5.1 Heredity

Why doesn't a cow quack and why don't puppies look like kittens?

Has anyone ever come up to you and told you that you look just like your parents? You probably have some **traits** in common with each of your parents. Traits are characteristics that you inherit from your parents. Your parents also have traits that they inherited from their parents (your grandparents.) For a long time people understood that traits are passed down through families. However, the rules of how this worked were unclear. The work of Gregor Mendel was crucial in explaining how traits are passed down to each generation from parent organism to their offspring.

Mendel's Experiments

What does the word **inherit** mean? You may have inherited something of value from a grandparent or another family member. To inherit is to receive something from someone who came before you. You can inherit objects, but you can also inherit traits. For example, you can inherit a parent's eye color, hair color, or even the shape of your nose and ears!

Genetics is the study of inheritance. The field of genetics seeks to explain how traits are passed on from one generation to the next.

In the late 1850s, an Austrian monk named Gregor Mendel performed the first genetics experiments.

To study genetics, Mendel chose to work with pea plants because they have easily identifiable traits. For example, pea plants are either tall or short, which is an easy trait to observe. Furthermore, pea plants grow quickly, so he could complete many experiments in a short period of time.

Mendel studied the inheritance patterns for many different traits in peas-- including round seeds versus wrinkled seeds, white flowers versus purple flowers, and tall plants versus short.

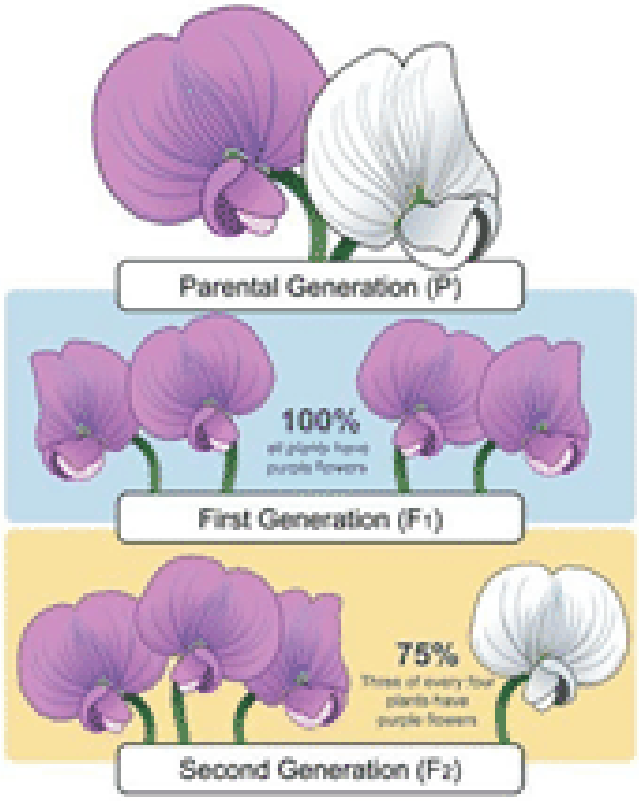
Seed		Flower	Pod		Stem	
Form	Cotyledon	Color	Form	Color	Place	Size
						
Round	Yellow	White	Full	Green	Axial pods	Tall
						
Wrinkled	Green	Violet	Constricted	Yellow	Terminal pods	Short
1	2	3	4	5	6	7

In one of Mendel's early experiments, he crossed a short plant and a tall plant. What do you predict the **offspring** (babies) of these plants were? Medium-sized plants? Most people during Mendel's time would have said medium-sized. But an unexpected result occurred. Mendel observed that the offspring of this cross were all tall plants!

Next, Mendel let this generation self-pollinate. That means the pollen from the flowers of the tall plant offspring were mixed **(crossed)** with each other. He found that 75% of the offspring from this second generation of pea plants were tall, while 25% were short. Shortness skipped a generation. But why?

In all, Mendel studied seven characteristics, with almost 20,000 plants from the 2nd generation. All of his results were similar to the first experiment—about three out of every four plants had one

way of exhibiting a certain trait, while just one out of every four plants had a different way of exhibiting the same trait.



