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Chapter 1 Exploring the Living World

Biology is the study of life, as in the life that covers the surface of the Earth like a living blanket, filling every nook and cranny from dark caves and dry deserts to blue oceans and lush rain forests. Living things interact with all these environments and each other, forming complex, interconnected webs of life.

In this chapter, we give you an overview of the big concepts of biology. Our goal is to show you how biology connects to your life and to give you a preview of the topics we explore in greater detail later in this book.

Living Things: Why Biologists Study Them, What Defines Them

Biologists seek to understand everything they can about living things, including

- » The structure and function of all the diverse living things on planet Earth

- The relationships between living things
- How living things grow, develop, and reproduce, including how these processes are regulated by DNA, hormones, and nerve signals
- The connections between living things and their environment
- How living things change over time
- How DNA changes, how it's passed from one living thing to another, and how it controls the structure and function of living things

REMEMBER

An individual living thing is called an *organism.* All organisms share eight specific characteristics that define the properties of life:

- **Living things are made of cells that contain DNA.** A *cell* is the smallest part of a living thing that retains all the properties of life. In other words, it's the smallest unit that's alive. *DNA,* short for *deoxyribonucleic acid,* is the genetic material, or instructions, for the structure and function of cells.
- **Living things maintain order inside their cells and bodies.** One law of the universe is that everything tends to become random over time. According to this law, if you build a sand castle, it'll crumble back into sand over time. Living things, as long as they remain alive, don't crumble into little bits. They constantly use energy to rebuild and repair themselves so that they stay intact.
- **Living things regulate their systems.** Living things maintain their internal conditions in a way that supports life. Even when the environment around them changes, organisms attempt to maintain their internal conditions; this process is called *homeostasis.* Think about what happens when you go outside on a cool day without wearing a coat. Your body temperature starts to drop, and your body responds by pulling blood away from your extremities to your core in order to slow the transfer of heat to the air. It may also trigger shivering, which gets you moving and generates more body heat. These responses keep your internal body temperature in the right range for your survival even though the outside temperature is low.

- **Living things respond to signals in the environment.** If you pop up suddenly and say "Boo!" to a rock, it doesn't do anything. Pop up and say "Boo!" to a friend or a frog, and you'll likely see him or it jump. That's because living things have systems to sense and respond to signals (or *stimuli*). Many animals sense their environment through their five senses just like you do, but even less familiar organisms, such as plants and bacteria, can sense and respond. For example, during the process of *phototaxis,* plants direct their growth toward areas where they have access to light.
- **Living things transfer energy among themselves and between themselves and their environment.** Living things need a constant supply of energy to grow and maintain order. Organisms such as plants capture light energy from the sun and use it to build food molecules that contain chemical energy. Then the plants, and other organisms that eat the plants, transfer the chemical energy from the food into cellular processes. As cellular processes occur, they transfer most of the energy back to the environment as heat.
- **Living things grow and develop.** You started life as a single cell. That cell divided to form new cells, which divided again. Now your body is made of approximately 100 trillion cells. As your body grew, your cells received signals that told them to change and become special types of cells: skin cells, heart cells, liver cells, brain cells, and so on. Your body developed along a plan, with a head at one end and a "tail" at the other. The DNA in your cells controlled all these changes as your body developed.
- **Living things reproduce.** People make babies, hens make chicks, and plasmodial slime molds make plasmodial slime molds. When organisms reproduce, they pass copies of their DNA onto their offspring, ensuring that the offspring have some of the traits of the parents.
- **Living things have traits that evolved over time.** Birds can fly, but most of their closest relatives — the dinosaurs — couldn't. The oldest feathers seen in the fossil record are found on a feathered dinosaur called *Archaeopteryx.* No birds or feathers have been found in any fossils that are older than those of *Archaeopteryx.* From observations like these, scientists can infer that having feathers is a trait that wasn't always present on Earth; rather, it's a trait that developed at a certain point in time. So, today's birds have characteristics that developed through the evolution of their ancestors.

Meet Your Neighbors: Looking at Life on Earth

Life on Earth is incredibly diverse, beautiful, and complex. Heck, you could spend a lifetime exploring the microbial universe alone. The deeper you delve into the living world around you, the more you can appreciate the similarities between all life on Earth — and be fascinated by the differences. The following sections give you a brief introduction to the major categories of life on Earth (called *domains*, as we explain in the upcoming section "Organizing Life into Smaller and Smaller Groups: Taxonomy").

