Prokaryotes Reading

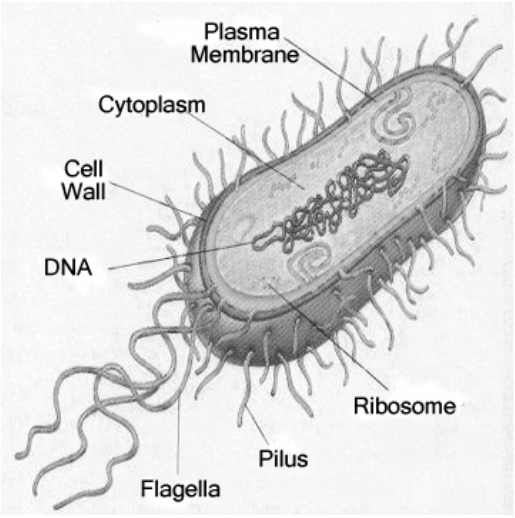
Did you ever wonder what happens to all the leaves that fall from the trees every autumn? In a few years if they just piled up, the leaves in the woods would be knee-deep, and eventually they would cover the trees themselves!!! This does not happen because the leaves decompose after they fall from the trees. Many bacteria (with fungi) break down the leaves. Bacteria are all around us. Some are helpful like the ones that break down the leaves but some are harmful and cause disease like strep throat.

Bacteria

Imagine yourself going back in time 3.5 billion years. You wander around the young Earth and find yourself face-to-face with the first life on this planet. Dinosaurs? Saber-toothed tigers? No. You would be face-to-face the most ancient and diverse form of life on Earth: bacteria.

Characteristics of Bacteria

Bacteria are classified into two very different kingdoms-Archaebacteria and Eubacteria. All bacteria have the same basic structure. Look at the picture to the left as you read each part.



Like all cells, bacteria have a **plasma membrane** that controls what can enter and leave the cell. The plasma membrane is surrounded by a **cell wall.** The cell wall gives the bacteria shape and support. Certain kinds of bacteria have yet another coat around the cell wall. Its called a capsule. The capsule is a thick and sticky overcoat that some bacteria have. Because the bacteria that have a capsule usually cause disease, scientists think the capsule helps the bacteria to stick to its host.

Some bacteria have one or more **flagella** sticking out of the plasma membrane. The flagella are used to move the cell around. Bacteria also have a circular piece of **DNA** instead of a nucleus proper. They also have many **ribosomes** which make proteins for the bacteria. The bacteria also have one or more **pili (singular = pilus)** sticking through the cell membrane. Bacteria use the pilus to trade pieces of its DNA with other bacteria.

There are lots of differences between the Archaebacteria and the Eubacteria.
They are:

1. Their cell walls have different structures
2. The lipids in their plasma membranes are different.
3. The their tRNA and rRNA bases are different.
4. They react differently to antibiotics.

Archaebacteria and Eubacteria probably split from each other several billion years ago, but nobody knows exactly when.

Archaebacteria – the extreme bacteria

The Archaebacteria include three types of bacteria that are found mainly in extreme habitats where little else can live.

- One group lives in oxygen-free environments and produces methane. This group of Archaebacteria are called **Methanogens**.
- A second group can live only in bodies of concentrated salt water such as the Great Salt Lake in Utah and the Dead Sea in the Middle East. These are the **extreme halophiles**.
- The third group is found in the hot acidic waters of sulfur springs. Members of this group are called **thermoacidophiles**.

Eubacteria- all the other bacteria

Eubacteria, the second main group of bacteria, live in lots of different habitats and have different types of metabolism. Some characteristics of eubacteria are:

- Bacteria are the smallest and simplest of living things.
- Bacteria are also prokaryotes, which means they have no membrane-bound organelles like a nucleus, mitochondria, or chloroplasts.
- Their ribosomes are smaller than those of eukaryotes.
- Their inherited information is held in a single circular chromosome, rather than in paired chromosomes.

Some examples of eubacteria are streptococcus which causes strep throat, *e. coli* which helps us digest our food, and *Streptomyces erythraeus* which produces the antibiotic streptomycin.

