SUPERCHARGED SCIENCE

Unit 17:
Life Science Part 2

www.ScienceLearningSpace.com

Appropriate for Grades:
Grades K-8 (see notes on each lesson)

Duration: 3-25 hours, depending on how many activities you do!

Living things are all around us. Sometimes the living things we notice the most are animals, whether its birds chirping in the trees, our pet dogs, or even our fellow human beings. However, most living things are not animals. In these sections, we will learn about bacteria, archae, fungi, protists, and plants. These organisms are extremely important to learn about. They make life possible for animals, including human beings, by keeping soil ready for growth, and providing oxygen for our survival. No life would be possible without these remarkable organisms.

Table of Contents

Key Vocabulary

Angiosperms – Plants with flowers

Asexual Reproduction – Reproduction requiring only one parent

Autotrophs – Organisms that get energy from photosynthesis

Bacilli – Bacteria shaped like rods

Binary Fission – Asexual reproduction in which the parent organism splits into two identical offspring

Budding – Process of reproduction where a small appendage, or “bud” grows on the parent organism, eventually breaking off to form its own organism

Cell – The smallest structure still considered to be living

Cell Wall – Structure on the outside of a cell that protects it from harmful substances trying to enter

Chemotrophs – Bacteria that get energy by breaking down chemical compounds

Chitin – Material that makes up shells of beetles and lobsters, and makes up the cell walls of fungi

Chromosome – Area of the cell in which the genetic information is found

Cilia – Small tail-like structures that aid in motion

Classification – Putting things into groups

Cocci – Bacteria shaped like spheres

Commensalism – Symbiotic relationship in which one organism benefits while the other is unaffected

Corolla – Collective term for all the petals of a flower

Cross-Pollination – Method of reproduction in angiosperms where the pollen from a plant goes into the stigma of a different plant

Decomposers – Bacteria that get their energy by breaking down waste and dead organisms

Diploid – Containing all the genetic material of the organism

Dormant – State in which seeds do not sprout

Eukaryotes – Cells that have a nucleus

Eukaryotic – Having cells with nuclei

Flagella – Tail-like structures found in some bacteria

Flagellum – Tail found on some cells

Fragmentation – Method of asexual reproduction where part of the organism breaks off and forms a new organism

Fruiting Body – Part of the fungus that produces spores

Gametes – Cells used in reproduction

Gametophyte – Haploid generation that produces gametes

Gymnosperms – Plants with seeds considered “naked,” because they are not covered in fruit

Haploid – Containing only half the genetic material of a full organism

Heterotrophic – Needing to eat in order get energy

Hormones – Chemicals which cause changes in an organism based on things going on in the outside environment.

Host – Living organism from which another organism, such as a fungus, takes nutrients

Hyphae – Thread-like structures in fungi

Multi-cellular – Being made of more than one cell

Mutualism – Symbiotic relationship in which both organisms benefit

Mycelium – Bunched up hyphae in fungi

Nonvascular Plants – Plants without vascular tissue

Nucleus – Part of the cell that controls the cell's functions

Organism – Living thing

Parasitism – Symbiotic relationship in which one organism benefits while the other is harmed

Peptidoglycan – Mixture of sugars and amino acids that make up the cell call of bacteria

Phloem – Vascular tissue that carries sugars

Photosynthesis – Process in which plants convert sunlight into the energy they need to survive

Pollen – The male gametophyte in angiosperms

Prokaryote – Cell without a nucleus

Protozoa – Animal-like protists

Pseudopodia – False foot used by some protists to move

Self-Pollination – Method of reproduction in angiosperms where the pollen from a plant goes into the stigma of the same plant

Sepals – Outside layer of a flower that covers it before it opens

Sexual Reproduction – Reproduction requiring two parents

Spirilli – Bacteria shaped like spirals

Spores – Haploid cells that divide to form the gametophyte

Sporophyte – Diploid generation that produces spores

Stigma – Female part of a flower

Symbiotic – Long-term relationship between two organisms

Thermophile – Archaea that live in extremely hot environments

Unicellular – Being made of only one cell

Vascular Seedless Plants – Plants containing vascular tissue, but no seeds

Xylem – Vascular tissue that carries water and minerals

Unit Description

Living things are all around us. Sometimes the living things we notice the most are animals, whether its birds chirping in the trees, our pet dogs, or even our fellow human beings. However, most living things are not animals. In these sections, we will learn about bacteria, archae, fungi, protists, and plants. These organisms are extremely important to learn about. They make life possible for animals, including human beings, by keeping soil ready for growth, and providing oxygen for our survival. No life would be possible without these remarkable organisms.

Objectives

Lesson 1: Prokaryotes

In this section, you will learn about the two major groups of prokaryotes, bacteria and archaea. For each group, we will talk about how these living things survive and grow, by discussing their physical structure, methods of getting energy, and methods of reproduction. We will also discuss how these living things interact with other living things, including humans.

This is important because prokaryotes are incredibly common and have a huge impact on our lives. You may already know some of the ways bacteria can be harmful to you, and this is certainly important information. It is also important, however, to understand how prokaryotes help us. Scientists have used knowledge of prokaryotes to create medications and vaccines that have led to a healthier life for billions of people.

At the end of this section, you will know:

1. The major parts of the bacteria cell and what each of the do

2. The ways bacteria move

3. The ways bacteria reproduce

4. Ways bacteria are helpful and harmful

5. How archae and bacteria are similar and how they are different

6. The places archae live

Objectives

Lesson 2: Protists & Fungi

In this section, you will learn about two kingdoms of living things, fungi and protists. We will start with fungi, discussing things such as body structure, methods of eating, methods of reproduction, and impact on other living things. We will then move on to protists, talking about the major types of protists as well as the role they serve.

All of this is important because fungi and protists are absolutely critical for the survival of other organisms. Without these living things, soil would be unusable and we would not have made many of the advances we have made in medicine, industry, and food production. Understanding these fascinating organisms will help us understand the crucial role they play in our lives.

At the end of this section you will know:

1. Several examples of fungi
2. The parts of fungi, and what they do
3. Ways fungi can be helpful or harmful
4. Examples of symbiosis in fungi
5. How fungi reproduce
6. Why protists are considered a "junk drawer" kingdom
7. The major way of classifying protists
8. Ways protists move
9. Ways protists reproduce

Objectives

Lesson 3: Plants

From the bushes outside your window, to the tree that produced the apple you had with lunch, to moss on a log, plants are all around us.

In this section, you will learn all about plants including their parts and methods of reproduction and survival. You will see that although all plants have some things in common, there are many different kinds of plants. You will also see that plants have an impact on their environment, and that they are affected by their environment as well.

When you think about all the times you interact with plants during your life, you can see how important it is to understand them!

At the end of this section, you will know:

1. What makes something a plant

2. Important structures that many plants have, and what they do

3. The major groups of plants

4. How plants reproduce

5. The role of flowers in plant reproduction

6. How plants are helpful to people

Textbook Reading

Lesson 1: Prokaryotes

Introduction

You, me, a tree on your street, and a bacterium in your body are all alive. Being alive, all of these things are made of one or more **cells**, the smallest things that are considered living. Cells have many parts, and each part has an important role in helping the cell carry out its functions. Some cells have a **nucleus**, which is kind of like the brain of the cell. Nuclei (that's the plural of nucleus) control everything that happens in the cell.