Unsung heroes: Bacteria

Consisting mostly of single-celled organisms, bacteria are *prokaryotic*, meaning they lack a nuclear membrane around their DNA. Most bacteria have a cell wall made of *peptidoglycan:* a hybrid sugar-protein molecule.

REMEMBER

Most people are familiar with disease-causing bacteria such as *Streptococcus pyogenes*, *Mycobacterium tuberculosis*, and *Staphylococcus aureus.* Yet the vast majority of bacteria on Earth don't cause human diseases. Instead, they play important roles in the environment and health of living things, including humans. Photosynthetic bacteria make significant contributions to planetary food and oxygen production, and *E. coli* living in your intestines make vitamins that you need to stay healthy. So when you get down to it, plants and animals couldn't survive on Earth without bacteria.

Generally speaking, bacteria range in size from 1 to 10 micrometers (one millionth of a meter) in length and are invisible to the naked eye. Along with being nucleus-free, they have a genome that's a single circle of DNA. They reproduce *asexually* (meaning they produce copies of themselves) by a process called *binary fission.*

Bacteria have many ways of getting the energy they need for growth and various strategies for surviving in extreme environments. Their great metabolic diversity has allowed them to colonize just about every environment on Earth.

Bacteria impersonators: Archaeans

Archaeans are prokaryotes, just like bacteria. In fact, you can't tell the difference between the two just by looking, even if you look very closely using an electron microscope, because they're about the same size and shape, have similar cell structures, and divide by binary fission.

Until the 1970s, no one even knew that archaeans existed; up to that point, all prokaryotic cells were assumed to be bacteria. Then, in the 1970s, a scientist named Carl Woese started doing genetic comparisons between prokaryotes. Woese startled the entire scientific world when he revealed that prokaryotes actually separated into two distinct groups — bacteria and archaea — based on sequences in their genetic material.

The first archaeans were discovered in extreme environments (think salt lakes and hot springs), so they have a reputation for being *extremophiles* (*-phile* means "love," so *extremophiles* means "extreme-loving"). Since their initial discovery, however, archaeans have been found everywhere scientists have looked for them. They're happily living in the dirt outside your home right now, and they're abundant in the ocean.

Because archaeans were discovered fairly recently, scientists are still learning about their role on planet Earth, but so far it looks like they're as abundant and successful as bacteria.

A taste of the familiar: Eukaryotes

Unless you're a closet biologist, you're probably most familiar with life in eukaryotic form because you encounter it every day. As soon as you step outside, you can find a wealth of plants and animals (and maybe even a mushroom or two if you look around a little).

On the most fundamental level, all eukaryotes are quite similar. They share a common cell structure with nuclei and organelles, use many of the same metabolic strategies, and reproduce either asexually or sexually.

Despite these similarities, we bet you still feel that you're pretty different from a carrot. You're right to feel that way. The differences between you and a carrot are what separate you into two different kingdoms. In fact, enough differences exist among eukaryotes to separate them into four different kingdoms:

- **Animalia:** Animals are organisms that begin life as a cell called a *zygote* that results from the fusion of a sperm and an egg. The fertilized egg then divides to form a hollow ball of cells called a *blastula.* If you're wondering when the fur, scales, and claws come into play, these familiar animal characteristics get factored in much later, at the point when animals get divided up into phyla, families, and orders (see the "Organizing Life into Smaller and Smaller Groups: Taxonomy" section later in this chapter for more on these groupings).
- **Plantae:** Plants are photosynthetic organisms that start life as embryos supported by maternal tissue. This definition of plants includes all the plants you're familiar with: pine trees, flowering plants (including carrots), grasses, ferns, and mosses. All plants have cells with cell walls made of cellulose. They reproduce asexually by mitosis, but they can also reproduce sexually.

  The definition of plants, which specifies a stage where an embryo is supported by maternal tissue, excludes most of the algae, like seaweed, found on Earth. Algae and plants are so closely related that many people include algae in the plant kingdom, but many biologists draw the line at including algae in the plant kingdom.
- **Fungi:** Fungi may look a bit like plants, but they aren't photosynthetic. They get their nutrition by breaking down and digesting dead matter. Their cells have walls made of *chitin* (a strong, nitrogen-containing polysaccharide). This kingdom includes mushrooms, molds that you see on your bread and cheese, and many rusts that attack plants. Yeast is also a member of this kingdom even though it grows differently; most fungi grow as filaments (that look like threads), but yeast grow as little oval cells.
- **Protista:** This kingdom is defined as everything else that's eukaryotic. Seriously. Biologists have studied animals, plants, and fungi for a long time and defined them as distinct groups long ago. But many, many, eukaryotes don't fit into these three kingdoms. A whole world of microscopic protists exists in a drop of pond water. The protists are so diverse that some biologists think they should be separated into as many as 11 kingdoms of their own.