Name:_____
Date:_____

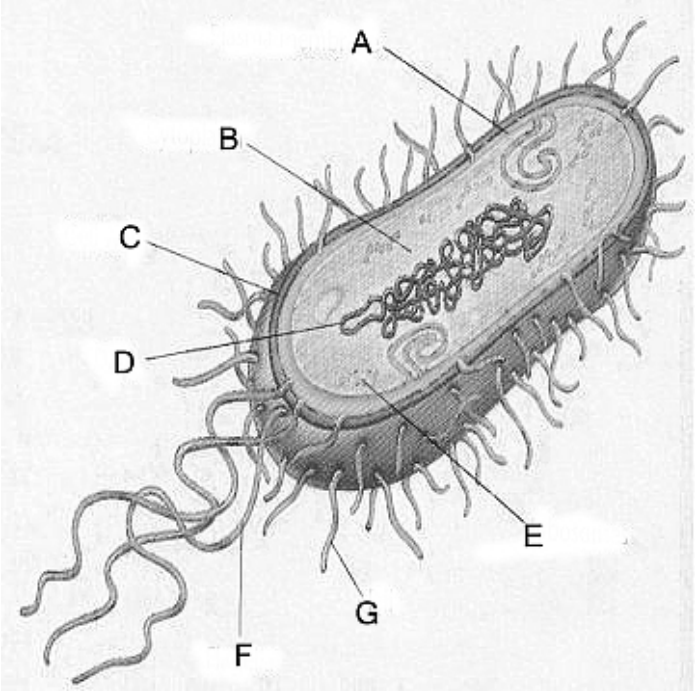
Bacteria Review Worksheet 1

1. If you were able to go back in time 3.5 billion years ago, what is the only living things you would find?

2. What are the two kingdoms of bacteria?

   a. b.

3. Label the parts of the bacterium in the picture below.



A.	E.
B.	F.
C.	G.
D.	

4. Name 3 differences between Archaebacteria and Eubacteria.
   a.

   b,

   c.

5. Fill in the missing information in the table below about the parts of a bacteria and what they do.

Part of a Bacteria	What it does
A.	controls what enters and leave the bacteria
Cell Wall	B.
C.	sticky covering outside the cell wall that helps disease causing bacteria stick to its host
Pili	D.
E.	circular piece of genetic information that keeps the information needed to run the cell
Ribosome	F.
G.	Movement

6. Name the three groups of Archaebacteria.

a. b.

c.

7. Name 3 characteristics all Eubacteria have.

a.

b.

c.

8. Where do each of the following Archaebacteria live?

a. thermoacidophiles -

b. methanogens -

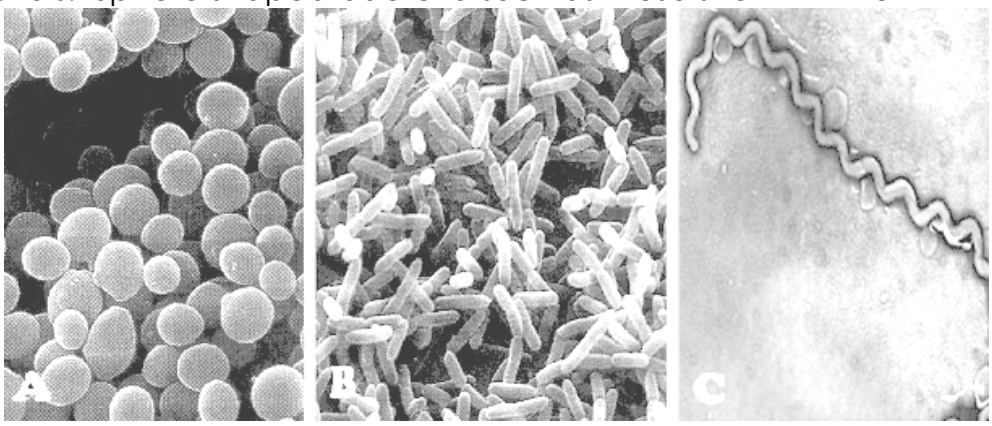
c. extremehalophiles -

Classification of Bacteria

Eubacteria can be classified several different ways. Bacteria can be grouped by shape, by energy source, and by membrane structure.

