# Adaptations

## Section 15.2
## Adaptations in Plants

**Pre-View 15.2**

- **Cuticle** – the waxy coating on leaves
- **Guard cells** – cells on either side of a stoma that cause the stoma to open or close
- **Stomata** – openings usually on the underside of a leaf that allow carbon dioxide to enter and oxygen and water to escape
- **Transpiration** – the process of losing water through a plant's leaves

Structural adaptations in plants include differences in roots, stems, and leaves as well as those in fruits, seeds, and flowers. Consider some of the structural adaptations that may be seen in plants.

### Roots

The roots of plants take in water and nutrients, and they hold the plant in place in the ground. To allow the roots to absorb as much water and nutrients as possible, the roots are covered with tiny root hairs that increase the surface area sometimes as much as 130% more than the surface area of the stems and leaves of a plant. Plant roots can have several adaptations depending on where they grow and especially how much water is available.

**Desert plant adaptations:** Because water is scarce, plants that live in the desert usually have very extensive root systems, which are either deep or wide. They have extra root hairs to quickly absorb the water after it rains.

**Rain forest plant adaptations:** If plants in the desert have deep roots, what kind of roots do plants in a rain forest most likely have? Trees and plants in a rain forest often have shallow root systems, and because the ground remains moist most of the time, the roots have developed adaptations to resist rotting.

### Stems

Plant stems have several important functions. Most obviously, they support the leaves and flowers.

**Vascular material adaptations:** In most types of plants, stems contain vascular material, which are like small tubes that allow water and nutrients to pass through. The adaptation of some plants to have vascular material allow them to grow larger than those without vascular material. For example, mosses do not contain vascular material and can grow only close to the ground or surface. Grasses, on the other hand, do contain vascular material, and can therefore grow much taller.

**Woody stem adaptations:** Another adaptation in stems is the production of wood. Plants that produce wood in their stems can grow very tall and have additional support and protection. How tall do you think an oak tree could grow without a woody trunk? Woody stems are an advantage to the types of plants that have them.

**Herbaceous stem adaptations:** Stems that lack woody tissues are called herbaceous stems. Herbaceous stems are more flexible and can also be an advantage to plants. Aquatic plants, for instance, often lack woody tissue because the buoyancy of the water provides them the support they need for growth. (*Buoyancy* is the force of a liquid that allows objects to float.) A flexible, herbaceous stem also allows aquatic plants to bend in flowing water, but a rigid, woody stem may cause the plant to be uprooted.

## Allopatric Speciation

As previously mentioned, geographic isolation can lead to the formation of a subspecies, or it may lead to speciation. Speciation occurs due to **reproductive isolation**, which is the inability of different populations to breed due to some kind of barrier.

**Allopatric speciation** is the most common form of speciation, and it occurs when populations of a species are geographically isolated from breeding with one another. (*Allo* means *different*; *patric* means *homeland*.) If the divided populations are unable to interbreed because of their separation, the new, smaller populations may develop specific adaptations through natural selection or genetic drift. In time, allopatric speciation may result from geographic isolation if each new population becomes so different that they are considered different species.

**Example 2:** The vastness of Arizona's Grand Canyon and the Colorado River are insurmountable geographic barriers for small rodents such as squirrels and mice. For example, two species of antelope squirrels live in the canyon. The Harris antelope squirrel lives on the south rim of the canyon, and the White-tailed antelope squirrel lives on the north rim of the canyon. What makes the antelope squirrels of the Grand Canyon an example of allopatric speciation?

These two distinct species of antelope squirrels are descended from a common ancestor, but even given the chance with human intervention, they can no longer interbreed. They are an example of allopatric speciation because at some point in the past, the Grand Canyon and the Colorado River created geographic isolation in the antelope squirrel population, and the end result was two different species.

Figure 16-8 summarizes how geographic isolation may affect a species. Natural selection and/or genetic drift can cause a divided population to develop into a subspecies or a new species.

**Effects of Geographic Isolation**

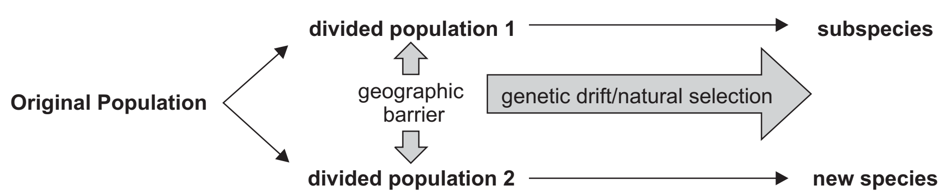



Fig. 16-8

**Example 3:** Clearcutting through a tropical rainforest created a small section of trees that were separated from the main forest by a barren area. As a result, a population of salamander living among the trees was isolated from other members of its species in the main forest. Over time, what could happen to this smaller population of isolated salamanders?