Classifying Living Things

Much like you'd draw a family tree to show the relationships between your parents, grandparents, and other members of your family, biologists use a *phylogenetic tree* (a drawing that shows the relationships among a group of organisms) to represent the relationships among living things.

Although you probably know how your family members are related to each other, biologists have to use clues to figure out the relationships among living things. The types of clues they use to figure out these relationships include

- **Physical structures:** The structures that biologists use for comparison may be large, like feathers, or very small, like a cell wall.
- **Chemical components:** Some organisms produce unique chemicals. Bacteria, for example, are the only cells that make the hybrid sugar-protein molecule called peptidoglycan.
- **Genetic information:** An organism's genetic code determines its traits, so by reading the genetic code in DNA, biologists can go right to the source of differences among species.

REMEMBER

The more characteristics two organisms have in common with each other, the more closely related they are. Characteristics that organisms have in common are called *shared characteristics.*

REMEMBER

Based on structural, cellular, biochemical, and genetic characteristics, biologists can classify life on Earth into groups that reflect the evolutionary history of the planet. That history indicates that all life on Earth began from one original universal ancestor after the Earth formed 4.5 billion years ago. All the diversity of life that exists today is related because it's descended from that original ancestor.

Organizing Life into Smaller and Smaller Groups: Taxonomy

Biologists need to work with small groups of living things in order to determine how similar the different types of organisms are. Hence, the creation of the *taxonomic hierarchy*, a naming system that ranks organisms by their evolutionary relationships. Within this hierarchy, living things are organized from the largest, most-inclusive group down to the smallest, least-inclusive group.

REMEMBER

The taxonomic hierarchy is as follows, from largest to smallest.

- **Domain:** Domains group organisms by fundamental characteristics such as cell structure and chemistry. For example, organisms in domain Eukarya are separated from those in the Bacteria and Archaea domains based on whether their cells have a nucleus, the types of molecules found in the cell wall and membrane, and how they go about protein synthesis. (We introduce the three domains in the earlier section "Meet Your Neighbors: Looking at Life on Earth.")
- **Kingdom:** Kingdoms group organisms based on developmental characteristics and nutritional strategy. For example, organisms in the animal kingdom (Animalia) are separated from those in the plant kingdom (Plantae) because of differences in the early development of these organisms and the fact that plants make their own food by photosynthesis, whereas animals ingest their food. (Kingdoms are most useful in domain Eukarya because they're not well defined for the prokaryotic domains.)
- **Phylum:** Phyla separate organisms based on key characteristics that define the major groups within the kingdom. For example, within kingdom Plantae, flowering plants (Angiosperms) are in a different phylum than cone-bearing plants (Conifers).
- **Class:** Classes separate organisms based on key characteristics that define the major groups within the phylum. For example, within phylum Angiophyta, plants that have two seed leaves (dicots, class Magnoliopsida) are in a separate class than plants with one seed leaf (monocots, class Liliopsida).
- **Order:** Orders separate organisms based on key characteristics that define the major groups within the class. For example, within class Magnoliopsida, nutmeg plants (Magnoliales) are put in a different order than black pepper plants (Piperales) due to differences in their flower and pollen structure.
- **Family:** Families separate organisms based on key characteristics that define the major groups within the order. For example, within order Magnoliales, buttercups (Ranunculaceae) are in a different family than roses (Rosaceae) due to differences in their flower structure.

- **Genus:** Genera separate organisms based on key characteristics that define the major groups within the family. For example, within family Rosaceae, roses (Rosa) are in a different genus than cherries (Prunus) thanks to differences in their flower structure.
- **Species:** Species separate eukaryotic organisms based on whether they can successfully reproduce with each other. You can walk through a rose garden and see many different colors of China roses (Rosa chinensis) that are all considered one species because they can reproduce with each other.