For example, for the trait of the color of the pea plant flower, he crossed purple flowered-plants and white flowered-plants. Do you think the colors blended? No, they did not. Just like the previous experiment, all offspring in the first generation of this cross were one color: purple. In the second generation, 75% of plants had purple flowers and 25% had white flowers. There was no blending of traits in any of Mendel's experiments.

Mendel's work provided the basis to understand the passing of traits from one generation to the next.

Traits

Some trees grow very tall with thick bark while others are very short with thin bark. It all depends on an **organism**'s heredity from parents to their young. An **organism** is any living thing. Heredity, the passing of traits from parent to offspring, applies to all organisms including humans, plants, insects and even bacteria.

In a pond, every frog is unique because of various traits it inherits from its parents. A **trait** is a characteristic that determines how an organism looks, acts, or functions. An **inherited trait** is a characteristic passed from parents to their offspring. Some examples of inherited traits are fur color, fur with stripes, or fur with spots. The big cats pictured show inherited traits. Can you see similarities and differences between the two cats?

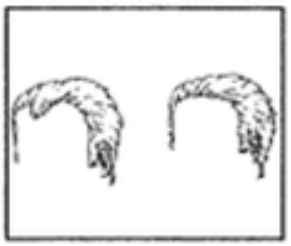

Just like dogs will always have puppies, cats will always have kittens, and acorns will always grow into oak trees, people are alike in most ways because we will always look like people!

All organisms are made up of small building blocks called cells. A person consists of about ten trillion of these cells which come in over 200 varieties. Cells are the building blocks that give organisms their individual traits and vary from organism to organism. These small differences are enough to keep organisms from looking identical. These differences establish our color of hair and eyes, whether we are tall or short, and whether we have freckles or not. Each of us has inherited his/her own mixture of traits from our parents. Within each building block are special instructions that tell an organism how it will grow and what traits it will develop.

Parent organisms, the producers of offspring, pass these instructions to their **offspring**, the young of an organism. For example, a puppy will inherit its hair color from its parents; a seedling will develop wide, broad leaves from its parent plant; and human beings will inherit a variety of traits. A few of these inherited traits include: ability to roll your tongue, a widow’s peak or straight hairline, attached or unattached earlobes, color of skin and hair, freckles, cleft in chin, naturally curly or straight hair, and a hitchhiker's thumb.