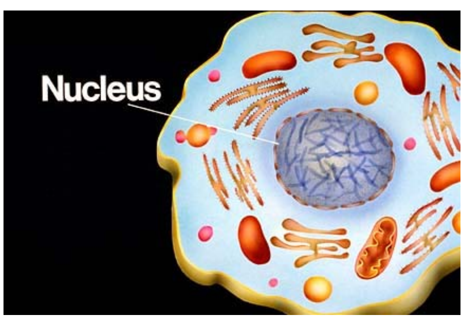

Figure 1 – The nucleus is sometimes called the "brain" of the cell.

When you hear that nuclei control everything that happens in a cell, it might make you think that all cells need to have a nucleus. In fact, however, many cells do not have nuclei. Cells without nuclei are called **prokaryotes.**

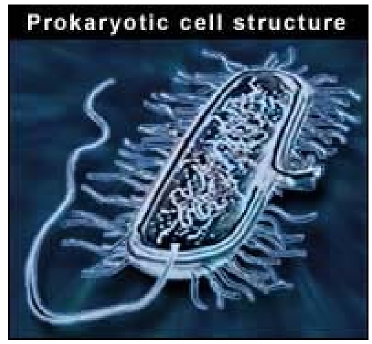

Figure 2 – Prokaryotic cells, like this one, do not have a nucleus.

What are bacteria?

When you hear the word "bacteria" what do you think of? If you're like most people, you probably think of things that can make you sick. Although some bacteria do make us sick, this is not true for all of them. In fact, as we'll see a little later, some bacteria are very helpful.

What *is true* about bacteria is that they are made of only a single cell, are prokaryotes, and are very common. They are the most common living things on Earth. In fact, there are more bacteria living in the mouth of a single person than there are people on the planet!

Since bacteria are made of only one cell, they are very cell. The only way to see bacteria is to look at them in a microscope. When you look at bacteria in a microscope, they usually have one of three shapes.

Bacilli are shaped like rods, **cocci** are shaped like spheres, and **spirilli** are shaped like spirals. Using shapes to describe bacteria helps scientists but bacteria into groups, which is often called **classification**.

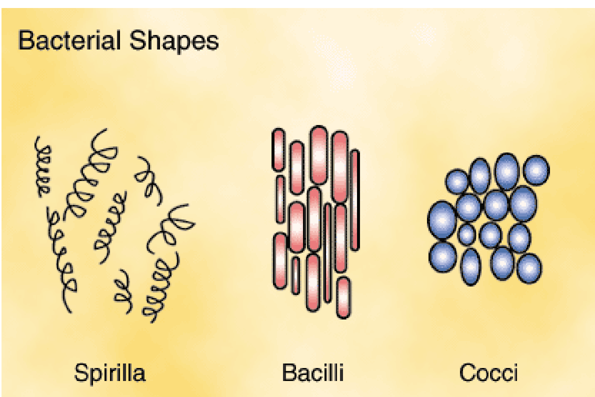

Figure 3 – Bacteria can be classified based on their shape.

Structure of Bacteria

All bacteria have certain structures inside of them. These structures allow the bacterium (that's the singular form of bacteria) to go through its life cycle, complete the jobs it has to do, reproduce, and eventually die. Unlike a single cell inside a multi-cellular organism like a plant or animal, which relies on other cells, the single cell of a bacterium can complete all of life functions by itself.

Cell Wall

Think about your skin for a moment. Although we may take it for granted, our skin is extremely important. This organ (yes, skin is an organ!) protects the body, keeping most of the things that could hurt us from getting into our bodies.

Imagine for a minute if we didn't have skin. Dangerous things could easily enter our body and make it to our internal organs. Of course, bacteria don't have skin, because they are only one cell, but they do have something that acts like skin, keeping things out if they could harm the cell. This structure is called a **cell wall**.

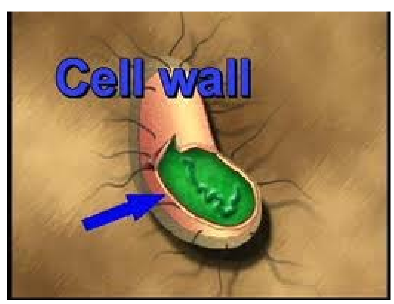

Figure 4 – The cell wall protects harmful materials from entering the cell.

All bacteria have a cell wall. The cell wall is made of a mixture of sugars and amino acids called **peptidoglycan.**

The cell wall is so important to the bacterium that certain medicines, like penicillin, work by keeping cell walls of harmful bacteria from forming. This causes the cell to die. For bacteria that live inside of other living things, a capsule or slime layer often surrounds the cell wall to keep it from being destroyed.

Cell Membrane, Cytoplasm, and Ribosomes

Like all cells, bacteria have a cell membrane, cytoplasm, and ribosomes. Inside the cell wall is the cell membrane, which provides even more protection for the cell. Inside the cell membrane is a liquid material called cytoplasm.

Cytoplasm holds all the structures inside the cell. One of these structures are called ribosomes. Ribosomes have the very important job of creating proteins. Proteins are needed for the cell to do pretty much anything, so ribosomes are very important.

Structures Involved in Reproduction

In cells that have nuclei, the material needed for reproduction, called **DNA**, is found in the nucleus. Bacteria, of course, have no nucleus, but they do reproduce, which means they do have DNA. In bacteria cells, most of the DNA is found in a circular strand packed tightly in a structure called the **nucleoid**. Along with DNA found in the nucleoid, many bacteria have circular strands of DNA called **plasmids**.

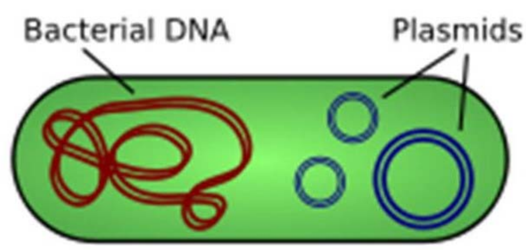

Figure 5 – In bacteria, DNA is found in the nucleoid (shown in red) and the plasmids (shown in blue.)

Flagella

Some bacteria have one or more tail-like structures called **flagella**. A flagellum (that's the singular form of flagella) swings back and forth, which makes the bacterium spin and pushes it forward.

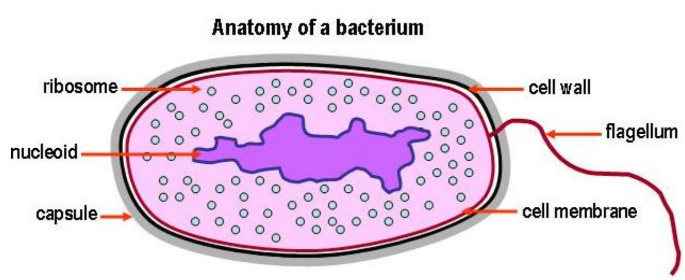

Figure 6 – Test yourself by seeing if you can name the function of each of these parts of a bacterium.