The geographic separation of the salamanders prevents gene flow from one population to the other. The isolated population may become different from the population in the main forest especially if the environmental conditions are different between the isolated forest and the main forest. Genetic drift could cause the isolated population to become a distinct subspecies. Natural selection in changing environments may even lead to speciation in the separated populations over a long period of time.

## Taxonomy

**Example 1:** The chart on the right shows the classification of a dog and a gorilla. What is the LOWEST taxonomic level that they have in common?

| | Dog | Gorilla | |
|---|---|---|---|
| **Kingdom** | Animalia | Animalia | same |
| **Phylum** | Chordata | Chordata | same |
| **Class** | Mammalia | Mammalia | same |
| **Order** | Carnivora | Primates | different |
| **Family** | Canidae | Hominidae | |
| **Genus** | *Canis* | *Gorilla* | |
| **Species** | *familiaris* | *gorilla* | |

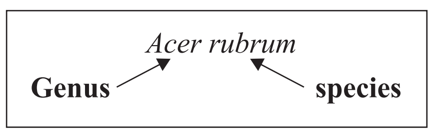
The smallest taxonomic level that the dog and the gorilla have in common is the class of Mammalia. The chart shows that they are in the same kingdom, phylum, and class, but they are in different orders.

## Naming Organisms

Organisms are named using their genus name followed by their species name. The genus name is always capitalized, and the species name is always lowercase. Both the genus and the species are italicized. This naming system is called **binomial nomenclature**.

**Example 2:** The scientific name for a red maple tree is *Acer rubrum.* Which word represents the genus name? Which word represents the species name?

Remember that genus name is always given first and then the species. *Acer* is the genus name and includes all types of maple trees. The name *rubrum* represents the specific species of maple tree, which in this case is the red maple.




## Evolutionary Relationships

Evolutionary theory dictates that scientific classifications also show ancestral relationships. Organisms that share a lower taxon are considered more closely related that organisms that share a higher taxon. For example, plants and animals are in two different kingdoms. Any two animals are considered more closely related than any plant and animal. An earthworm and a domestic cat are considered more closely related than an earthworm and an oak tree. So to determine which organisms are the most closely related, look for the smallest shared taxon.

**Example 3:** Study the chart below. Which two trees are the mostly closely related?

| | Oak Tree | Pine Tree | Palm Tree | Apple Tree |
|---|---|---|---|---|
| **Kingdom** | Plantae | Plantae | Plantae | Plantae |
| **Phylum** | Magnoliophyta | Coniferophyta | Magnoliophyta | Magnoliophyta |
| **Class** | Magnoliopsida | Pinopsida | Liliopsida | Magnoliopsida |
| **Order** | Fagales | Pinales | Arecales | Rosales |
| **Family** | Fagaceae | Pinaceae | Arecaceae | Rosaceae |

Class is the lowest taxon that any of the trees has in common. Notice that the oak tree and the apple tree share the same taxa down to class Magnoliopsida. Of these four trees, the oak tree and the apple tree are therefore the most closely related.

**Example 1:** What is the potential impact of introducing a non-native species into an ecosystem?

Introducing a non-native species into an ecosystem can be disastrous. It often results in an overall decrease in biodiversity in the ecosystem. Consider the problem of the rabbits in Australia. Rabbits were not native to Australia when some settlers took about two dozen rabbits there in the mid-1800s to use as game. The rabbits had no natural predators and now had a very large area of land with a huge food supply. They began to multiply quickly. Soon the rabbits were eating all of the grass that was intended for sheep and cattle. Even though "gentlemen hunters" could shoot as many as 1200 a day for sport, the rabbit population kept increasing. In about ten years, 2 million rabbits could be shot or trapped yearly with little effect on the rabbit population size. The rabbits destroyed vegetation and wiped out entire species of native plants. The extinction of certain plants led to the extinction of one-eighth (1/8th) of Australia's mammal species. Meanwhile, the rabbits continued to multiply. Eventually, Australians built miles of fences in an attempt to keep the rabbits from spreading into other parts of Australia. The rabbits are still a significant problem for Australian landowners today.

While populations grow continuously with unlimited resources, the rate of population growth slows down until it levels off or stops once there is competition for resources. The population growth levels off when the environment has reached its **carrying capacity, *k***, which is the maximum number of organisms that can be supported in a given environment. Most natural populations have a pattern of growth that, when graphed, follows an S-shaped curve as shown in figure 15-3. This S-shaped pattern represents **logistic growth**.