•Ability to roll your tongue

•A widow's peak or straight hairline



•Attached or unattached earlobes

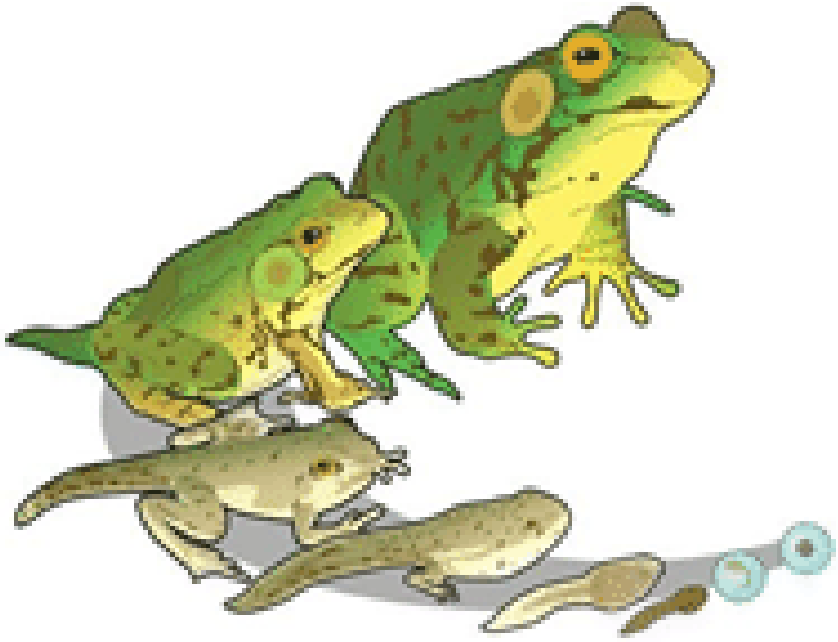
•Color of skin and hair

•Freckles

•Cleft in chin

•Naturally curly or straight hair

•Hitchhiker s thumb



Sometimes, offspring do not look like their parent organism. However, as they go through their **life cycles**, a series of changes that are normal for that organism, they begin to look more like their parents. For example, the legless little tadpole with its large tail looks very different than it will as a full-grown frog.

Compare puppies in a litter. Even though these puppies have had the same two parents, there are **variations**, differences in the appearance of an inherited trait among the members of a group or **species**, in how they look and act. The differences in paw size, tail length, or hair coloring are examples of variations. Some variations do not have much of an effect on an organism. For example, the different colors of hair puppies from the same litter will have little effect on whether or not each puppy will survive.

However, for some organisms living in the wild, color can be a matter of life or death. For example, a moth with brightly colored orange and yellow wings will not survive very long if its environment is the dark bark of pine trees because the brightly colored moth can easily be seen and eaten by birds. A moth with similar color patterns to its surroundings has a better chance of surviving long enough to produce offspring with similar coloring. These variations give a species, a certain group of plants, or

animals that can only reproduce among themselves, a better chance to live or survive.

Learned Behaviors vs. Instincts

Have you ever seen a dog sit on command? Have you ever watched a cat trying to catch a mouse? These are just two examples of the many behaviors of animals. Animal behavior includes all the ways that animals interact with each other and the **environment**. Some animal behaviors are **learned behaviors**, an action that is learned through trial and error or is brought about by the environment. Other behaviors are because of the animal's **instincts**, meaning animals are born with them. Herding for the sheep dog, in the photo below, is both learned and instinctual. The nursing of the piglet is an instinctual behavior, and the children blowing dandelion seeds is a learned behavior.

Each of these are examples of animal behavior. Can you think of other examples of animal behavior besides these three? Which of the behaviors are instincts and which are learned?

Nature vs. Nurture

Scientists have observed that some behaviors seem to be controlled solely by genes and others appear to be due to experiences in a given environment. Whether behaviors are controlled mainly by genes (nature) or by the environment (nurture) is often a matter of debate. This is called the nature-nurture debate.

Nature refers to the genes an animal inherits and nurture refers to the environment that the animal experiences. It seems that most animal behaviors are not controlled by nature or nurture**,**

but by nature and nurture. In dogs, for example, the tendency to like to live in packs (groups) is probably controlled by genes. This is why dogs make good pets for families. But for a dog to sit or roll over on command is a learned behavior. The dog learns that if it does the trick, it will get a treat from its owner.

How Behaviors Evolve

It's easy to see how many common types of behavior evolve. That's because they obviously increase the fitness of the animal performing them. For example, when wolves hunt together in a pack, they are more likely to catch prey. Therefore, hunting with others increases a wolf's fitness. The wolf is more likely to survive and pass its genes to the next generation by behaving

this way. Wolves hunt together in packs. This is adaptive because it increases their chances of killing prey and obtaining food.

Inherited Behavior

How do kittens know how to “hunt”? This kitten was probably adopted and separated from its mother at a young age. It never got a lesson in how to stalk and pounce on prey. So how does this kitten know how to attack the ball of yarn? Some behaviors do not need to be learned.

Many animal behaviors are ways that animals act, naturally. They don't have to learn how to behave in these ways. Cats are natural-born hunters. They don't need to learn how to hunt. Spiders spin their complex webs without learning how to do it from other spiders. Birds and wasps know how to build nests without being taught. These behaviors are called **inherited**.

An **inherited behavior** is any behavior that occurs naturally in all animals of a given species. An inherited behavior is also called an **instinct**, behaviors that are inherited from the parent organism. The first time an animal performs an inherited behavior, the animal does it well. The animal does not have to practice the behavior in order to get it right or become better at it.