TIP

Think of how biologists organize living things like how you might organize your clothing. In your first round of organizing, you might make groups of pants, shirts, socks, and shoes. From there, you might go into the shirt group and organize your shirts into smaller groups, such as short-sleeved versus long-sleeved shirts. Then perhaps you'd organize them by type of fabric, then color, and so on. At some point, you'd have very small groups with very similar articles of clothing — perhaps a group of two short-sleeved, button-down, blue shirts, for example. All your clothing would be organized in a hierarchy, from the big category of clothing all the way down to the small category of short-sleeved, button-down, blue shirts.

Table 1-1 compares the classification, or *taxonomy*, of you, a dog, a carrot, and *E. coli.*

TABLE 1-1 Comparing the Taxonomy of Several Species

Taxonomic Group	Human	Dog	Carrot	E. coli
Domain	Eukarya	Eukarya	Eukarya	Bacteria
Kingdom	Animalia	Animalia	Plantae	Eubacteria
Phylum	Chordata	Chordata	Angiophyta	Proteobacteria
Class	Mammalia	Mammalia	Magnoliopsida	Gammaproteobacteria
Order	Primates	Carnivora	Apiales	Enterobacteriales
Family	Hominidae	Canidae	Apiaceae (Umbelliferae)	Enterobacteriaceae
Genus	*Homo*	*Canus*	*Daucus*	*Escherichia*
Species	*H. sapiens*	*C. familiaris*	*D. carota*	*E. coli*

Of the organisms listed in Table 1-1, you have the most in common with a dog. You're both animals possessing a central nervous chord (phylum Chordata), and you're both mammals (class Mammalia), which means you have hair and the females of your species make milk. However, you also have many differences, including the tooth structure that separates you into the order Primates and a dog into the order Carnivora. If you compare yourself to a plant, you can see that you have certain features of cell structure that place you together in domain Eukarya, but little else in common.

REMEMBER

Two organisms that belong to the same species are the most similar of all. For most eukaryotic organisms, members of the same species can successfully sexually reproduce together, producing live offspring that can also reproduce. Bacteria and archaea don't reproduce sexually, so their species are defined by chemical and genetic similarities.

Biodiversity: Our Differences Make Us Stronger

The diversity of living things on Earth is referred to as *biodiversity.* Almost everywhere biologists have looked on this planet — from the deepest, darkest caves to the lush Amazonian rain forests to the depths of the oceans — they've found life. In the deepest, darkest caves where no light ever enters, bacteria obtain energy from the metals in the rocks. In the Amazonian rain forest, plants grow attached to the tops of trees, collecting water and forming little ponds in the sky that become home to insects and tree frogs. In the deep oceans, blind fish and other animals live on the debris that drifts down to them like snow from the lit world far above. Each of these environments presents a unique set of resources and challenges, and life on Earth is incredibly diverse due to the ways in which organisms have responded to these challenges over time.

The following sections clue you in not only to the reasons why biodiversity is so important and how human actions are harming it, but also how human actions can protect biodiversity moving forward.

Valuing biodiversity

Biodiversity is important — and worth valuing — for the following reasons:

REMEMBER

- **The health of natural systems depends on biodiversity.** Scientists who study the interconnections between different types of living things and their environments believe that biodiversity is important for maintaining balance in natural systems. Each type of living thing plays a role in its environment, and the loss of even one species can have widespread effects.
- **Many economies rely upon natural environments.** A whole industry called *ecotourism* has grown up around tour guides leading people on trips through natural habitats and explaining the local biology along the way.
- **Human medicines come from other living things.** For example, the anticancer drug paclitaxel (Taxol) was originally obtained from the bark of the Pacific yew, and the heart medicine digitalin comes from the foxglove plant.
- **Biodiversity adds to the beauty of nature.** Natural systems have an aesthetic value that's pleasing to the eye and calming to the mind in today's technologically driven world.

Surveying the threats posed by human actions

As the human population grows and uses more and more of the Earth's resources, the populations of other species are declining as a direct result. Following are the ways in which human actions pose major threats to biodiversity:

- **Development is reducing the size of natural environments.** People need places to live and farms to raise food. In order to meet these needs, they burn rain forests, drain wetlands, cut down forests, pave over valleys, and plow up grasslands. Whenever people convert land for their own use, they destroy the habitats of other species, causing habitat loss.