Getting Food and Energy

All living things need a way to get energy. Bacteria get their food and energy in many ways. Some bacteria can make food on their own, while others need other organisms. Some bacteria help other living things as they get energy, others hurt them while they get energy, and still others have no affect on living things at all.

Some living things, or organisms, are able to make their own food in a process called **photosynthesis**. In this process, the organism turns energy from the sun into energy that can be used for energy. Organisms that get their energy from photosynthesis are called **autotrophs**. Some bacteria get their energy this way.

Figure 7 – Cyanobacteria are autotrophs because they get their energy from the sun.

Some bacteria, called **chemotrophs**, get their energy by breaking down chemical compounds in the environment, including ammonia. Breaking down ammonia is important because ammonia contains the element nitrogen.

All organisms need nitrogen to survive, and the nitrogen released by bacteria is crucial to these living things' survival. Clearly, chemotrophs are very important and beneficial to other living things.

Living things that cannot get their energy through photosynthesis or from breaking down chemical compounds have to get their energy from other living things. Some bacteria, called **decomposers**, get their energy by breaking down dead organisms or waste products into simple nutrients and energy.

Figure 9 – Pseudomonas bacteria are decomposers found in the soil, where they recycle dead plant material.

The last groups of bacteria get energy from organisms that are still alive, and depend on these organisms to survive.

Mutualistic bacteria get their energy in ways that help another organism. For example, some bacteria live in the roots of legumes, including pea plants. The bacteria make the nitrogen the pea plants need and the pea plants provide a place for the bacteria to live.

Other bacteria, called **parasitic** bacteria, hurt the organism they are getting help from. For example, some bacteria cause illness. We will talk about ways bacteria can be helpful or harmful a little later.

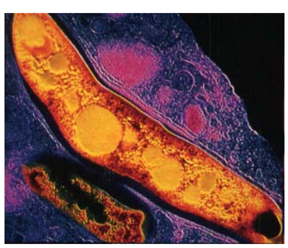

Figure 9 – Ryzobium bacteria (left) have a mutualistic relationship with legumes, but the tuberculosis bacterium (right) is parasitic.

Reproduction in Bacteria

All living things reproduce. This is the only way to ensure the organisms continued survival. Bacteria reproduce **asexually.** This means that a single "parent" organism produces offspring on their own.

In the case of bacteria, a process called **binary fission** is used. In binary fission, the DNA in the nuceleoid region and plasmids double, and the bacterium splits into two identical copies. If everything happens the way it's supposed to, the two new bacteria will be identical to the original bacterium.

These bacteria can then split again to increase the number of bacteria in the population. Through binary fission, bacteria reproduce very quickly. Some populations can double their size in less than ten minutes!

How Bacteria Help

Bacteria have a bad reputation. Walk down the cleaning aisle of any store and you'll see rows and rows of products promising to kill them. There are definitely some bacteria that cause problems for people, and we'll talk about them soon, but we are going to start off positive, and talk about the many ways bacteria can be helpful.

First, decomposers help control waste. Without these bacteria, the amount of waste in soil would quickly make the soil a place where nothing could grow. Bacteria are even used in sewage treatment plants to treat our waste. Decomposers also help provide organisms with nitrogen, as was discussed earlier.

Bacteria also have an important role in the foods we eat. Yogurt and some cheeses are made from using bacteria to ferment milk, and sauerkraut is made from using bacteria to ferment cabbage.

Figure 10 – This yogurt advertises that it has “live cultures” of bacteria.

Once we’ve eaten, bacteria continue to help us. Bacteria line the digestive tract and help us digest food. In your gut, the number of bacteria cells is greater than the number of your own cells.

In science labs, researchers have found ways to use bacteria to produce medicines. For example, some people with the disease diabetes need insulin. Mass-produced insulin, made possible by bacteria, has lowered the cost of insulin for people suffering from this disease.

How Bacteria Hurt

Some bacteria are responsible for diseases in humans and other organisms. Strep throat, tuberculosis, pneumonia, and the black death are all the result of bacteria.

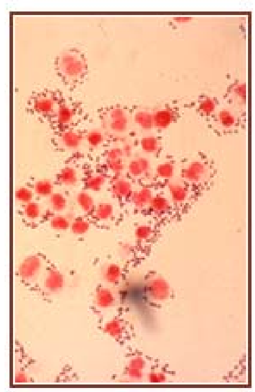

Figure 11 – The bacterium *Streptococcus pneumoniae* causes the diseases pneumonia, bactermia and meningitis. These diseases, known as pneumococcal diseases kill more people in the United States each year than all other vaccine-preventable diseases combined.

Bacteria can also be responsible for food poisoning. Raw eggs and undercooked meats can contain bacteria that can cause digestive problems. One simple step everyone can take to reduce these kinds problems is washing your hands before cooking or eating.

Cleaning cooking surfaces and fully cooking food can also help.

Archaea

Archaea are group of organisms that have many similarities to bacteria. Both groups are single-celled, microscopic prokaryotes. Both have cell walls and a single circular ring of DNA. Finally, both can have flagella to help them move.

Archaea are so similar to bacteria that for a long time, scientists thought that bacteria and archaea were the same thing. More recently, technology has improved and scientists have been able to study the DNA of these groups of organisms. This helped them to see that they do have some important differences.

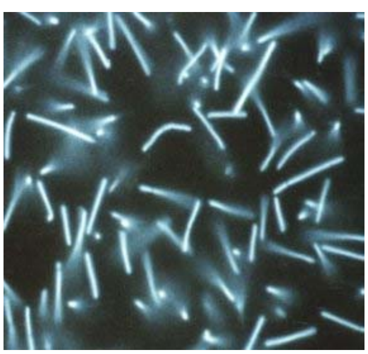

Figure 13 – Although these archaea look very similar to rod-shaped (bacilli) bacteria, DNA tests showed that they are actually quite different.

The first difference between archaea and bacteria has to do with the cell wall. Remember that bacteria cell walls are made of peptidoglycan.

In archaea, the cell wall serves the same purpose, protecting the cell, but is made of different proteins. The cell membrane of archaea are also made of different materials than bacterial cell membranes, although again, their job is basically the same.

Finally, the ribosomes of archaea are different than those in bacteria. In fact, archaea bacteria are similar to **eukaryotes**, which are cells that have a nucleus.

How Do Archaea Get Food and Energy?

Most archaea are chemotrophs. Remember that chemotrophs get their energy by breaking down chemical compounds. Other archaea are autotrophs, getting their energy from the process of photosynthesis.

Finally, some archaea form mutualistic relationships with other organisms, allowing both the archaea and the other organism to benefit. Like bacteria, many archaea help with digestion. As far as we know, there are not archaea that are parasites.

Archaea Reproduction

Archaea always reproduce asexually. They can produce using binary fission, like bacteria. They also can produce through a process known as **budding**. In budding, a small appendage, or "bud" grows on top of the parent organism. Once this organism is fully developed, it breaks off and becomes its own organism.

Figure 14 – An organism undergoing budding develops a "bud" which eventually becomes its own organism.

Archaea also reproduce through fragmentation, where pieces of the cell break off to form new cells. In all these cases, the offspring has the same DNA as the parent, making it genetically identical.

Where are Archaea Found?

