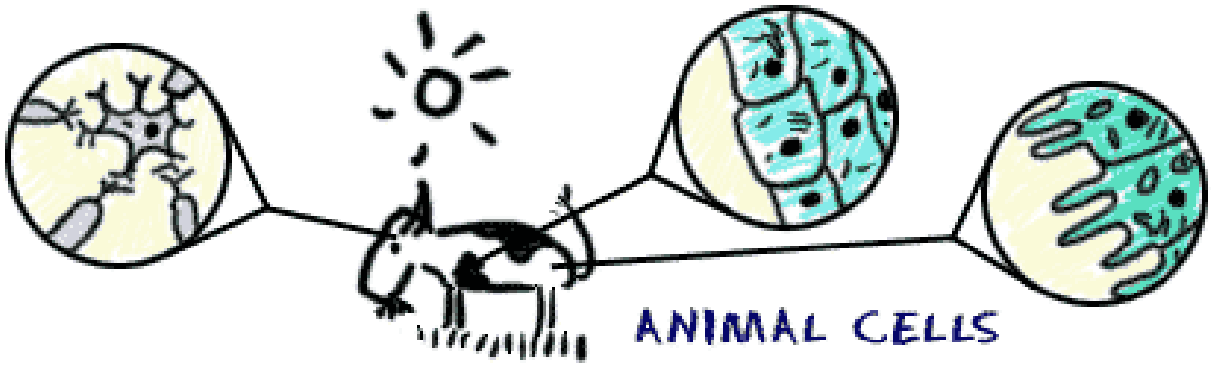
wall; animals do not. Plants also have organelles such as the green chloroplast or large, water-filled **vacuoles**. Chloroplasts are the key structure in the process of**photosynthesis**.

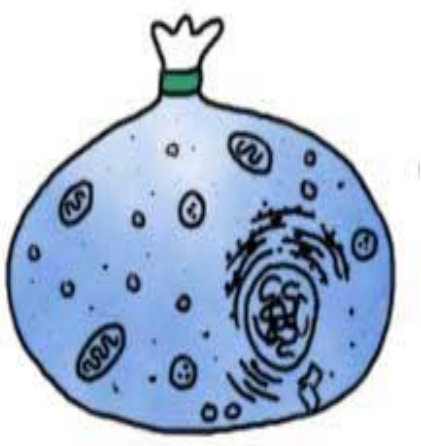


Cells are unique to each type of organism. If you look at very simple organisms, you will discover cells that have no defined nucleus (**prokaryotes**) and other cells that have hundreds of nuclei (**multinucleated**).

Humans have hundreds of different cell types. You have red blood cells that are used to carry oxygen (O_2) through the body and other cells specific to your heart muscle. Even though cells can be very different, they are basically compartments surrounded by some type of **membrane**.

Cell Membranes

According to **cell theory**, cells are the main unit of organization in biology. Whether you are a single cell or a blue whale with trillions of cells, you are still made of cells. All cells are contained by a **cell membrane** that keeps the pieces inside. When you think about a membrane, imagine it is like a big plastic bag with some tiny holes. That bag holds all of the cell pieces and



carbohydrate. They all serve the same purpose of protecting and maintaining structure, but they are very different molecules.

Cell Connections and Communication

All living things communicate in one way or another. When you start looking at the world on a cellular level, you won't find communication in writing or words. Cellular communication is on a **molecular level**. This section talks about cells in a larger organism that are near each other. We don't cover the communication between **single-celled organisms**. They behave in different ways.

Gap Junctions

Gap junctions are one type of cell connection. When two cells are right next to each other, their **cell membranes** may actually be touching. A **gap junction is an opening** from one cell to another. It's not a big opening, but it is large enough for cytoplasm to move from one cell to another. The connections are called channels and they act like tunnels for the movement of molecules.

Desmosomes

Desmosomes are a second type of cell connection. They physically connect cells like the gap junction, but no opening is created. **Proteins** that bond the membrane of one cell to its neighbor create the desmosomes. You will find desmosomes in your skin cells. All of those proteins hold your skin together. The distance between the cells, however small, is about 10 times wider than the gap junction connections.

ER. It looks bumpy under a microscope. The attached ribosomes make proteins that will be used inside the cell and proteins made for export out of the cell. There are also ribosomes attached to the nuclear envelope. Those ribosomes synthesize proteins that are released into the perinuclear space.