- **Unnatural, human-produced wastes are polluting the air and water.** Automobiles and factories burn gasoline and coal, releasing pollution into the air. Metals from mining and chemicals from factories, farms, and homes get into groundwater. After pollution enters the air and water, it travels around the globe and can hurt multiple species, including humans.
- **The overharvesting of species to provide food and other materials for human consumption is driving some species to near extinction.** Because they can reproduce, living things such as trees and fish are considered renewable resources. However, if people harvest these resources faster than they can replace themselves, the numbers of individual trees and fish decline. If too few members of a species remain, the survival of that species becomes very unlikely.
- **Human movements around the globe sometimes carry species into new environments.** An *introduced (*or *non-native) species* is a foreign species that's brought into a new environment. Introduced species that are very aggressive and take over habitats are called *invasive species.* Invasive species often have a large environmental impact and cause the numbers of *native species* (organisms belonging to a particular habitat) to decline; they can also attack crop plants and cause human diseases.

Exploring the extinction of species

The combined effects of all the various human actions in Earth's ecosystems are reducing the planet's biodiversity. In fact, the rate of extinctions is increasing along with the size of the human population. No one knows for certain how extensive the loss of species due to human impacts will ultimately be, but there's no question that human practices such as hunting and farming have already caused numerous species to become extinct.

Many scientists believe Earth is experiencing its sixth *mass extinction*, a certain time period in geologic history that shows dramatic losses of many species. (The most famous mass extinction event is the one that occurred about 65 million years ago and included the extinction of the dinosaurs.) Scientists theorize that most of the past mass extinctions were caused by major changes in Earth's climate and that the current extinctions (most recently including black rhinos, Zanzibar leopards, and golden toads) began as a result of human land use but may increase as a result of global warming.

The loss in biodiversity that's currently happening on Earth could have effects beyond just the loss of individual species. Living things are connected to each other and their environment in how they obtain food and other resources necessary for survival. If one species depends on another for food, for example, then the loss of a prey species can cause a decline in the predator species.

The sections that follow introduce you to two classifications of species that biologists are keeping an eye on when it comes to questions of extinction.

Keystone species

REMEMBER

Some species are so connected with other organisms in their environment that their extinction changes the entire composition of species in the area. Species that have such great effects on the balance of other species in their environment are called *keystone species.* As biodiversity decreases, keystone species may die out, causing a ripple effect that leads to the loss of many more species. If biodiversity gets too low, then the future of life itself becomes threatened.

An example of a keystone species is the purple seastar, which lives on the northwest Pacific coast of the United States. Purple seastars prey on mussels in the intertidal zone. When the seastars are present, they keep the mussel population in check, allowing a great diversity of other marine animals to live in the intertidal zone. If the seastars are removed from the intertidal zone, however, the mussels take over, and many species of marine animals disappear from the environment.

Indicator species

REMEMBER

One way biologists can monitor the health of particular environments and the organisms that live in them is by measuring the success of *indicator species:* species whose presence or absence in an environment gives information about that environment.

In the Pacific Northwest region of the United States, the health of old-growth forests is measured by the success of the northern spotted owl, a creature that can make its home and find food only in mature forests that are hundreds of years old. As logging decreases the number and size of these old forests, the number of spotted owls has declined, thereby making the number of spotted owls an indicator of the health, or even the existence, of old-growth forests in the Pacific Northwest. Of course, old-growth forests aren't just home to spotted owls — they shelter a rich diversity of living things, including plants, such as sitka spruce and Western hemlock, and animals, such as elk, bald eagles, and flying squirrels. Old-growth forests also perform important environmental functions such as preventing erosion, floods, and landslides; improving water quality; and providing places for salmon to spawn. If old-growth forests become extinct in the Pacific Northwest, the effects will be far reaching and have many negative impacts on the people and other species in the area.

Protecting biodiversity

Biodiversity increases the chance that at least some living things will survive in the face of large changes in the environment, which is why protecting it is crucial. What can people do to protect biodiversity and the health of the environment in the face of the increasing demands of the human population? No one has all the answers, but here are a few ideas worth trying:

- Keep wild habitats as large as possible and connect smaller ones with *wildlife corridors* (stretches of land or water that wild animals travel as they migrate or search for food) so organisms that need a big habitat to thrive can move among smaller ones.
- Use existing technologies and develop new ones to decrease human pollution and clean up damaged habitats. Technologies that have minimal effects on the environment are called *clean* or *green technologies.* Some businesses are trying to use these technologies in order to reduce their impact on the environment.
- Strive for sustainability in human practices, including manufacturing, fishing, logging, and agriculture. Something that's *sustainable* meets current human needs without decreasing the ability of future generations to meet their needs.
- Regulate the transport of species around the world so that species aren't introduced into foreign habitats. This step

includes being careful about the transport of not-so-obvious species. For example, ships traveling from one port to another are often asked to empty their ballast water offshore so they don't accidentally release organisms from other waters into their destination harbors.