**Natural Population Growth (Logistic Growth)**

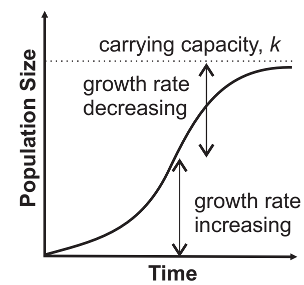
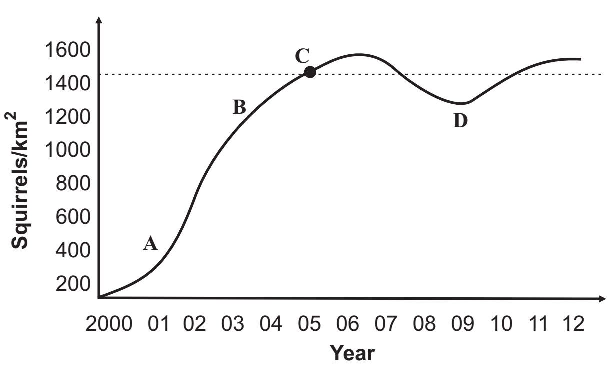



Fig. 19-4

The S-shaped pattern shown in figure 19-4 is theoretical. In reality, a population often fluctuates around carrying capacity, *k*. For example, as a population reaches carrying capacity or exceeds it, the population may experience crashes or die offs as a result of limited resource availability. The decline in the population makes additional resources available to the remaining individuals, and as a result, the population may rebound and approach its carrying capacity once again.

**Example 2:** The population graph below shows the population growth of gray squirrels introduced into a large, newly-developed residential area. What do each lettered area of the graph represent?




**A:** In this section of the graph between 2000 and 2002, the squirrel population increases rapidly because resources are abundant and competition is minimal.

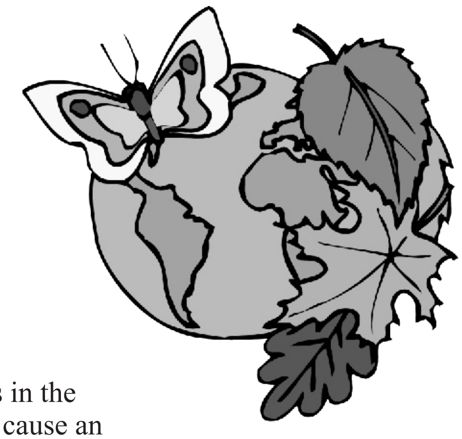
**B:** Between 2002 and 2006, the population continues to increase but at a slower rate most likely because of increasing competition for resources. The population begins to stabilize as it approaches its carrying capacity.

**C:** At Point C around the year 2005, the carrying capacity is reached.

**D:** Once the squirrel population reaches and exceeds its carrying capacity, the population experiences a crash followed by a rebound. This trend will likely continue as the population hovers around its carrying capacity.

# Environmental Interdependence

## Section 20.3
## Interdependence and the Importance of Biodiversity



### Interdependence

Food chains and food webs show herbivory and predation relationships. If the population of one species changes, it will affect the populations of other species in the food chain or food web. For example, a decrease in one population will usually cause an increase in the trophic level populations below it and a decrease in trophic level populations above it.

**Example 1:** Consider the food chain below that you saw in figure 20-2.

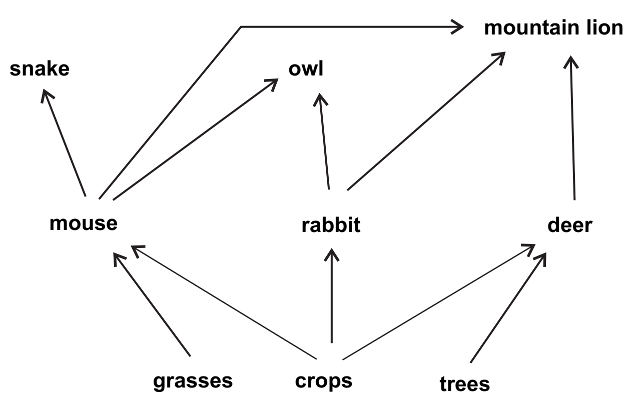
**grass** → **grasshopper** → **mouse** → **snake** → **hawk**

A harsh winter with below-average temperatures greatly decreases the number of grasshoppers that survive until spring. How will the decreased grasshopper population affect the grass? How will it affect the mouse population?

A decrease in the grasshopper population would increase the grass population because fewer grasshoppers would be feeding on the grass. However, with fewer grasshoppers to eat, the mice population would also decrease.

Interdependency can also be seen in food webs.

**Example 2:** Consider the food web below.




A bacterial infection spreads in the mouse population and causes a drastic decrease in the number of mice in the ecosystem. How would you explain a decrease in the number of rabbits in the ecosystem as well?

Notice that rabbits are in the same trophic level as the mice. Mice are prey for snakes, owls, and mountain lions. If fewer mice are available for prey, owls and mountain lions will have to get more of their food from hunting rabbits. As a result, a decrease in the mouse population may cause a decrease in the rabbit population.