Two Pieces Make the Whole

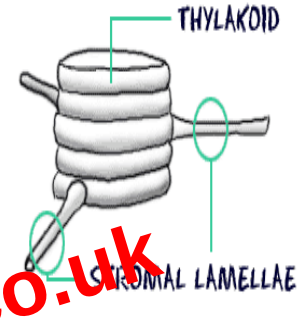
There are two pieces or subunits to every ribosome. In eukaryotes, scientists have identified the 60-S (large) and 40-S (small) subunits. Even though ribosomes have slightly different structures in different species, their functional areas are all very similar.

For example, **prokaryotes** have ribosomes that are slightly smaller than eukaryotes. The 60-S/ 40-S model works fine for eukaryotic cells while prokaryotic cells have ribosomes made of 50-S and 30-S subunits. It's a small difference, but one of many you will find in the two different types of cells. Scientists have used this difference in ribosome structure to develop drugs that can kill prokaryotic microorganisms which cause disease. There are even structural differences between ribosomes found in the mitochondria and free ribosomes.

Mixing and Matching Amino Acids

chloroplast.

Plants are the basis of all life on Earth. They are classified as the producers of the world. In the process of photosynthesis, plants create sugars and release oxygen (O_2). The oxygen released by the chloroplasts is the same oxygen you breathe every day. **Mitochondria** work in the opposite direction. They use oxygen in the process of releasing chemical energy from sugars.

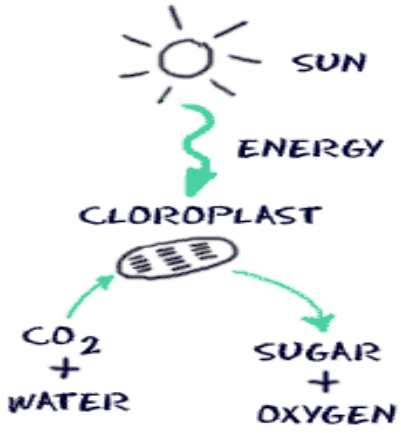


Special Structures

We'll hit the high points for the structure of a chloroplast. Two membranes contain and protect the inner parts of the chloroplast. They are appropriately named the **outer** and **inner membranes**. The inner membrane surrounds the **stroma** and the **grana** (stacks of **thylakoids**). One **thylakoid stack** is called a **granum**.

Chlorophyll molecules sit on the surface of each thylakoid and capture light energy from the Sun. As energy rich molecules are created by the light-dependent reactions, they move to the stroma where carbon (C) can be **fixed** and sugars are synthesized.

The stacks of thylakoid sacs are connected by **stroma lamellae**. The lamellae act like the skeleton of the chloroplast, keeping all of the sacs a safe distance from each other and maximizing the efficiency of the organelle.
If all of the thylakoids were overlapping and bunched together, there would not be an efficient way to capture the Sun's energy.



Making Food

The purpose of the chloroplast is to make sugars that feed the cell's machinery. **Photosynthesis** is the process of a plant taking energy from the Sun and creating sugars. When the energy from the Sun hits a chloroplast and the chlorophyll molecules, light energy is converted into the chemical energy found in compounds such as **ATP** and NADPH.

Those energy-rich compounds move into the stroma where enzymes fix the carbon atoms from carbon dioxide (CO_2). The molecular reactions eventually create sugar and oxygen (O_2). Plants and animals then use the sugars (**glucose**) for food and energy. Animals also breathe the oxygen gas that is released.

Different Chlorophyll Molecules

Not all chlorophyll is the same. Several types of chlorophyll can be involved in photosynthesis. You will hear about chlorophyll a and b most often. All chlorophylls are varieties of green and have a common chemical structure called a **porphyrin ring**.

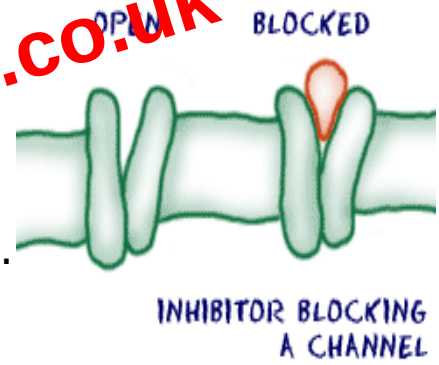
There are other molecules that are also photosynthetic. One day you might hear about **carotenoids** in carrots, **phycocyanin** in bacteria, **phycoerythrin** in algae, or **fucoxanthin** in brown algae. While these compounds might be involved in photosynthesis, they are not all green or the same structure as chlorophyll. Accessory pigments such as carotenoids and fucoxanthin pass absorbed light energy to neighboring chlorophyll molecules instead of using it themselves.

Endoplasmic Reticulum - Wrapping it Up

of the cell. The **membrane proteins** are very specific. One protein that moves glucose will not move calcium (Ca) ions. There are hundreds of types of these membrane proteins in the many cells of your body.

