominant allele from one or both parents (Pp or PP). A plant will have white flowers only when both parents contribute an allele for the recessive trait (pp).

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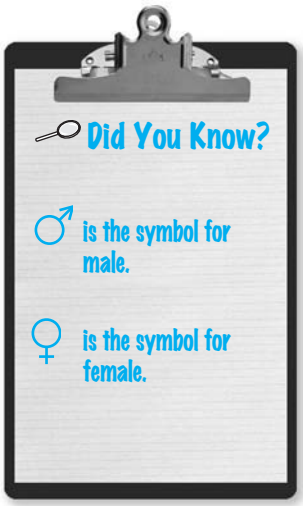


**So what happens when a purple pea plant is crossed with a white pea plant?**

Let's say a purple-flowered male with one dominant and one recessive allele (Pp) is crossed with a white-flowered female with two recessive alleles (pp). To show the combinations of alleles that can occur, we can use a Punnett square. A *Punnett square* is a table showing all the possible combinations of the alleles for a trait that can occur in offspring from a genetic cross.

Punnett Square

| pp ♀ \ Pp ♂ | P | p |
|---|---|---|
| p | Pp | pp |
| p | Pp | pp |

**O.K., the Punnett square shows four combinations. Does that tell us there will be only four offspring?**

No. Each box in the square represents one possible combination of alleles. An offspring has an equal chance of getting any one of these combinations. Since there are four combinations, there is a 25% chance that an offspring will end up with the allele combination given in a particular box. At the same time, there might be any number of offspring, each with the same chance of having one of the four possible combinations of alleles.

**What do the allele combinations "Pp" and "pp" from the Punnett square tell us?**

Two out of every four (50%) of the offspring are likely to have purple flowers because they have one dominant allele (Pp). Two out of every four offspring (50%) are likely to have white flowers because they have two recessive alleles (pp). Actual offspring do not always occur exactly in these ratios because of random chance in the combining of genes.

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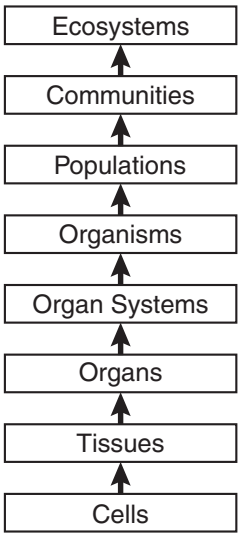
### So is this the way all genes are inherited?

No, not all traits are inherited in this simple dominant-recessive pattern. This pattern was explained by Gregor Mendel in the 1860s. Since that time we have discovered that some traits result from other genetic patterns. You will learn more about these other patterns in high school biology.

### O.K., I understand levels of organization and how traits are passed on to offspring. How does all this fit into an ecosystem?

Let's look at the parts of an ecosystem first. An *ecosystem* includes the living and nonliving parts of an environment. The nonliving part includes water, soil, light, and air. The living part includes plants, animals, and other living organisms. The living part of the ecosystem makes up the *community*. A community is a group of different types or *populations* of plants, animals, and other organisms living and interacting with one another in an environment. Each population of plant, animal, or other organism in a community lives in a particular part of that environment called a *habitat*. A habitat is the specific place in which an organism makes its home.

Remember the levels of organization we talked about earlier? We can add population, community, and ecosystem to the diagram. As we move up the diagram, each level is more complex.



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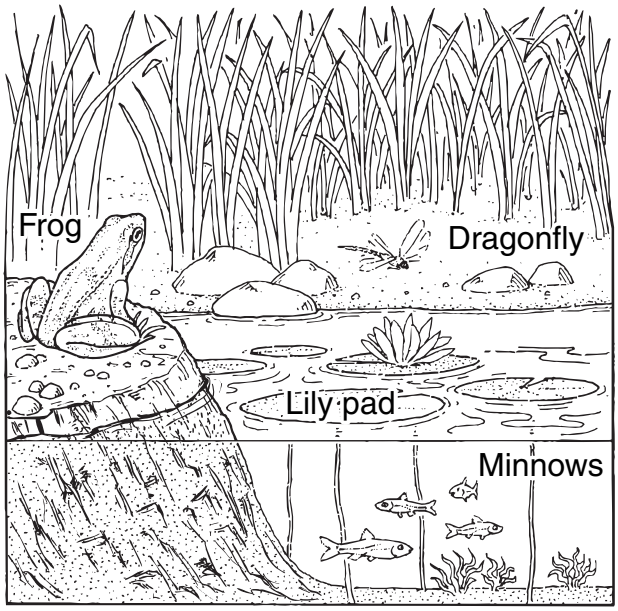
All organisms interact with their environment. For example, minnows, frogs, lily pads, and dragonflies might live together in a pond community. They are each affected by the other organisms and by nonliving things, like sunlight, water, and air. Each part of the community has its own function, but together they form the entire pond ecosystem.