1. By Shape

The first way we will classify them is by shape. The three most common shapes are spheres, rods and spirals. Sphere shaped bacteria such as those shown in the A section of the photo to the right are called **coccus** (pl. is cocci) bacteria. They usually have coccus in their name like streptococcus. Another group in the shape classification system is the **bacillus** (bacilli =plural). These bacteria are rod shaped. These bacteria are pictured above in B. The third group is the **spirillum** (spirilla plural). These are the corkscrew shaped bacteria. These bacteria are pictured above in C.



Because scientist wished to give as much information as they can when naming bacteria, scientist use their shape as well as if they are found in pairs, chains, or clusters.

If they are found in pairs, adding the prefix **diplo-** to their shape forms the name. An example is diplococci (a sphere shaped bacteria that is found in pairs).

If the bacteria are found in chains, the prefix **strepto-** is added to their shape (ex. streptococci = long chains of sphere shaped bacteria).

Bacteria that are found in grapelike clusters have the prefix **staphylo-** added to their shape (ex. staphylobacilli = grapelike clusters of rod shaped bacteria).

2. By cell walls makeup

The second way to classify bacteria is by the structure of their cell walls. Bacteria cell walls come in three varieties, **gram +, gram -**, and **mycoplasmas**. It would seem not all cell walls are created equally. The differences in what makes up the cell wall can be shown by a procedure called gram staining.

The steps in the gram staining procedure are:

1. Bacteria are stuck to a slide
2. They are stained with a purple dye solution called **crystal violet**.
3. The purple dye is washed off with water
4. A solution of iodine is added to the slide.
5. The bacteria are rinsed with alcohol and then restained with a pink dye called **safranin**.

Bacteria with a thick outer layer with protein in it in their cell walls will stain purple and are called **gram positive**. **Gram-negative bacteria** have cell walls that are made a

weird lipid outer layer. The lipoprotein layer does not hang onto the purple stain so it gets washed away. This layer, however, does hand onto the pink safranin so gram-negative bacteria appear pink after gram staining.

The third type of bacteria does not have cell walls at all and are called **mycoplasmas**. Instead of cell walls, these bacteria have a triple layered membrane made of lipids. These organisms are considered the simplest of the simplest organisms. Scientist think the first organisms on earth were very much like. These bacteria cause certain types of pneumonia in humans and cattle. The problem with mycoplasmas is penicillin doesn't work on them. Penicillin kill bacteria by stopping the growth of the cell wall. That doesn't work with these little charmers since they do not have a cell wall. If you get a type of pneumonia that is caused by a mycoplasma, you will just have to get over it.

3. By how they get their energy

The third way bacteria are classified is by how they get their energy. Some of these terms should sound familiar since we had some of them when we were studying ecology. They are broken up into three groups.

1. The first group is the **heterotrophs**. These bacteria get their energy by decomposing other organisms. These bacteria have a huge roll in recycling materials in an ecosystem.

2. The second group is the **photosynthetic autotrophs**. Before you have a large word freak out, this group is not as scary as its name. These bacteria are able to change sunlight into food (that's the photosynthetic part) all by themselves (that's the autotroph part). These bacteria are important because they are the producers in almost all aquatic ecosystems. They capture the sunlight and change it into energy the consumers in the ecosystem can use.

3. The third group is the **chemosynthetic autotrophs**. This group can make their own energy but instead of using sunlight to do it they use chemicals around them. These bacteria are important in changing the nitrogen in the atmosphere that we can't use into a form that we can use to make proteins.

Name:_____
Date:_____

Classification of Bacteria Review

1. Name the three ways bacteria are classified.

a.

b.

c.

2. How do heterotrophs get their energy?

3. Why are photosynthetic autotrophs important to the ecosystem?

4. What color do gram positive bacteria stain when you are using the gram staining procedure?

5. What do diplospirillum bacteria look like?

6. What shape do bacillus bacteria have?

7. How do chemosynthetic autotrophs get their energy?

8. What color do gram negative bacteria stain?

9. Why are chemosynthetic autotrophs important to an ecosystem?

10. What to staphylobacillus bacteria look like?

11. Why don't mycoplasmas stain with gram stain?

12. What do streptococcus bacteria look like?

13. Why are heterotrophs important to the ecosystem?

14. What are the three groups all bacteria fit into if you are grouping them **based on how they get their energy?**

a.

b.

c.