Perhaps the most amazing thing about archaea is where they are found. Quite simply, archaea can be found in places that scientists thought, for many years, no living thing could possibly live. Their homes are some of the most extreme places on the planet, and they have found a way to survive there.

Thermophiles

"Therm" means heat. (Think about the words thermometer or thermostat.) "Phile" refers to loving something, so archaea who are **thermophiles** love heat, and live in incredibly hot environments. You might think this would be an environment like the desert, but we're actually talking about places like hot springs, geysers, and the areas near volcanoes, where the temperature gets close to 100 degrees Celsius. Just to give some perspective, the hottest temperature ever recorded was 57.8 degrees Celsius, in El Azizia, Libya in 1922.

Figure 15 – The hot springs in Yellowstone National Park were one of the first places archaea were discovered.

Halophiles

Other archae live in similarly strange places. The Dead Sea in Israel got its name because it was assumed that the sea was so salty that nothing could survive in it. However, archaea called **halophiles** have been found alive and well in this salty environment.

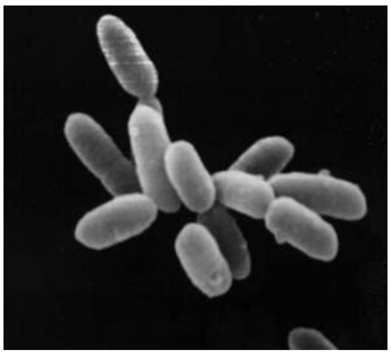

Figure 16 – Halophiles like these halobacteria live in very salty waters such as the Dead Sea or Utah's Great Salt Lake.

Methanogens

Still other archaea, called methanogens, live in swamps, and in the guts of termites and cows. Those living inside the cows help the cow by breaking down cellulose, a tough carbohydrate made by the plants eaten by the cow. If you identified this as an example of mutualism, you are absolutely right!

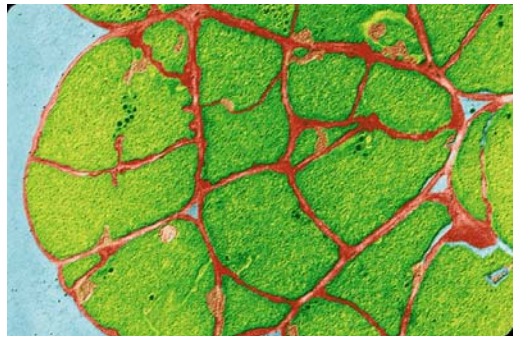

Figure 17 - *Methanosarcina rumen* can be found in the gut of cows, where it breaks down cellulose.

Methanogens get their name from the waste product they produce, a compound called methane. These organisms make methane when they use hydrogen gas to obtain energy. Since methane is a greenhouse gas, methanogens contribute to global warming. Scientists studying climate change are very interested in the methane levels of swamps where methanogens live.

Although archaea are known for the unusual places they live, some live in much less extreme places. Recent studies have shown that archaea can be found in soil and living along with plankton in the ocean.

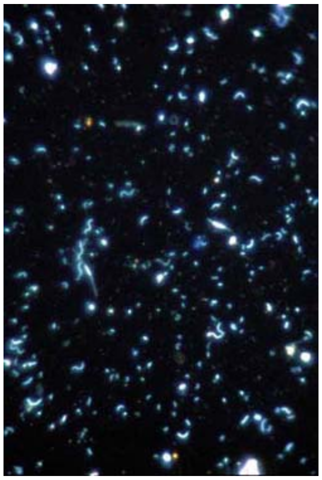

Figure 18 – This microscopic image of the ocean shows many types of plankton, including those classified as plants, animals, bacteria, and archaea.

Conclusion

The prokaryotes, bacteria and archaea represent an amazingly diverse group of organisms only visible when one looks under a microscope. These single-celled organisms obtain energy and reproduce in a variety of ways, although all engage in asexual reproduction.

Though some bacteria are harmful, causing disease, many are very helpful, providing the nitrogen we need to live and aiding in digestion. Archaea have been found in some of the most extreme environments on the planets, including environments that are remarkably hot or salty.

Lesson 2: Fungi & Protists

Introduction to Fungi

If you have ever seen mold growing on an old loaf of bread or eaten a mushroom, you have encountered a fungus. Fungi (that's the plural of fungus) are a group of **organisms**, or living things, that are all around us.

Figure 1 – Mold on bread and mushrooms on pizza are both examples of fungi.

Fungi have an important job. They help break down other material, so that living things are able to grow in soil. This helps make nutritious foods for other organisms. Fungi are needed for life!

What Exactly Are Fungi?

You just read that mushrooms are one example of fungi. Did you think mushrooms were plants? If you did, don't feel bad. For many years, scientists thought that all fungi were plants. Now they know that there are some very important different between these two groups of organisms. One of the most important differences is that plants are **autotrophic**. This means that they can make their own food, just by using the sunlight. Fungi can't do this. They have to "eat" other living things in order to get the energy they need. This is called being **heterotrophic**.

Another difference between plants and fungi is that fungi have cell walls like plants do, but their cell walls are made of **chitin**. Chitin is a material containing nitrogen that is also found in the shells of animals including beetles and lobsters.

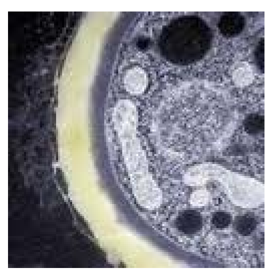

Figure 2 – The cell wall of a fungus is made of chitin.

Finally, fungi do not have a vascular system, the system used to transport water and nutrients in plants, but do have hyphae, a structure you will learn about in the next section.

Although mold and mushrooms are easy to see, most fungi are a lot harder to see. Some are so small they can only be seen with a microscope.

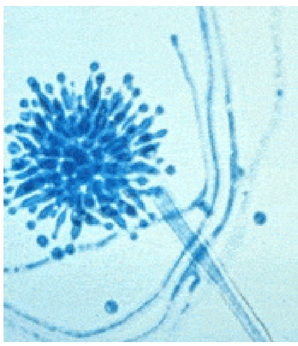

Figure 3 – This microscopic fungus can cause diseases.

Others are big enough to see, but live in places that make them hard to find. For example, some fungi live deep in the soil, in decaying logs, inside plants and animals, or even inside or on top of other fungi!

Figure 4 – A rotting log can be a good location for finding fungi

Fungus Body Parts

Fungi have a **cell wall**. The cell wall acts as protection for the cells of the fungi from destruction. Fungi also have **hyphae**. These are thread-like structures which are connected to each other and bunched up. Bunched up hyphae are called **mycelium.** Mold on a piece of food or on a rotting piece of wood are really mycelia (that's the plural of mycelium.

Figure 5 – These rotting strawberries are covered with *Rhizopus* mycelium.

Mycelia absorb nutrients from other organisms they are living in or on, called **hosts**. Fungi also have special structures for reproduction. One example of this is a **fruiting body**. Fruiting bodies produce **spores**. These are the basic unit of reproduction in fungi, and will be discussed later in this section.