**Remember!**

Biotic parts of an ecosystem are the living organisms. Abiotic parts can be either nonliving materials or environmental factors.

Pond Ecosystem




**You said all the pond organisms are affected by one another. How are they connected?**

They are connected by the energy that flows through the pond community. Both plants and animals require energy. This flow begins with the plants using energy from the sun and continues through all the organisms in an ecosystem.

Plants change radiant energy from the sun into chemical energy through a process called *photosynthesis*. During photosynthesis, carbon dioxide and water are converted into sugar and oxygen. The process of photosynthesis is shown in the equation below:

**Photosynthesis**

$$6CO_2 \text{ (carbon dioxide)} + 6H_2O \text{ (water)} \xrightarrow{\text{(sunlight energy)}} C_6H_{12}O_6 \text{ (sugar (chemical energy))} + 6O_2 \text{ (oxygen)}$$

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### Why is sugar important in an ecosystem?

Sugar is food for the plants and for other organisms. When plants are eaten, the energy in the plant matter is passed on to other organisms in a food chain. The sugar produced during photosynthesis provides the energy used by all organisms in an ecosystem.

### So chemical energy passes from plants to animals through a food chain. How does that work?

Organisms that can make their own food, such as plants, are called *producers*. *Primary consumers* are animals that get their energy from eating plants. But energy flows even further in an ecosystem. Where would the energy keep flowing?

### Animals eat other animals, right?

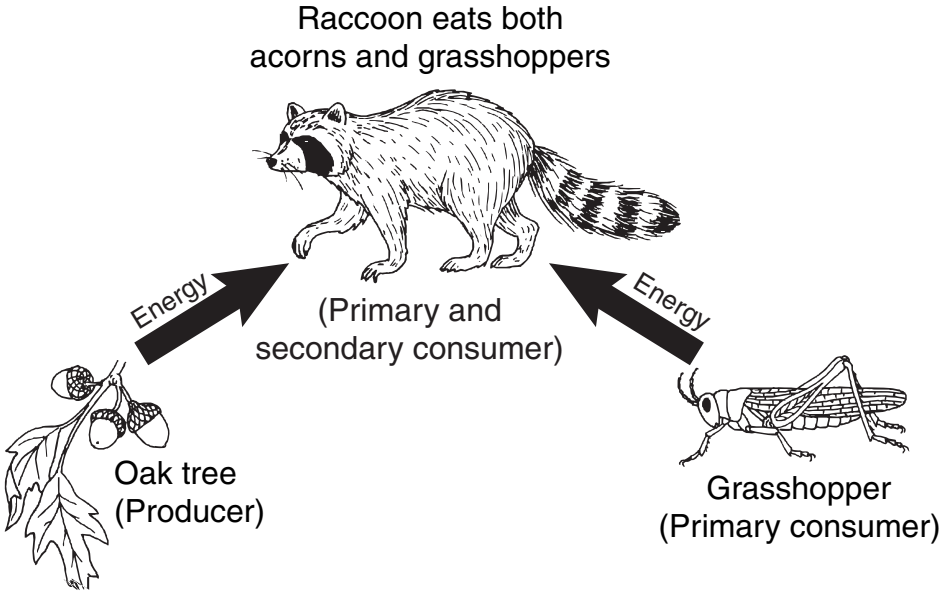
Yes! Some animals get their energy from the other animals they eat. These are *secondary* (second-order) *consumers*. They eat animals that are primary consumers.

### Does each animal have just one role in the ecosystem?

Not necessarily. Sometimes an animal's diet may include more than one type of organism, such as plants and different types of consumers. For example, a raccoon eats acorns from oak trees as well as grasshoppers. Oak trees are producers, and grasshoppers are primary consumers. So the raccoon is both a primary consumer and a secondary consumer.

**Remember!**

Arrows in a food chain or food web point in the direction that energy is being passed.



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**Remember!**

Organisms that make their own food are called producers, and those that depend on other organisms for food are called consumers. Organisms that feed on dead plants and animals are called decomposers.