15. What are the three groups all bacteria can fit into **if you are grouping them based on shape?**

a.

b.

c.

Miscellaneous Bacteria Info

Some of the oldest known fossils are of bacteria. These organisms lived on Earth when it had a climate and atmosphere very different from those of today. Some of these fossils contain substance similar to chlorophyll and were among the first producers. As Earth's atmosphere got more oxygen, these bacteria evolved adaptations that allowed them to survive in the changing environment.

Some bacteria, when faced with bad environmental conditions produce structures called **endospores**. Endospores have a hard outer covering and are resistant to drying out, boiling, and many chemicals. While in the endospore form, the bacterium is in a state of hibernation, and it does not reproduce. When condition are again right, the endospore germinates and starts to grow and reproduce. Some endospores have been found to germinate after thousands of years.

Endospores are a great help for bacteria. Because endospores can survive boiling, canned foods and medical instruments must be sterilized under high pressure. This can be done either in a pressure cooker or in an autoclave. When water is boiled under high pressure, it is hotter than the normal boiling point of water. This great heat and high pressure kill endospores.

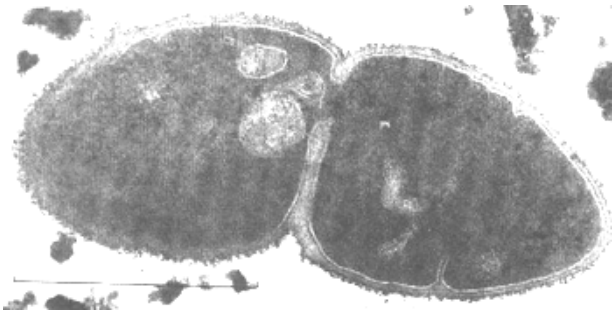
The clostridia are a group of bacteria are anaerobic (must live in an environment that is free of oxygen). One member of this group, *Clostridium botulinum*, produces an extremely powerful poison. Instead of dying when exposed to oxygen, *Clostridium botulinum* forms endospores. These endospores can find their way into canned food. If the canned food has not been properly sterilized, the endospores will germinate and the bacteria will grow and produce their deadly toxin. Although the resulting disease, botulism, is extremely rare, it is often fatal.

Another member of the clostridium group produces a nerve toxin that causes the often-fatal disease, tetanus. This bacteria *Clostridium tetani* is pictured to the left. Because endospores of *C. tetani* are found on nearly every surface, they can easily enter a wound. A puncture wound can introduce the *C. tetani* into the body. The endospores germinate in the wound, and the bacteria reproduce in great numbers. The bacteria produce a toxin, which enters the bloodstream and attacks the nerve cells in the spinal cord. Fortunately, there is an immunization for tetanus. You received this shot as a child. A booster shot is given as a precaution after a puncture wound. Deep wounds are hard to clean and provide ideal conditions for growth of the tetanus bacteria.

Reproduction

Bacteria cannot reproduce by mitosis or meiosis because they have no nucleus. Instead, they have evolved different methods of reproduction, binary fission and conjugation.

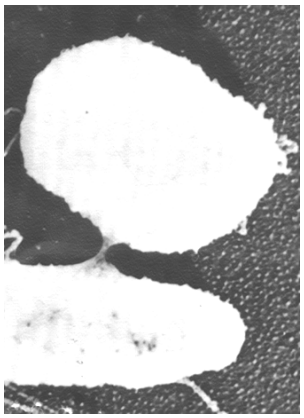
Bacteria reproduce asexually by a process known as **binary fission**. The steps in this process are:



1. The bacterium first copies its single chromosome.
2. The copies attach to the cell's plasma membrane.
3. As the cell grows in size, the two copies of the chromosome separate.
4. The cell then divides in two as a partition forms between the two new cells as shown in the picture to the right.

