CELL: The Basic Unit of Life

One day a long time ago, maybe 3.5 billion years ago, give or take a couple hundred million years, life happened. It was a simple kind of life—a protein membrane wrapped around a small volume of liquid. A primitive **cell** was born.

When Earth formed 4.5 billion years ago, there was no life. About a billion years later life appeared. Since that first single-celled **organism** appeared on Earth 3.5 billion years ago, life has flourished. Today there are tens of millions of different kinds of organisms living here. As different as life-forms are, however, all living things share one important characteristic: **cells.**

Life happens in cells. It did then and it still does today. Every living thing is composed of cells. The simplest organisms are single cells; the most complex organisms are made of billions of living cells working together. No matter how simple or complex an organism is, it is made of cells, and the cells are alive.

WHAT IS A CELL?

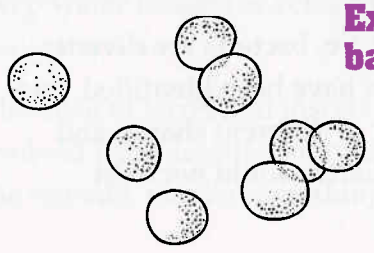
Robert Hooke, the first scientist to report observing cells through a microscope, thought he saw a bunch of little rooms. That's what *cell* means: a little room. We know now that they are much more than little rooms. Cells are chemical factories that run on energy (usually from the Sun), take in raw materials, produce chemical products, and discard waste materials. And most amazing of all, cells can replicate themselves. That means they can reproduce an exact copy of themselves that can do all the same kinds of things. A living cell can produce another living cell. Life keeps itself going.

WHERE DID THE FIRST CELL COME FROM?

Where did the first cell come from? Nobody knows, but scientists have ideas. The ancient sea was full of chemicals, and one thing similar chemicals do is stick together. Some scientists think that chemicals called **amino acids** stuck together and formed little spheres, like amino-acid bubbles filled with water. The amino-acid film that formed the bubble was the ancient cell membrane.

After millions of years of refining the composition of the amino-acid bubble, the membrane acquired the ability to gather amino-acid molecules from the environment and incorporate them into the membrane. This allowed the bubble to grow. When the bubble got big, it elongated and formed two bubbles, each with the ability to gather amino acids and grow. At about this point the bubbles became cells, and the first life-forms had appeared on Earth.

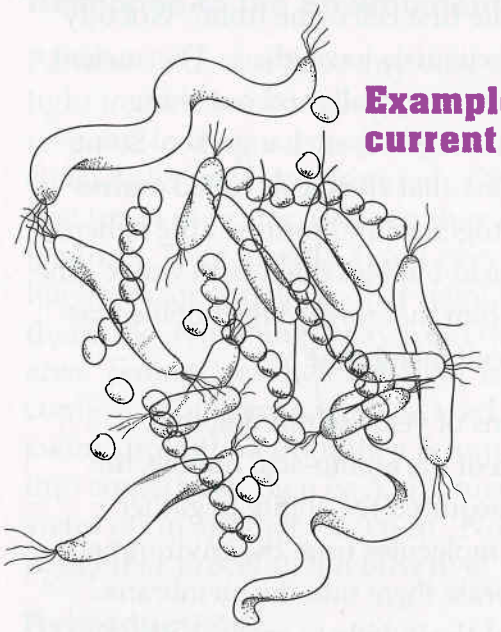
Most of the living organisms on Earth today are not much more complex than the first cells. These life-forms, descendants of the first cells, are **bacteria** (singular, bacterium). They make up one of the kingdoms of life, the **Monera** (moe•NER•uh).



Example of early bacteria

Most bacteria are tiny. They are filled with cell liquid, **cytoplasm** (SY•toe•plaz•um), but don't have organized internal structures. Simple cells with very little organization of the materials inside are called **prokaryotic** (pro•care•ee•AH•tik) **cells.** Prokaryotic cells (bacteria) always live alone as single-celled organisms. Even when the cells of a species of bacteria stick together in masses or strands, they are still living solitary lives.