Many times, proteins have to work **against a concentration gradient**. That term means they are pumping something (usually ions) from areas of lower to higher concentration. This happens a lot in **neurons**. The membrane proteins are constantly pumping ions in and out to get the membrane of the neuron ready to transmit electrical impulses.

Stopping the Transport

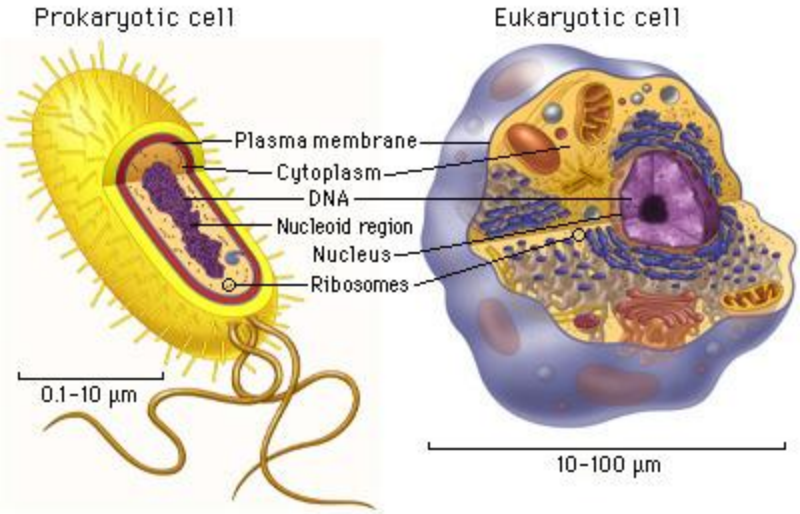


Even though these proteins are working to keep the cell alive, their activity can be stopped. There are poisons that stop the membrane proteins from transporting their molecules. These poisons are called **inhibitors**. Sometimes the proteins are destroyed and other times they are just plugged up.

Imagine that you are a cell and have ten proteins working to pump calcium into the cell. What if a poison came along and blocked eight of them? You could not survive with just two pumps working and would slowly die. It would be like expecting you to breathe with your mouth and nose plugged up.

Phagocytosis - Time to Eat!

Simply put, cells need to eat and drink just like you. Phagocytosis is the process of a cell eating. It is one type of endocytosis. **Endocytosis** happens when a cell goes out and takes in something. **Phagocytosis** is the situation when it gets a solid. **Pinocytosis** is the act of grabbing some liquid. The



The common features of prokaryotic and eukaryotic cells are:
1. **DNA**, the genetic material contained in one or more chromosomes and located in a nonmembrane bound nucleoid region in prokaryotes and a membrane-bound nucleus in eukaryotes

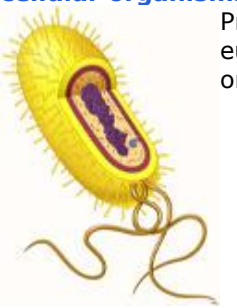
2. **Plasma membrane**, a phospholipid bilayer with proteins that separates the cell from the surrounding environment and functions as a selective barrier for the import and export of materials

3. **Cytoplasm**, the rest of the material of the cell within the plasma membrane, excluding the nucleoid region or nucleus, that consists of a fluid portion called the cytosol and the organelles and other particulates suspended in it

4. **Ribosomes**, the organelles on which protein synthesis takes place

Concept 2: Features of Prokaryotic Cells

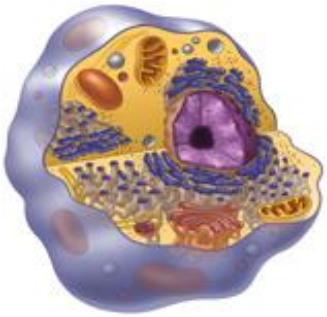
Prokaryotes, which include all bacteria and archaea (archaebacteria), are the simplest cellular organisms.



Prokaryotic cells are fundamentally different in their internal organization from eukaryotic cells. Notably, prokaryotic cells lack a nucleus and membranous organelles.

Concept 3: Features of Eukaryotic Cells

Eukaryotic cells contain a membrane-bound nucleus and numerous membrane-enclosed organelles (e.g., mitochondria, lysosomes, Golgi apparatus) not found in prokaryotes.



Prokaryotic cells are fundamentally different in their internal organization from eukaryotic cells. Notably, prokaryotic cells lack a nucleus and membranous organelles.
The nucleus is bounded by the nuclear envelope, a double membrane with many nuclear pores through which material enters and leaves. Animals, plants,