Each new cell receives one copy of the chromosome. Therefore, the daughter cells have the same information as each other. Bacterial reproduction can be extremely rapid. Under ideal conditions, bacteria can reproduce every 20 minutes. Such a rate of reproduction yields enormous numbers of bacteria in a short time

When you have an infection, billions of bacteria grow in your body. If you are given an antibiotic for the infection, you should take the antibiotic for the full prescribed period—even though you feel better after just one or two days. Shortly after you begin to take the antibiotic, most of the bacteria are killed. However, if you stop taking the antibiotic and even a single bacterium is left, it will start reproducing. A day later, you will have millions of bacteria in your body and you will be sick again. Completing the antibiotic as prescribed ensures that all of the bacteria will be killed so you will not get sick again.



In addition to reproducing by binary fission, some bacteria have a simple form of sexual reproduction called **conjugation**. You will remember that conjugation is not sexual reproduction in the strict sense of the word since there are no specialized sex cells involved. In conjugation, one bacterium transfers all or part of its chromosome to another cell through a bridge like structure called a pilus (pl. pili) that connects the two cells. This transfer of genetic material can be seen in the picture to the left.

Name:_____
Date:_____

Miscellaneous Bacteria Information

1. Name 2 ways bacteria can reproduce.

    a.

    b.

2. What is the term used to describe a bacteria that is in hibernation inside a hard outercoat?

3. How do humans get botulism?

4. What are the 4 steps in binary fission?

    a.

    b.

    c.

    d.

5. What causes tetanus?

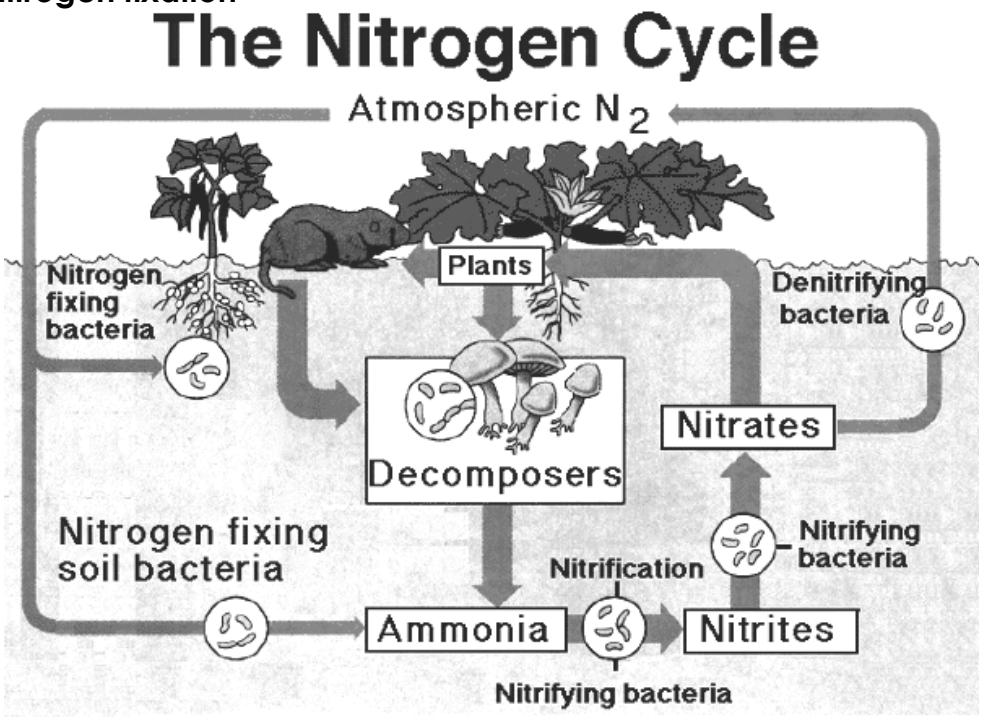
6. Which special structure is used to transfer DNA from one bacteria to another during conjugation?