Symbiotic Relationships and Fungi

Every organism interacts with other organisms every day. These interactions can be helpful, harmful, or have no effect at all. Think about some of the interactions you have had with other organisms. If you've ever been sick with strep throat, you and some bacteria had a harmful interaction. If you pet a dog while you were walking down the street, you had an interaction that probably had no effect at all. If you sat in the shade under a tree when you were hot you had an interaction that was helpful to you.

Many fungi have relationships that are helpful to them. These relationships, and any relationship in which at least one organism benefits, are called **symbiotic** relationships. A true symbiotic relationship however, is very different that the relationship between you and the tree in the example above. First, your interaction with the tree was very brief. Second, although it's always nice to relax under a tree, you didn't actually *need* to sit under it. In a true symbiotic relationship, the two organisms spend their entire lives together, and it is often very difficult, or even impossible, for one of the organisms to survive without the other.

We said earlier that in symbiosis one of the organisms benefits, but what about the other one? Does it benefit too? The answer to this very important question helps determine what type of symbiosis it is. In **parasitism,** the other organism is harmed. In **commensalism,** the other organism is unaffected, and in **mutualism** the other organism benefits as well. Look at the examples below for some examples of the types of symbiosis.

Figure 6 – These fungi have a parasitic relationship with the horse whose leg is pictured, causing a severe infection

Figure 7 – The moss in this picture benefits from sunlight, while the tree is unaffected, an example of commensalism.

Figure 8 – Many fungi, like this sticky white mushroom called *Amanita thiersii,* have mutualistic relationships with the plants around them. Read more about this relationship below.

Fungi and Mutualism

As shown in the figure above, fungi grow close to the roots of many plants. The plant and the fungus help each other out by "feeding" each other. The plant undergoes the **photosynthesis**, a process in which sunlight is changed to the sugars glucose and sucrose.

Fungi need these sugars to survive, and the plants provide this needed energy source. (Remember that fungi are heterotrophs, so they can't make the energy on their own.) In return for the food, the fungus provides minerals and water for the roots of the plant. This is mutualistic symbiosis because each organism benefits from being around the other one, and provides something in return.

Another interesting example of mutualism are lichens. Lichens are crusty, hard organisms that can be found on trees, walls, logs, and rocks. What makes lichens so unique is that they are really two organisms in one. Cells from an algae or bacteria live inside of a fungus. Both organisms provide nutrients for the other. Their relationship is mutualistic.

Figure 9 – Lichens like this one are an example of mutualism between bacteria or algae and fungi.

A final example of mutualism amongst fungi involves certain species of ants and termites. The ants and termites grow fungi in underground “fungus gardens.” The fungi get a place to live, and the insects get something as well. When the termites or ants have eaten a large meal of wood or leaves, they eat fungus to help with the digestion of cellulose, a hard to digest protein found in plant material.

Figure 10 – These leaf cutting ants bring back leaves to grow a “fungus garden.”

Fungi as Parasites

Not all symbiotic relationships involving fungi are mutualistic. As you saw in figure six above, sometimes a fungus benefits at the expense of another organism, making it a parasitic relationship. Dutch elm disease is one example of such a relationship. Trees are infected with a fungus, and lose the ability to gain water. As a result of the lack of water, the tree quickly dies.

Figure 11 – This tree has been struck with Dutch Elm Disease and has lost its ability to take up water.

In humans, fungi are responsible for diseases such as athlete’s foot and ringworm. In both these diseases, fungi feed on the moist, outer layer of human skin.

Fungi as Predators

We’ve been using mushrooms and mold as examples of fungi, so you might get the idea that fungi don’t do all that much activity, and certainly don’t hunt for their food. The truth is that there are some fungi that are predators, hunting mainly nematodes. Nematodes are small worms, and serve as a food source for some fungi. In these fungi, the hyphae act almost like arms and legs. The fungi make a circle with their hyphae with a lure inside of it, trapping the nematode in these sticky body structures.

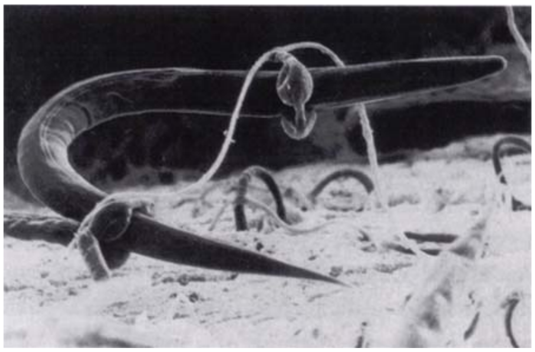

Figure 12 – This nematode is being trapped by the mycelium of a predatory fungus.

Reproduction in Fungi

There are two types of reproduction, and fungi engage in both of them. In **asexual reproduction**, the first type, only one parent is required. In one form of asexual reproduction, involving spores, thousands of spores are released from a puffball fungus in a giant "puff." These spores then create new fungi.

Figure 13 – This puffball fungus is releasing spores.

Budding is another type of asexual reproduction carried out by fungi, in which the fungus grows part of its body, which eventually breaks off. This broken off piece eventually becomes a new organism.

A final form of asexual reproduction is mycelial fragmentation. In this form, the mycelia split off, eventually forming a new organism.

The second form of reproduction, **sexual reproduction**, requires two parents. It involves cells called **diploid** cells, that have all of the genetic material of the organism, and **haploid** cells, which have only half of this information. Sperm and egg cells are examples of haploid cells in animals.

In animals and plants, two haploid cells come together to form a diploid cell, which eventually becomes the new organism. But fungi do things very differently. In fungi, two haploid cells fuse to two other haploid cells, making four haploid cells. This structure then splits, producing an “adult” organism that has haploid cells. This is not something that is seen in any other group of organisms.

Roles of Fungi

Scientists have estimated that there are 1.5 million species of fungi, and these organisms live all over. Most are found on land, although some do live in water. Some fungi can even live in deserts. No matter their environment, fungi act as **decomposers.** This means that the fungi break down materials to make their environment better for other organisms to grow.

Humans use fungi for many purposes. One of the most common uses is in food. Mushrooms are eaten by many people on pizza or in salads. But yeast is used in the fermentation process to make beer, wine, and bread.

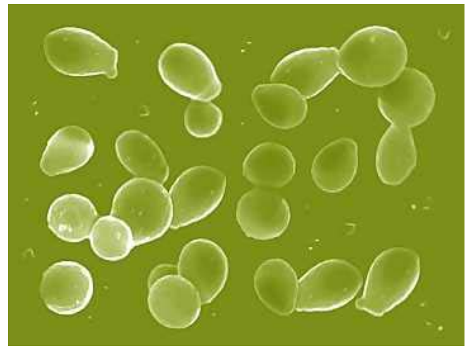

Figure 14 – These yeast are used in the production of wine.

Fungi are also important in the production of some antibiotics, including penicillin and the chitin in cell walls has been said to have wound healing properties.

Introduction to Protists

If your kitchen is like most kitchens, you probably have cabinets for cups and pots and pans, along with drawers for silverware and cooking utensils. You might also have a drawer you call the “junk drawer.” The things in this drawer aren’t actually “junk.” If they were, you’d throw them away. Instead, things usually get put here because they just don’t fit anywhere else. You might be surprised to learn that the system for classifying organisms has its own “junk drawer.” It’s called the protist kingdom. Its members, like the contents of your kitchen junk drawer, are important, but don’t fit nicely in one of the other kingdoms.