Example of current bacteria



Some bacteria get energy by producing their own food through photosynthesis. Others take up simple chemicals from the environment or discharge substances that dissolve their food source, and then soak up the nutritious chemicals.

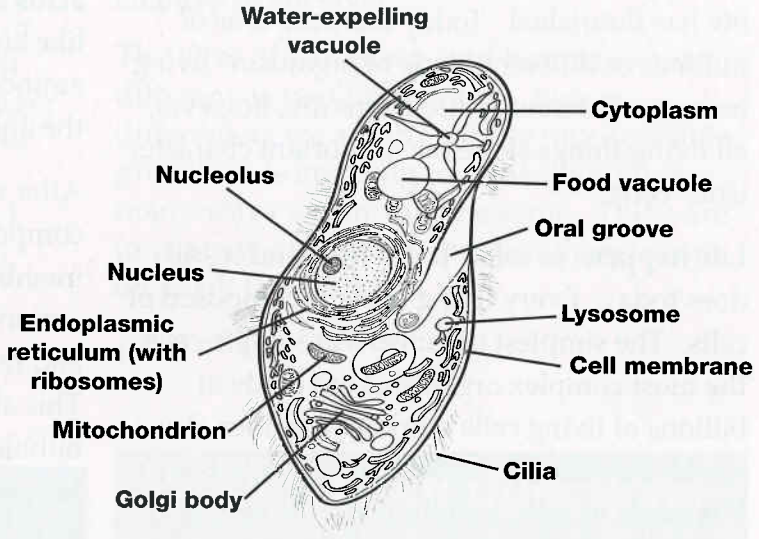
This all happens in an aquatic environment. The aquatic environment might be as large as an ocean or lake or as small as the inside of your mouth or the invisible layer of moisture on your skin.

As simple as they are, bacteria are diverse. Some 8000 species have been identified, and they come in a lot of different shapes and designs. Life on Earth would not exist without bacteria.

A CELL WITH A NUCLEUS

Bacteria were the only life-forms on Earth for about 2 billion years. Then, about 1.5 billion years ago, a new kind of cell appeared. This cell had structures *inside* the membrane. Most important was the cell **nucleus,** the director of cellular activities. The new cells, called **eukaryotic** (you•care•ee•AH•tik) **cells,** also had other organized structures in the cytoplasm called **organelles,** including endoplasmic reticulum, mitochondria, chloroplasts, ribosomes, lysosomes, and more.

Protist eukaryotic cell
(Paramecium)



Each organelle has a specific job to perform for the cell, like capturing energy, releasing energy, manufacturing proteins, or synthesizing energy-rich carbohydrates. These complex cells formed a whole new kingdom of organisms, **Protista.**

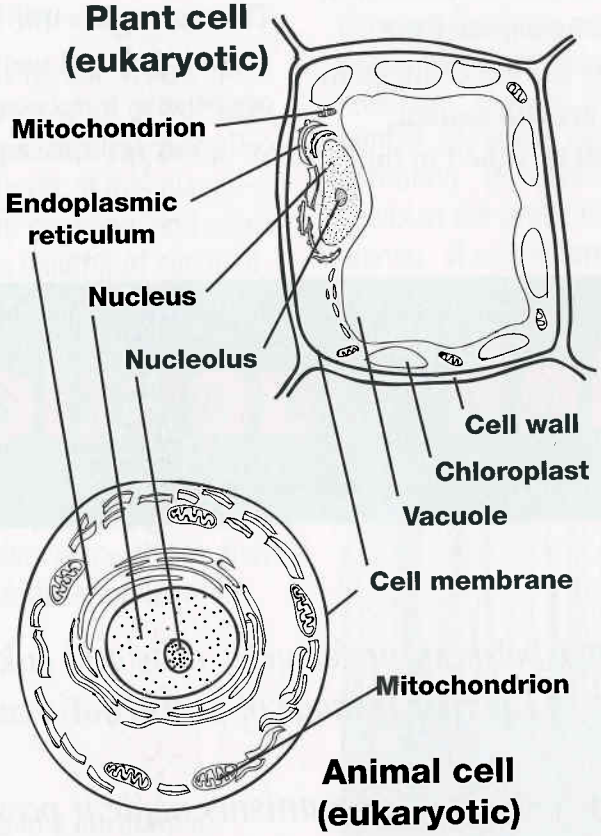
Protists were then and still are today mostly single-celled, aquatic organisms. They are larger than bacteria. Often they are fast swimmers, like paramecia, and some are able to feed by engulfing whole bacteria or smaller protists as food, like *amoebae.* Others are able to perform photosynthesis, so they make their own food, like the algae.