Inherited behaviors are also predictable, meaning all members of a species perform an inherited behavior in the same way. From the examples described above, you can probably tell that inherited behaviors usually involve important actions, like eating and caring for the young.

There are many examples of behaviors that are based on an animal's instincts. Did you know honeybees dance? When a honeybee locates a source of food it will return to the hive and do a dance. This dance is called the waggle dance. The way the bee moves during its dance tells other bees in the hive where to find the food. Honeybees do the waggle dance without learning it from other bees, so it is an instinct.

Besides building nests, birds have other instincts. One example occurs in gulls. One of the chicks is pecking at a red spot on the mother's beak, his inherited behavior causes the mother to feed the chick. In many other species of birds, the chicks open their mouths wide whenever the mother returns to the nest. This inherited behavior, called gaping, causes the mother to feed them.

Spider spinning a web

Bird building a nest

Caterpillar making a cocoon

Dolphin leaping from the water

Inherited behaviors are rigid and predictable. All members of the species perform the behaviors in the same way. Inherited behaviors usually involve basic life functions, such as finding food or caring for offspring. If an animal were to perform such important behaviors incorrectly, it would be less likely to survive

or reproduce. These inherited behaviors are necessary for **survival** (living) and reproduction (creating a next generation.)

This female gray lag goose is a ground-nesting water bird. Before her chicks hatch, the mother protects the eggs by using her bill to push eggs back into the nest if they roll out. This is an example of an inherited behavior.

All animals have inherited behaviors, even humans. Can you think of human behaviors that do not have to be learned? Chances are, you will have a hard time thinking of any. The only truly inherited behaviors in humans are called reflex behaviors, an involuntary response to a stimulus. They occur mainly in babies. Like instincts in other animals, reflex behaviors in human babies help them survive.

An example of a reflex behavior in babies is the sucking reflex. Newborns instinctively suck on a pacifier that is placed in their mouth. It is easy to see how this behavior evolved. It increases the chances of a baby feeding and surviving. Another example of a reflex behavior in babies is the grasp reflex. Babies instinctively grasp an object placed in the palm of their hand. Their grip may be surprisingly strong. How do you think this behavior might increase a baby's chances of surviving?

Learned Behavior

Learning is a change in behavior that occurs as a result of experience. Compared with inherited behaviors, **learned behaviors**, behaviors in response to a stimulus, are more flexible. They can be modified to better meet changing conditions. This may make them more adaptive than instincts. For example, drivers may have to modify how they drive when roads are wet or icy. Otherwise, they may lose control of their vehicle. Animals learn behaviors in a variety of ways.

Do you play a sport? If you play a sport like soccer, then you realize it takes a lot of work. Remember how you didn't know what you were doing when you first started? You had rules to figure out and skills to practice. Playing a sport is an example of a learned behavior.

Just about all human behaviors are learned. **Learned behavior** is behavior that occurs only after experience or practice. Learned behavior has an advantage over inherited behavior, it is more flexible.

Learned behavior can be changed if conditions change. For example, you probably know the route from your house to your school. Assume that you moved to a new house in a different place, so you had to take a different route to school. What if following the old route was an instinct? You would not be able to adapt. Fortunately, it is a learned behavior. You can learn the new route just as you learned the old one.

Although most animals can learn, animals with greater intelligence are better at learning and have more learned behaviors. Humans are the most intelligent animals. They depend on learned behaviors more than any other species. Other highly intelligent species include apes, our closest relatives in the animal kingdom. They include chimpanzees and gorillas. Both are very good at learning behaviors.

You may have heard of a gorilla named Koko. A psychologist, Dr. Francine Patterson, raised Koko. Dr. Patterson wanted to find out if gorillas could learn human language. Starting when Koko was just one year old, Dr. Patterson taught her to use sign language. Koko learned to use and understand more than 1,000 signs. Koko showed how much gorillas can learn.