Broadly, protists can be classified as animal-like, plant-like, or fungus-like. It is important to remember that being "animal-like" does not make a protist an animal. Such and organism, like plant-like or fungus-like protists, are members of an entirely different group of living things.

Do Protists Have Anything in Common?

Protists are so different, it sometimes seems like they have *nothing* common. That's not true. For example, all protists are **eukaryotic**, meaning their cell or cells have nuclei.

Also, they prefer to live in aquatic environments. Many protists are parasites. Finally, most (although not all) protists are **unicellular**, meaning they are made of a single cell. One common protist that is *not* unicellular is kelp. In fact, kelp can be over 100 meters long (longer than a football field.)

Figure 15 – Kelp can grow to over 100 meters.

You can see that kelp looks like a plant. In fact, it conducts photosynthesis and has many cells like a plant too. So, why don't we just call it a plant? One major reason is that the cells of kelp are not specialized. Unlike plants or animals, where different cells have different jobs (think about a brain cell versus a blood cell versus a liver cell,) the cells of kelp do not specialize and form tissue. This is another thing that is true of all protists. If they are multi-cellular, the cells are not specialized.

Animal-Like Protists

Animal-like protists are called **protozoa**. Like animals, protozoa can move on their own and are heterotrophic. Some protozoa eat by wrapping their bodies around their prey, creating a "food storage compartment." Toxins are then produced which paralyze the prey, and food moved into the waiting protist.

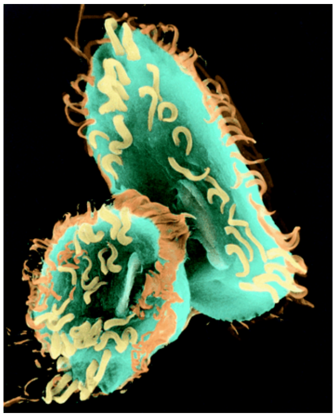

Figure 16 – A larger protozoan is eating a smaller protozoan.

Other protozoa have **flagella**, or tails, that assist in feeding. The flagella whip back and forth creating a current that brings food to the protist. Still other protozoa are parasites, and get nutrients from a host organism, harming the host in the process.

Animal-like protists can be classified, or placed into groups, based on how they move. As mentioned above, some move with the aid of a flagellum (that's the singular form of flagella.)

Others have many small tail-like structures called **cilia** which they move back and forth to get around. Still others have what is known as a "fake foot" or **pseudopodia**. These protozoa have a part of their cell stretch out, which pulls the rest of the organism along.

The amoeba is a common example of this type of protozoan.

Figure 17 – The use of cilia (left) or a false foot (right) allow some protozoa to move.

Finally, some protozoa don't move at all.

Plant-Like Protists

Plant-like protists are similar to plants because they are autotrophic, producing their own food through photosynthesis and releasing the oxygen needed for animals to survive.

These protists can be found in aquatic environments as well as in soil and on the outside of plants.

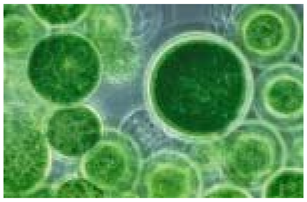

Figure 18 – Algae like these are plant-like protists.

Fungus-Like Protists

Like fungi, the fungus-like protists are heterotrophs with cell walls that produce by creating spores. Most of these types of protists cannot moves. For many years, scientists believed that slime molds were fungi; however they now see that there are enough differences between this organism and true fungi to classify it as a fungus-like protist.

Figure 19 – This slime mold, sometimes called vomit slime mold, is a fungus-like protist.

Lesson 3: Plants

Plants are a crucial part of many environments, from deserts to rain forests, from oceans to plains. They provide animals with food, produce oxygen allowing animals to breathe, and provides shelter from weather or predators for animals. In short, without plants, animals would not be able to survive.

Figure 1 – Besides providing oxygen and food, plants provide shelter for animals.

What are Plants?

All plants have three things in common. First, they are **eukaryotic**. This means that the cells they are made of have nuclei. Second, all plants engage in **photosynthesis.** In this process, plants convert sunlight into energy that plants can use. In this process, the plants take in carbon dioxide, a waste product for animals and release oxygen, which all animals need.

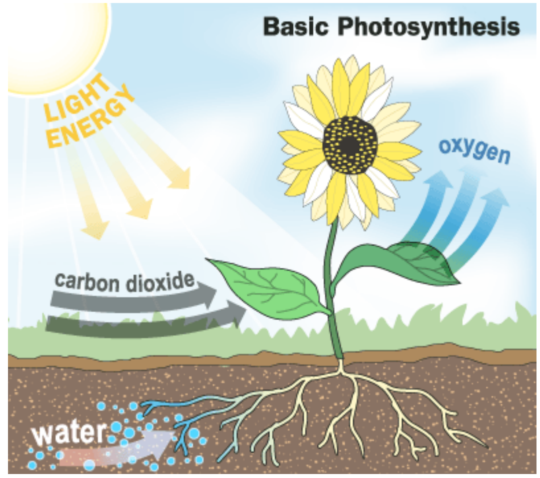

Figure 2 – At the most basic level, photosynthesis involves light energy and carbon dioxide entering a plant and oxygen exiting.

Finally, all plants are **multicellular**, meaning they are made of more than one cell. Specialized groups of plant cells working together form **tissues.** Some protists, including kelp, seem plant like, and kelp is in fact eukaryotic and photosynthetic. The cells of kelp, however, are not specialized, meaning this organism is not a plant.

Plant Parts

When we think about the parts of plants, we often thing about stems, leaves, seeds, or flowers. Many plants have these parts. However a plant does not *need* to have any of these parts to be considered a true plant. So, instead of talking about parts that *all* plants have, we'll talk about parts that *some* plants have. Then, as we talk about different groups of plants, we'll talk about which parts they do or do not have.

Cuticle and Stomata

Many plants have a waxy layer called a **cuticle**. The cuticle helps keep water in the plant, and prevents water loss. However, the cuticle also keeps gases from entering or exiting the plant. This is a pretty big problem, when you think about how important photosynthesis is in plants. Remember that in photosynthesis, carbon dioxide has to come in and oxygen has to go out. So, plants have small openings called **stomata**. Stomata can open when the weather is cool to allow gases in and out. When the weather is hot, stomata close up, conserving water and keeping it from escaping.

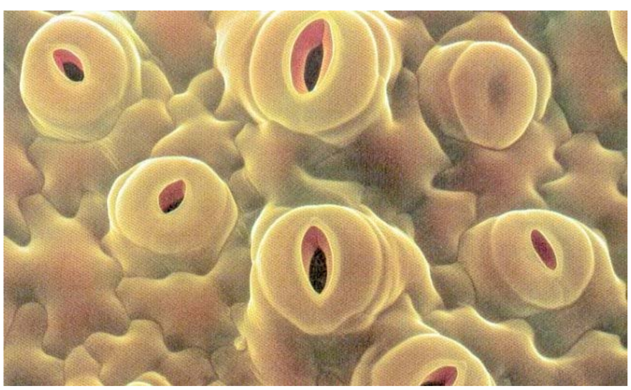

Figure 3 – Stomata can open or close as needed to allow gas exchange but prevent water loss.