7. Why do bacteria make endospores?

8. How fast can bacteria reproduce?

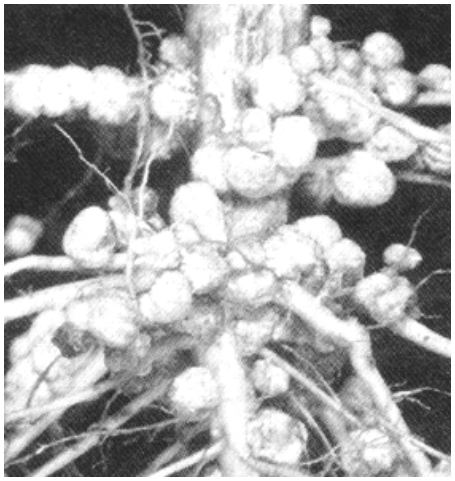
Economic Importance

Nitrogen fixation



As seen in the diagram of the nitrogen cycle to the left, most of the nitrogen on Earth is in the form of nitrogen gas (N_2) that makes up 80 percent of the atmosphere. We can't use this type of nitrogen to make proteins.

Several species of bacteria have enzymes that convert N_2 gas into ammonia (NH_3) in the process known as **nitrogen fixation**. Other bacteria then convert the ammonia into nitrite (NO_2^-) and nitrate (NO_3^-), which can be used by plants. This processes is called **nitrification**. Bacteria are the only organisms that can fix nitrogen. Some nitrogen-fixing bacteria form symbiotic relationships with legumes such as peas, peanuts, and soybeans. Thus The bacteria live in nodules around the roots of the plant. You can see the nodules pictured to the right. The relationship is also an advantage to agriculture. When legumes are grown and then harvested, the remaining roots with nodules add lots of usable nitrogen to the soil. The following season, other crops can be grown in the newly nitrogen-rich soil. This is the basis of crop rotation.



Recycling nutrients

When we studied ecology, you learned that life could not exist if bacteria did not breaks down the organic matter in dead organisms and wastes, returning the nutrients to the environment to be used by producers at the bottom of food chains.

Cyanobacteria, along with plants and algae, replenish the supply of oxygen in the atmosphere. Autotrophic bacteria convert carbon dioxide into the air to the organic compounds that are passed to consumers in food chains and webs. All life depends on bacteria.

Food and Medicines

Because bacteria are so metabolically diverse, different species produce a wide variety of molecules as the result of a process called fermentation. Many of these molecules have distinctive flavors and smells. As a result, the bacteria that produce them are used to make vinegar, yogurt, butter, cheese, pickles, and sauerkraut.

Strains of bacteria have evolved the ability to make chemicals that kill other organisms that are their competition. We take advantage of this by using the chemicals as antibiotics to kill bacteria that are infecting us. Streptomycin, erythromycin, chloromycetin, and kanmycin are some of the antibiotics that are are produced from bacteria.

Bacteria and disease

Although only a few kinds of bacteria actually cause disease, those that do have a great impact on our lives. It is estimated that bacteria cause about half of all human diseases. In the past, bacterial illnesses took a major toll on human populations. As recently as 1900, life expectancy in the U.S. was only 47 years. The leading killers of the time were tuberculosis and pneumonia, both bacterial diseases. In the intervening century, life expectancy has increase to about 78 years. This remarkable increase of about 50% is the result of many factors. People now have better living conditions. We have less poverty. Better public health systems, improved water and sewage treatment, better nutrition and better medical care. These improvements, combined with the presence of antibiotics, have reduced death rates from bacterial diseases to very low levels.

Some of the diseases caused by bacteria are strep throat, tetanus, bubonic plague, leprosy and botulism.

Name:_____
Date:_____

Economic Importance of Bacteria Review

1. Name 2 antibiotics produced by bacteria.

   a. b.

2. What is the process called that changes atmospheric nitrogen into ammonia?

3. Name 4 diseases caused by bacteria.

   a. b.

   c. d.

4. What is the process called that changes ammonia (NH_3^+) into nitrates (NO_3^-)?

5. Name 2 ways bacteria are important to ecosystems.

   a.

   b.

6. Name 4 foods that are made using bacteria.

   a.

   b.

   c.

   d.

7. What are two plants that have bacteria filled nodules that fix atmospheric nitrogen for the plant.

   a. b.