Click here for a link to the video, A Conversation with Koko.

http://go.uen.org/aYu

Think about some of the behaviors you have learned. They might include riding a bicycle, using a computer, and playing a musical instrument or sport. You probably did not learn all of these behaviors in the same way. Perhaps you learned some behaviors on your own, just by practicing. Other behaviors you may have learned from other people. Humans and other animals can learn behaviors in several different ways.

5.2 Adaptations

Why don't cactuses grow in the rainforest, and why aren't their tropical flowers in the desert?

Adaptations

The characteristics of an organism that help it to survive in a given environment are called **adaptations**. Adaptations are inherited traits that an organism receives from its parents. Within a **population** of organisms, each organism has genes which contain coding for a certain number of traits. For example, a human population may have genes for eyes that are blue, green, hazel, or brown, but as far as we know, not purple or lime green.

Adaptations develop when certain variations, occur within the coding contained within the genes of a population the benefit the organisms ability to survive. **Variations** are differences in organisms from the same species. Because the parent organism survives to pass its variations of a trait to the next generation, the variation continues. The variation may already exist within the population, but often the variation comes from a mutation, a random change in an organism's genes. Sometimes, mutations are harmful and the organism dies. In that case, the variation will not remain in the population.

Many mutations are neutral and remain in the population. If the environment changes, the mutation may be beneficial and it may help the organism adapt to the changed environment. The organisms that survive pass this favorable trait onto their offspring.

One example of a variation helping an organism adapt to its changing environment is what happened to the peppered moth population during the Industrial Revolution in England. Most of the peppered moths before the Industrial Revolution were light

colored, while only some of them had the variation of being darker gray. Because the bark of the trees these moths lived on was lighter in color, the light colored moths were harder for birds to see, so the parent moths with the trait of light-colored genes lived to pass this color trait to their offspring.

Once the Industrial Revolution began, however, the pollution from the coal burned to run the factories greatly increased, and it clung to the bark of the trees, making the bark much darker. Scientists found that the light-colored moth population decreased greatly because now the birds could see them against the soot on the bark of the tree more easily. Scientists also found that the numbers of moths with the variation for dark-colored wings increased. They thought it might be because now the dark-colored moths were harder for the birds to see against the soot on the bark of the trees. This variation of dark-colored wings was now passed on to the next generation of pepper moths as an adaptation that helped the moth survive. What do you think happened when the Industrial Revolution ended in England and the air became cleaner?

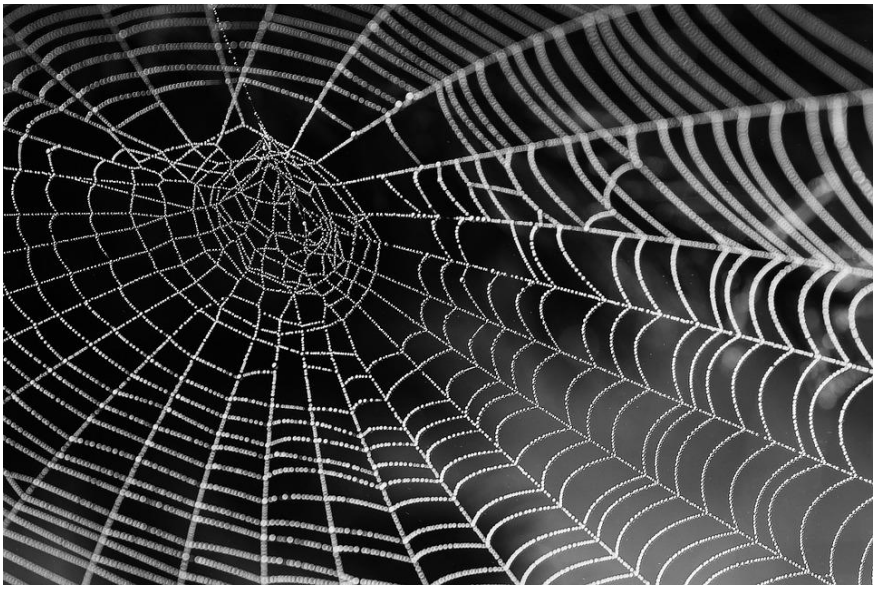
Camouflage is the ability some organisms have to blend into their surroundings. This ability to hide or disguise the presence of, is one way an animal can survive.