Vascular Tissue

Some plants also have tissue designed to move water, nutrients, and food to the places in the plants where it is needed. Plants with vascular tissue have to types of tissue. **Xylem** carries water and minerals. Water goes from the roots to all the other parts of the plants and also replaces the water that plants lose during photosynthesis. **Phloem**, the other type of vascular tissue, mainly carries sugars made during photosynthesis to the parts of the plants that need it.

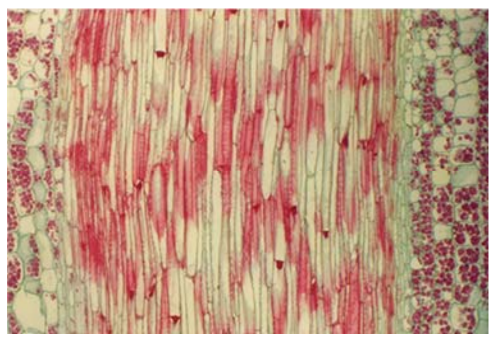

Figure 3 – This view of phloem under a microscope at 100X magnification shows the tissue through which sugars would travel in the plant.

Seeds

At some point in your life, maybe when you were just a few years old, you may have planted a seed and watched with fascination as the roots went down as a plant grew. Seeds are rather remarkable structures. Events like droughts and harsh winters would kill adult plants, but a plant embryo, protected carefully in a seed, can survive these conditions by remaining **dormant**. Being dormant simply means that the seed does not sprout. Seeds will stay dormant until conditions are just right, at which point they will sprout. Some seeds can stay dormant for hundreds of years if that's how long it takes until conditions are right!

Figure 4 – Seeds will stay dormant until conditions are right for them to sprout.

Seeds are extremely helpful in ensuring plant survival. Although not all plants have seeds, they can be found in most of the species that have been highly successful in surviving and reproducing.

Flowers and Fruit

Flowers and fruit generally have the function of attracting animals, which will assist the plant in reproducing, and get something for themselves in the process. When insects visit various flowers, getting sweet nectar, or when various animals eat fruit from a plant, getting nourishment, they help plants reproduce. We'll talk more about the specifics of plant reproduction a little bit later on.

Nonvascular Plants

There are four major plant types, and they are classified based on the structures the plants do or do not have. The **nonvascular plants** do not have vascular tissue. Remember that the vascular tissues, xylem and phloem, move water, minerals, and food to the parts of the plants that need it. Without these tissues, the nonvascular plants do not have true stems, roots, or leaves, (although they have some structures that look like roots, stems, and leaves. They also must be very short, since nutrients cannot go up a stem.

Mosses are one group of vascular plants. These plants are the green "fuzz" you might have seen on damp rocks and trees. A second group of nonvascular plants, the hornworts, tend to grow in moist environments, and a final group, the liverworts, can be found along riverbeds.

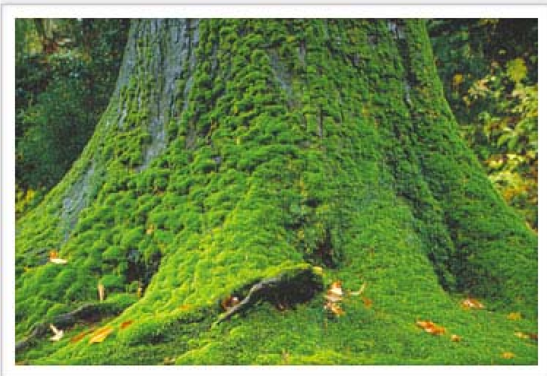

Figure 5 – Moss (top) can be found on the trunks of trees in the forest. Hornworts (center) are found in moist areas. Liverworts (bottom) are found along riverbeds.

Vascular Seedless Plants

Based on their name, you can probably figure out that **vascular seedless plants** have vascular tissues, but don't have seeds.

With xylem and phloem bringing water, minerals, and food up to the parts of the plants that needed it, these plants had the ability to grow very tall. Many of did, but the large vascular seedless plants are mostly extinct now. Those vascular seedless plants that remain tend to be small. Ferns are the most common of this group of plants. They are found in environments ranging from aquatic areas to tropical rainforests. Other vascular seedless plants are shown below.

Figure 6 – The club moss (upper left), fern (upper right), horsetail (bottom left), and whisk fern (bottom right) are vascular seedless plants.

Some seedless plants are used by people today. *Sphagnum*, or peat moss, is used to improve soil, because it has the ability to absorb water and hold it in. Ferns are found in many gardens and even in some foods.

Gymnosperms

Gymnosperms have seeds, but they are considered "naked" seeds, because they are not enclosed by fruit. Instead of fruit, the seeds of gymnosperms are usually found in cones. The most common group of gymnosperms is the conifers, which include pines, firs, spruces, cedars, and coastal redwoods. Conifers are an important source of lumber, paper, and the resin used by baseball players to keep their grip or by musicians to increase the friction between the bow and stringed instruments.

Figure 7 – The California Redwoods, a species of gymnosperms, are the tallest living vascular plants.

The gnetophytes, another group of gymnosperms, include the plant *ephedra*. This plant is used to make ephedrine, an important medicine used to treat diseases including asthma.

Angiosperms

Angiosperms, or flowering plants, are by far the most common type of plants. Angiosperms all have flowers. Although all flowers are different, they do have some things in common. The structure on the outside of the flower is called the **sepals**. Sepals are usually green, and cover the flower until it opens. Inside the sepals are the petals, which all together are known as the **corolla.** These are often bright, and designed to attract animals. Inside the petals are the male and female parts of the plant. These will be discussed later, when we talk about plant reproduction. Flowers with all these parts are called **complete flowers.** Those without all of them are called **incomplete flowers.**

Figure 8 – Angiosperms are plants with flowers.

The most obvious importance of angiosperms for animals, including humans, is as a source of food. Corn, potatoes, peanuts, and beans all come from angiosperms. All fruit is from angiosperms. Besides food, angiosperms are the source of other important products. Cotton for cloth and hardwood trees for lumber also come from this very common group. No other group of plants is more important for people and other animals.

Plant Reproduction

Think about animal reproduction for a moment. A parent has an offspring who looks pretty similar to them. Sure, they may be smaller when they are first born, but animal offspring are pretty much the same as their parents. This is not true in plants. In fact, plants undergo a process known as alternation of generations, in which the offspring are dramatically different than the parents.

In order to understand plant reproduction, it is important to understand **chromosomes.** Chromosomes are the places in the cells where genetic information, or DNA, is found. When a new organism is formed, information from the chromosomes of the parents or parents is passed on to the offspring. These chromosomes help determine many of the characteristics of the offspring.

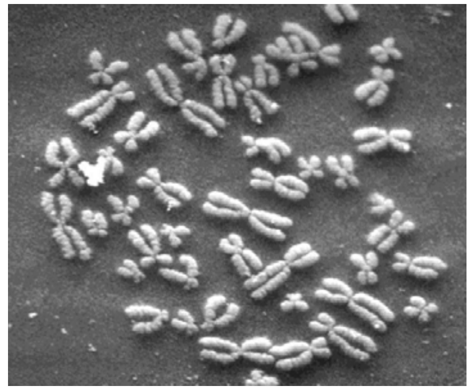

Figure 9 – Chromosomes determine many of the characteristics of living things.