Making Sense of the World through Observations

The true heart of science isn't a bunch of facts — it's the method that scientists use to gather those facts. Science is about exploring the natural world, making observations using the five senses, and attempting to make sense of those observations. Scientists, including biologists, use two main approaches when trying to make sense of the natural world:

- **Discovery science:** When scientists seek out and observe living things, they're engaging in *discovery science,* studying the natural world and looking for patterns that lead to new, tentative explanations of how things work (these explanations are called *hypotheses*). If a biologist doesn't want to disturb an organism's habitat, he or she may use observation to find out how a certain animal lives in its natural environment. Making useful scientific observations involves writing detailed notes about the routine of the animal for a long period of time (usually years) to be sure that the observations are accurate.
- **Hypothesis-based science:** When scientists test their understanding of the world through experimentation, they're engaging in *hypothesis-based science,* which usually calls for following some variation of a process called the scientific method (which we explain in a moment). Modern biologists are using hypothesis-based science to try to understand many things, including the causes and potential cures of human diseases and how DNA controls the structure and function of living things.

Hypothesis-based science can be a bit more complex than discovery science and relies on the scientific method. The *scientific method* is basically a plan that scientists follow while performing scientific experiments and writing up the results. It allows experiments to be duplicated and results to be communicated uniformly. Here's the general process of the scientific method:

1. **Make observations and come up with questions.**

   The scientific method starts when scientists notice something and ask questions like "What's that?" or "How does it work?" just like a child might when he sees something new.

2. **Form a hypothesis**.

   Much like Sherlock Holmes, scientists piece together clues to try to come up with the most likely hypothesis (explanation) for a set of observations. This hypothesis represents scientists' thinking about possible answers to their questions.

   Say, for example, a marine biologist is exploring some rocks along a beach and finds a new worm-shaped creature he has never seen before. His hypothesis is that the creature is some kind of worm.

   REMEMBER

   One important point about a scientific hypothesis is that it must be testable, or *falsifiable.* In other words, it has to be an idea that you can support or reject by exploring the situation further using your five senses.

3. **Make predictions and design experiments to test the idea(s).**

   Predictions set up the framework for an experiment to test a hypothesis, and they're typically written as "if . . . then" statements.

   If the marine biologist predicts that the creature he found is a worm, then its internal structures should look like those in other worms he has studied.

4. **Test the idea(s) through experimentation.**

   Scientists must design their experiments carefully in order to test just one idea at a time. As they conduct their experiments, scientists make observations using their five senses and record these observations as their results or data. Scientists conduct multiple tests to ensure that their observations are repeatable.

Continuing with the worm example, the marine biologist tests his hypothesis by dissecting the wormlike creature, examining its internal parts carefully with the assistance of a microscope, and making detailed drawings of its internal structures.

5. **Make conclusions about the findings.**

   Scientists interpret the results of their experiments through *deductive reasoning,* using their specific observations to test their general hypothesis. When making deductive conclusions, scientists consider their original hypothesis and ask whether it could still be true in light of the new information gathered during the experiment. If so, the hypothesis can remain as a possible explanation for how things work. If not, scientists reject the hypothesis and try to come up with an alternate explanation (a new hypothesis) that could explain what they've seen.

   In the worm example, the marine biologist discovers that the internal structures of the wormlike creature look very similar to another type of worm he's familiar with. He can therefore conclude that the new animal is likely a relative of that other type of worm.

6. **Communicate the conclusions with other scientists.**

   Communication is a huge part of science. Without it, discoveries can't be passed on, and old conclusions can't be tested with new experiments. When scientists complete some work, they write a paper that explains exactly what they did, what they saw, and what they concluded. Then they submit that paper to a scientific journal in their field. Scientists also present their work to other scientists at meetings, including those sponsored by scientific societies. In addition to sponsoring meetings, these societies support their respective disciplines by printing scientific journals and providing assistance to teachers and students in the field.