Why would an organism match its background? Wouldn't it be better to stand out? An organism that blends with its background is more likely to avoid predators. If it survives, it is more likely to have offspring. Those offspring are more likely to blend into their backgrounds. Can you find the mudskipper fish in this picture?

The octopus is well known for its ability to camouflage- an adaptation that helps in survive in a variety of environments. Watch to see how the octopus can change its color, shape, and texture to help it blend in with the ocean plants and floor.

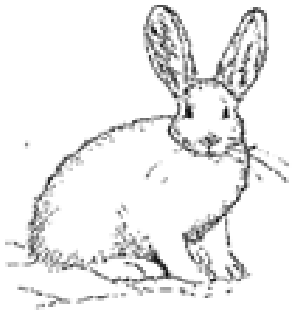
http://go.uen.org/aZa

Instincts



Instincts are also behaviors that are inherited from the parent organism. These instincts help organisms survive. This explains why salmon migrate upstream to spawn, a cat purrs, a duck swims, a spider spins a web, or a termite rots wood.

Specialized Structures



Snowshoe Rabbit

Jackrabbit

Other variations include **specialized structures**, a body part unique to a species for survival in its environment, the area in which an organism lives. A snowshoe rabbit has small ears and broad feet. Its smaller ears prevent it from losing body heat, enabling it to stay warmer in its cold northern habitat. Its broad-sized feet are well suited to help it travel over snowy terrain.

A jackrabbit lives in the hot, dry areas of the southwest. It has long, large ears and powerful hind feet. These ears provide a large surface area that allows excess heat to escape. The powerful hind legs enable it to outrun predators. Even though they are both members of the rabbit family, the specialized structures of the snowshoe rabbit and jackrabbit enable them to live and reproduce in different environments.

All birds have a beak but all beaks do not look the same. A goldfinch has a short beak for eating seeds. A woodpecker has a slender beak to get insects from under tree bark. A hawk has a hooked beak for ripping and tearing prey, such as rabbits.

Variations among plants can also help them with survival. Pine seedlings compete for sunlight, water, and soil nutrients. Fast-growing seedlings are more likely to crowd out their slow-growing neighbor. How does this variation help the fast-growing seedlings survive to produce offspring (seeds for a new generation of pine trees)?

Most organisms compete for resources such as food, air, water, and space. Variations that make it easier for organisms to find or use a resource are better able to survive.

The environment is constantly changing. Sometimes the changes are gradual, as in cycle of a lake's life which gradually effects the plant and animal life that live by it. . Other changes may be sudden, such as what happens to an environment after a wildfire, flood, landslide, or violent storms, such as hurricanes.

When an environment changes, some organisms die and other organisms move to a new environment. Some have variations for better survival. The helpful variations will be inherited by some of the offspring. After many generations, most organisms in that species will have helpful variations.

Years ago, when DDT (a poison that kills insects) was used in the environment, a few mosquitoes were resistant to DDT. These mosquitoes with this variation were better suited to survive in an environment that contained DDT. They lived and produced offspring that DDT could not kill. As a result, the population, the number and kind of organisms in an area, of DDT-resistant mosquitoes has grown larger in recent years.

Plant Adaptations

Plants have adapted to a variety of environments, from the desert to the tropical rain forest to lakes and oceans. In each environment, plants have become crucial to supporting animal life. Plants are the food that animals eat. Plants also provide places for animals, such as insects and birds, to live- from tiny mosses, to gorgeous rose bushes, to extremely large redwood trees.

This flower is from an aloe plant. Aloes are succulent plants which have adaptations that allow them to store water in their enlarged fleshy leaves, stems, or roots. This allows them to survive in arid environments.