Plants have two types of generations. The first generation is **gametophyte** generation. Gametophytes are **haploid**. This means that the plant has only one set of chromosomes. The gametophyte produces the cells needed for reproduction, called **gametes**, sperm and egg, through a process known as **mitosis**. In mitosis a cell splits into two cells, each of which has the same number of chromosomes as the original cell. So, since gametophytes are haploid, gametes are haploid too.

Next, the sperm fertilizes the egg, producing an offspring. This offspring is referred to as the **sporophyte** generation. Since the sporophyte is created from the combination of two haploid cells, it has two sets of chromosomes.

Cells that have two sets of chromosomes are called **diploid**.

The sporophyte now undergoes a process known a **meiosis**, in which a cell divides to form cells with half the number of chromosomes. Through meiosis, the diploid sporophyte produces haploid **spores.** Spores undergo mitosis producing a haploid gametophyte, and the process begins again.

Plants typically do not spend the same amount of time in the sporophyte and gametophyte generations. Some plants are mainly sporophytes, while others are mainly gametophytes. Plants with flowers are mainly sporophytes, with the female gametophyte remaining in the sporophyte, and with pollen as the male gametophyte.

Reproduction in Seedless Plants

Plants reproduce differently depending on which group they belong to. Seedless nonvascular plants can reproduce **asexually**, meaning only one parent is necessary.

Hornworts and liverworts can both undergo **fragmentation,** where a small bit of the plant is broken off, eventually forming an entirely new plant. These plants can also reproduce **sexually,** meaning two parents are involved.

For nonvascular plants, the gametophyte generation is most important, and when most people talk about the plant, they are talking about the gametophyte generation. The male gametophyte produces a sperm with a tail called a **flagellum**. The sperm must swim to the egg made by the female gametophyte.

For this reason, sexual reproduction in nonvascular plants can only happen in moist environments. Once the sperm reaches the egg, it forms a sporophyte. The sporophyte is dependent on the gametophyte and only exists to make spores so that a new gametophyte can be formed.

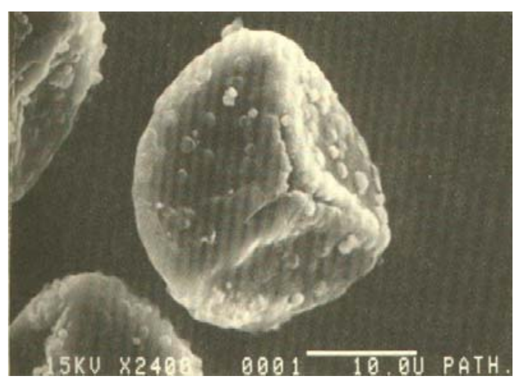

Figure 10 – The spore of nonvascular plants (seen here under magnification) produces a new gametophyte.

Like nonvascular plants, the sperm of the vascular seedless plants must swim to the egg. However unlike nonvascular plants, in vascular seedless plants, it is the sporophyte that is dominant. If you have ever admired a fern in someone's yard, the plant you are admiring is a sporophyte.

Seed Dispersal

If a plant has seeds, the seeds must be dispersed, or spread out. If is helpful for a plant to spread its seeds out as far as possible, so that its offspring can spread in many areas and not compete with each other for resources. Plants have developed many ways to make sure their seeds are spread out.

Some plants allow the wind to carry their seeds. If you've ever blown on the puff of a dandelion, you've seen an example of this. Some other plants, including pine and maple, have seeds with wing-like structures on the bottom to help them travel in the wind.

Figure 11 – The "wing" shape of the maple leaf inspired engineers.

Another common strategy for seed dispersal is the development of fruit. Fruit is meant to be tasty to animals. The animal takes the fruit from a tree in one location and eats it as it walks.

At some point, the animal either drops the seeds onto the ground (if they are not edible) or releases them in its feces (if they are edible.)

Either way, the seeds come out and are now a pretty good distance away from the parent plant. When we think of fruit, we think of things we can eat, but **burrs** are actually also fruit. These structures are designed to stick to animal's fur, and be just annoying enough that the animal scratches them off some distance from the parent tree. If you've ever gone hiking, you might have found a burr in your sock. Who knows, maybe you even helped a plant reproduce.

Reproduction Involving Flowers

Many people have admired the beautiful colors and smells of flowers, and this is no accident. The whole point of many flowers is to be attractive to animals, generally insects, to help in reproduction.

Pollen, the male gametophyte, is found in many flowers. The **stigma**, the female part of the flower, needs pollen in order for reproduction to occur.

Often plants will **self-pollinate**. This means that the pollen of a plant will fall onto the stigma of that same plant. Other plants, however, will **cross-pollinate**. This means pollen from one plant falls into the stigma of another plant's flower. Some flowers rely on wind to spread their pollen.

Figure 12 – Pollen from some flowers is spread by the wind.

Pollen in the air spread by the wind can cause problems for people who have allergies.

Other plants rely on animals to spread their pollen. These plants are the ones with the beautiful colors and smells, designed to attract insects and other animals to them. As the insects go from plant to plant, they spread pollen from one flower into the stigma of another. The insect collects sweet nectar as a "reward" as it goes from flower to flower.

Figure 13 – In cross-pollination, plants rely on insects or other animals to spread their pollen.

Plant Responses

Just because plants don't usually move on their own doesn't mean they don't interact with their environment. In fact, plants take many actions depending on things like sunlight, the season, and even the presence of other plants. Plants, like animals, contain chemicals called **hormones**. Hormones travel through the plant from cell to cell, instructing the organism to exhibit some behavior in response to what is going on in the outside world.

Plant Hormones

Ethylene is a plant hormone involved in the ripening of fruit and the dropping of leaves, fruits, and flowers. When a piece of fruit is ripe, or a flower has finished blooming, ethylene is released to make it fall. Unlike most hormones, ethylene is a gas, so it can travel through the air from one fruit to another, ripening all of the nearby fruit. (See the lab activity "Two Bananas are Better than One" for more on this.)

Gibberellins are growth hormones. They signal plants to grow taller, and signal to a seed that it is time to stop being dormant and grow. Gibberellins are sometimes given to decorative plants so they will grow taller.

Cytokinins are hormones that increase cell division, and prevent the aging process. For this reason, florists sometimes add this hormone to cut flowers. Abscsisic acid closes the stomata and maintains dormancy. Finally, auxins do many things, including making the main stem of the plant dominant over other stems that may grow along the sides of the plant.

Figure 14 – Bonsai trees like this one are unusually small because they have an unusually low amount of gibberellins.

Conclusion

Plants are a tremendously diverse group of organisms. Some, such as the nonvascular plants have no tissues for carrying water or minerals, and must keep a small size. Others have such tissue, but no seeds. Still others have seeds or flowers, and have developed ways to reproduce by spreading their seeds or attracting animals to pollinate them. Plant reproduction consists of alternation of generations, with the plants alternating between gametophyte and sporophyte. Hormones in the plants cause changes based on the environment.