# Ecosystems and Their Development

## Section 21.4
## The Effects of Ecosystem and Habitat Disruption and Destruction

### Pre-View 21.4

- **Desertification** – the process of dry but fertile land becoming less and less able to support plant and animal life usually through the use of unsustainable or irresponsible farming methods
- **Extinction** – the complete death of a species
- **Migration** – the movement of animals, such as birds, from one area to another, usually occurring during a change of seasons

Natural events can disrupt ecosystems. A volcanic eruption can completely cover an area of land with lava. A forest fire started by lightning or a tornado can destroy acres of trees and kill or displace the populations of species living there. These natural events can cause ecological succession to occur as an ecosystem recovers from the disruption.

Humans have also greatly impacted ecosystems, but many times, humans prevent succession and recovery from taking place. As the human population has increased, humans have competed with other organisms for space, food, and water. The increased competition has disrupted the flow of energy within ecosystems and has interrupted how nutrients are recycled. Human activities can even threaten the survival of populations.

### Factors that Threaten Extinction

**Extinction** occurs when the last surviving organism in a particular species dies. Many species living today are considered endangered and could face extinction. What causes a species to be in danger of extinction while other species thrive? Several human and ecological factors contribute to the threat of extinction.

**Human Factors that Threaten Extinction**

- Habitat disturbance or destruction
- Hunting or poisoning
- Introducing non-native/exotic species
- Pollution

**Ecological Factors that Threaten Extinction**

- Low rate of reproduction/low birth rate
- Highly specialized diet
- Small or limited habitat area
- Inability to adapt to environmental changes

**Example 1:** The giant panda is a good example of an endangered species that faces extinction because of several human and ecological factors. In the wild, this panda species lives in isolated forests in southwestern China. Its main food source is bamboo. Mature panda parents average one cub every two years. What factors can you identify that contribute to the panda's threat of extinction?

By cutting down forest areas, humans have decreased the size of the giant panda's habitat so that it must survive in much smaller areas. Ecological factors that threaten the panda's ability to survive are its low rate of reproduction and its specialized diet of bamboo. Its habitat is limited to bamboo forests. As habitat size shrinks, so does the number of pandas that survive.

Some of the precipitation is taken in and used by plants and animals. Plants also give off water through a process called **transpiration**, which puts water back into the atmosphere. Some of the precipitation sinks into the ground and becomes groundwater beneath the earth's surface. Eventually, it may flow into lakes and oceans where some is evaporated into the atmosphere.

When conditions are right, the water vapor in the atmosphere will condense and form clouds. Whenever the clouds get too heavy to hold any more water vapor, precipitation occurs. Once again, water returns to the earth for organisms to use in a natural cycle.

## Importance and Effects on Ecosystems

The water cycle is very important to ecosystems because water is arguably the most important chemical compound found in ecosystems. An **ecosystem** is made up of all the living organisms in an area plus the nonliving parts of the environment. The amount of water an ecosystem receives determines the plants and animals that can live in the area. As you will see in Section 17 on biomes, deserts that receive little precipitation have few plants and animals, but tropical rain forests that receive a lot of precipitation have many plants and animals. In general, the more precipitation in an ecosystem, the greater the biodiversity.

**Construction**

Human actions can impact the water cycle. For example, areas paved with asphalt or concrete affect the amount of water that can percolate through the soil and enter the ground water table. Ground cleared of trees can also cause rainwater from a heavy rain to run into lakes, rivers, and streams instead of penetrating into the ground.

**Global warming**

Global warming, as you reviewed in Section 15.5, may also affect the water cycle and impact ecosystems in several ways:

Higher atmospheric temperatures increase the rate of evaporation, and warm air can hold more water vapor. Since water vapor is a greenhouse gas, the increased evaporation may cause global temperatures to rise further.

About 97% of all the water on the earth is found in the ocean. The remaining 3% of the earth's water is freshwater, but most of that freshwater, almost 70% of it, is frozen in glaciers or icecaps. Higher atmospheric temperatures due to global warming will cause more ice to melt from glaciers and icecaps. As this ice melts, ocean levels are predicted to rise. Melting ice can negatively affect the tundra biome and arctic ecosystems since many animals rely on ice coverage as a part of their survival. Rising ocean levels and higher ocean temperatures can negatively affect coral reef ecosystems by killing the coral.

Global warming may also speed up the water cycle. As more water evaporates, more water also falls as precipitation. Many scientists believe that this change in the water cycle may result in more severe weather events, such as violent storms. They also believe the precipitation will not be evenly distributed. Because the cycling of water between evaporation and precipitation is accelerated, wet ecosystems may get more precipitation, but dry ecosystems may get less. Droughts in already-dry ecosystems can lead to a decrease in ecosystem biodiversity. The more intense rainfall may increase freshwater runoff, which increases soil erosion, but it may also decrease the amount of available groundwater.