Plants live just about everywhere on Earth. To live in so many different habitats, plants have evolved adaptations that allow them to survive and reproduce under a diversity of conditions.

Most people think all plants are adapted to live on land. But are they? All living plants today have terrestrial (land) ancestors, but some plants now live in the water. They have had to evolve new adaptations for their watery habitat.

Aquatic plants are plants that live in water. Living in water has certain advantages for plants. One advantage is the water, which all plants need to survive. Therefore, most aquatic plants do not need adaptations for absorbing, transporting, and conserving water. They can save energy and matter by not growing extensive root systems, vascular tissues, or thick cuticles on leaves. Support is also less of a problem because of the buoyancy of water. As a result, adaptations such as strong woody stems and deep anchoring roots are not necessary for most aquatic plants.

Living in water does present challenges to plants, however. For one thing, pollination by wind or animals isn't possible under water, so aquatic plants may have adaptations that help them keep their flowers above water. Water lilies, for instance, have bowl-shaped flowers and broad, flat leaves that float. This allows the lilies to collect the maximum amount of sunlight, which does not penetrate very deeply below the water's surface. Plants that live in moving water, such as streams and rivers, may have different adaptations. For example, cattails have narrow, strap-like leaves that reduce their resistance to the moving water.

Water Lilies

Cattails

Plants that live in extremely dry environments have the opposite problem that aquatic plants do. The focus of plants in desert environments is how to get and keep water. Their adaptations may help them increase water intake, decrease water loss, or store water when it is available.

The saguaro cactus has adapted in all three ways. When it was still a very small plant, just a few inches high, its shallow roots already reached out as much as 2 meters (7 feet) from the base of the stem. As a full-grown plant, its root system is much more widespread. It allows the cactus to gather as much moisture as possible from rare rainfalls. The saguaro doesn't have any leaves to lose water by transpiration (taking in water through its roots and giving off water vapor through its leaves.) It also has a large, barrel-shaped stem that can store a lot of water. Thorns protect the stem from thirsty animals that might try to get at the water inside.

All living things inherit traits and instincts from their parent organisms. They can also learn different behaviors, skills, and abilities to adapt and survive in their environment. For life to go on, organisms must continue to change and adapt to the world around them using the specialized structures they have inherited and the behaviors they have learned.

5.3 Summary Section

Summary

- All organisms inherit traits from their parent organisms.
- Some instincts and traits are inherited and others are learned.
- Adaptations allow plants and animals to survive and reproduce under a variety of diverse conditions.
- Specialized structures help organisms survive in their environment.

Science Language Students Need to Know and Use

- Environment: the surroundings in which an organism lives.
- Inherited: traits or actions that a living thing is born with and does not need to learn.
- Instinct: behaviors that are inherited from the parent organism.
- Learned behavior: an action that is learned through trial and error or is brought about by the environment.
- Life cycle: a series of stages from birth to death of an organism
- Offspring: the young of an organism.
- Organism: any living thing
- Parent organisms: a producer of offspring.
- Population: the number and kind of organisms in an area.
- Specialized structures: a body part unique to a species for survival in its environment.
- Species: a certain group of plants or animals that can only reproduce among themselves.
- Survival: the continuation of life.
- Trait: characteristics that determine how an organism looks, acts, or functions.

Think like a Scientist

1. Why doesn't a cow quack and why don't puppies look kittens? Why do children look like their parents?

2. Compare and contrast learned behaviors and inherited behaviors.

3. How do inherited behaviors help organisms survive?

4. How do learned behaviors help organisms survive?

5. Why don't cactuses grow in the rainforest, and why aren't there tropical flowers in the desert?

7. Compare and contrast the adaptations of a cactus and the adaptations of a water lily.

8. How do specialized structures help organism survive in their environment? Provide examples.

Online Interactive Activities

- Review heredity and why offspring look like their parents and distinguish between physical traits and inherited traits on this site. http://go.uen.org/b07
- Video introduction to inherited traits and Punnett squares. http://go.uen.org/b09