Protists are much more complex than bacteria, but like bacteria, they still live bathed in water. Water provides access to food and resources, and a convenient place to get rid of waste. And all of the complex chemical interactions that are essential for life take place in solution. Water equals life.

CELLS INVADE THE LAND

Sometime after protists arrived on the scene 1.5 billion years ago, one group of protists, called algae, began to live together in colonies. Some of the colonies became huge. If there had been any humans around at the time, these colonial algae would have been the first life-forms big enough to see without a microscope. The giant kelps (algae) that grow today in the oceans of the world are examples of this kind of organism.

It was probably a descendant of an ancient colonial alga that first moved onto the land. Scientists think that the first plants colonized dry land about 410 million years ago. Just a short time passed—maybe a few million years—before the first land animals followed. These were some kind of ancient insects. So 400 million years ago Earth had plants and animals living and thriving on dry land. And, of course, the plants and animals were made of cells, and those cells were eukaryotic cells. In fact, all living organisms, with the exception of Monera (bacteria), are made of eukaryotic cells.



AQUATIC LIFE ON DRY LAND

These pioneers on the land had cellular functions that evolved in an aquatic environment. To keep their cells alive, organisms that moved out of the water had to keep their cells wet at all times. That was the secret to leaving the sea: bring a little bit of the sea along when you move onto the dry land.

Algae growing at the ocean's edge today are able to withstand short periods of exposure to air. Every time the tide goes out, the algae living in the intertidal zone are left high and dry. But they are able to stay alive partly because the algae cells have sturdy, waterproof cell walls. The cell wall helps to hold the precious water inside the cell. The ancient plants that invaded the land had cell walls to keep water inside the cells, so that life could leave the sea.

The ancient terrestrial insects probably evolved from aquatic animals with shells on the outside, maybe something like a shrimp

shell. The tough shell served to hold in the water that is the key to life.

As life on land diversified and increased in complexity, organisms evolved structures for supplying water to every one of their cells. At the same time all the other needs of the cells had to be satisfied. The cells needed food, oxygen, and waste removal.

When we compare the most ancient life-forms—the bacteria and protists—with the most modern life-forms—plants and animals—it is amazing to think about how much life has changed in 3.5 billion years. But when you compare the *environments of the cells*, it is striking how little life has changed in that period of time. Cells are still aquatic, even in humans. Every cell is bathed in fluid, and every cell is continually in contact with the blood that pumps through our vessels. In fact, the chemical composition of blood is very similar to that of seawater.

Because we are human, we live very comfortably on dry land as terrestrial organisms. As free-living life-forms we get along just fine as long as our millions of cells work together and stay alive and healthy. One of the most important things we have to do is keep our cells in an aquatic environment. We refresh the water supply by drinking liquids and eating food that contains water. The water goes into the blood, which in turn keeps every cell wet. We are dry-land organisms, but, because life happens in our cells, our cells are aquatic.

1. *What is the difference between prokaryotic cells and eukaryotic cells? Which is the only kingdom of life that is made of prokaryotic cells?*

2. *What features of ancient aquatic organisms made it possible for them to leave the sea and colonize the dry land about 400 million years ago?*

3. *Humans and many other organisms don't live in water. Why might a person make the statement that all life is aquatic?*

4. *Would you say cells, bacteria, algae, plants, or animals are the basic units of life? Explain why you think so.*