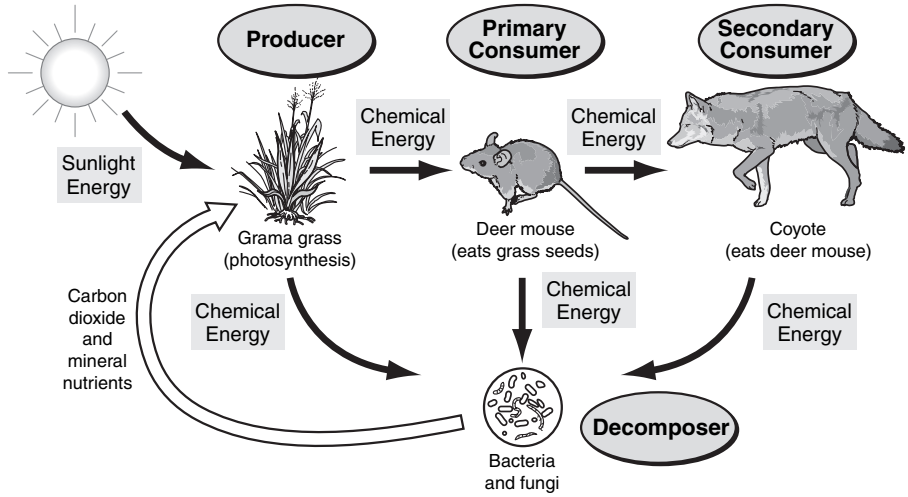
**Aren't there special names for animals to describe what materials they eat?**

Yes. Animals are also classified according to whether they eat plants, animals, or both. Animals that eat only plants are called *herbivores*. Animals that eat only other animals are called *carnivores*. Animals that eat both plants and animals are called *omnivores*.

**What happens to the dead plants and animals?**

Organisms called *decomposers* feed on dead plants and animals. This releases the chemical energy and nutrients in the dead plants and animals back into the environment. Bacteria and fungi are common decomposers. Decomposers play an important role in recycling nutrients and energy.

Grassland Food Chain




**O.K., I see now. Energy produced by plant photosynthesis flows to each organism in turn, and then decomposers recycle nutrients. Is this what we call a food chain?**

Yes. A *food chain* shows the flow of energy from one organism to another to yet another. But the relationships in ecosystems are more complex than just these food chains.

**Really? In what way are they more complex?**

In communities there are many species of producers and consumers. The primary consumers may feed on more than one species of producer. Several different types of secondary consumers may eat the primary consumers. The different food chains overlap, so energy passes in many different directions through all the organisms.

A complex system of energy flow through overlapping food chains is called a *food web*. In a food web diagram, arrows point in the direction that energy flows from one organism to the next. An example of a

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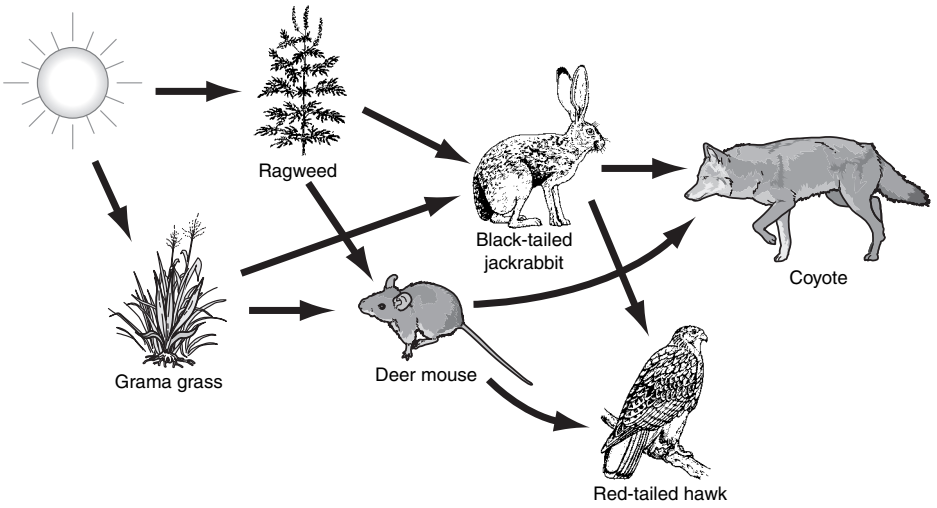
grassland food web is shown in the following diagram. Note the direction of energy flow from sun to grass to mouse to coyote.

Grassland Food Web





**So what about the "balance of nature"? How does that work in a food web?**

Every organism in a community has an effect on every other organism. For example, you might wonder how a producer could have an effect on a secondary consumer that doesn't eat producers.

Let's take a closer look at the grassland food web. Can you find a food chain that links a producer and a secondary consumer?

**Well, the grama grass is a producer, the deer mouse eats the grass, and the coyote eats the deer mouse, right?**

Correct. You're getting the hang of this now. O.K., let's suppose that a rancher plants more grama grass. The new grass will grow and reproduce grass seeds. The deer mice will have more seeds to eat, so their population will increase. What effect could more mice have on the coyotes?

**The coyotes will have more mice to eat.**

Right!

**The coyote population might increase too, right?**

Right again. This is an example of how secondary consumers are indirectly dependent on producers. Similar relationships exist throughout ecosystems, linking all the organisms together.

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**When environmental factors such as rainfall are reduced, do populations always decrease?**

Not always. Remember, the relationships between species in a food web can be complex. Some species can benefit from changes in the environment.

**Can you give me an example?**

O.K. Let's look at a stream ecosystem. Imagine that there is a lack of rainfall on the land area that drains into the stream. This might reduce the flow of the stream, trapping minnows in shallow pools. This will make the minnows easy for predators to catch and would reduce the minnow population.

However, the great blue herons that eat the minnows might benefit from this sudden increase in available food, and their population might increase. When the minnow population is reduced too low, the herons can fly to other areas where there are more minnows.

**Remember!**

Succession occurs when populations in a community change due to events in the environment. These changes may be sudden or they may happen very slowly.

A change in living (biotic) or nonliving (abiotic) parts of an ecosystem affects both local communities and the whole ecosystem. Every organism is dependent on the environment and the other organisms in one way or another.

**But what happens to populations when conditions in an environment change permanently?**

Permanent environmental change can affect species and populations. This change may be gradual, occurring as the environmental conditions in a community slowly change. Or it may be more sudden, such as when floods, fires, or other natural disasters occur. This rebuilding of populations in a community or ecosystem that has been changed is called *succession*.

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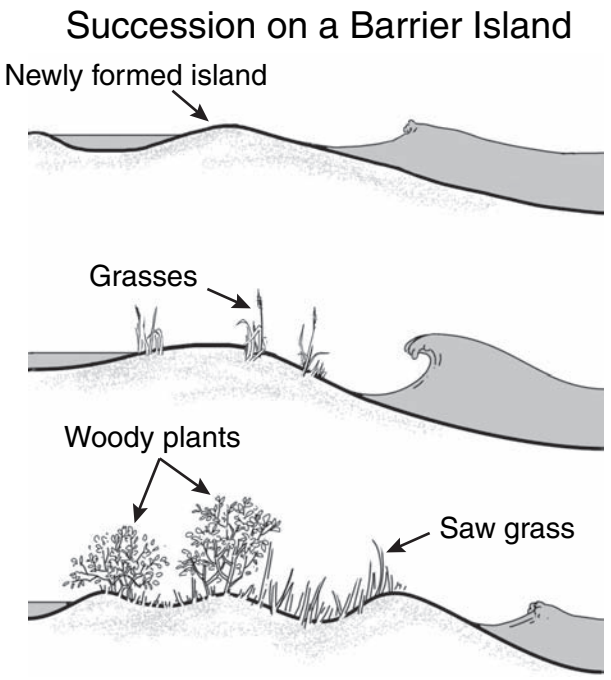
### How does succession happen?

Let's look at an example of an island that forms in the Gulf of Mexico. The island begins as bare sand, with no plants or animals. Seeds from plants on neighboring islands can be carried to the island by wind, water, or animals. Some may sprout and begin to grow.

### So, will any kind of plant grow on the island?

No, only those plants that are adapted to the conditions on the island. Since the island is bare, flat sand, it gets washed with ocean water quite often. The plants must be able to grow in these conditions.

But gradually, the conditions on the island change. As the first plants take root, they trap blowing sand, building the island higher. This creates areas where plants that are not adapted to constant waves can now grow.




### So the first plant types create a place for the second plant types to grow?

Exactly. This pattern continues, until the island may have a variety of plants and animals. These changes may happen quickly, or they may continue slowly for a very long time. Often an environment such as the island reaches a stage where the plants and animals remain stable for a long time.

### Does succession happen only on newly formed islands?

No, succession can happen in any environment where change occurs. For example, succession may occur in a plowed farm field, a burned forest, or grassland that gradually receives less rainfall.