

Cell Theory

Before the invention of the microscope, people knew only about organisms that they could see with the unaided eye.

Late 1500's: microscope invented

1590: Zacharias Janssen invents the 1st compound microscope

→ early microscopes were used as toys

1665: English physicist Robert Hooke used a microscope to look at cork. He called the empty spaces in rows “cells” because they reminded him of the tiny rooms in a monastery (which are also called cells). Scientists began using microscopes for investigating everything.

1674: Anton van Leeuwenhoek (Dutch) – 1st person to see living organisms under the microscope; examined things like blood and pond water

→ Leeuwenhoek called the tiny creatures he saw “animalcules” which means “little animals”

1838: German botanist Matthias Schleiden concluded that all plants are made of cells

1839: German zoologist Theodore Schwann concluded that all animals are made of cells; he later concluded that all living things are made of cells

1855: German doctor Rudolf Virchow reasoned that new cells only come from already existing cells

The ideas of Schleiden, Schwann, and Virchow make up what is known as the cell theory. It has 3 main points:

- 1. Cells are the basic units of life.**
- 2. All organisms are made of one or more cells.**
- 3. New cells are produced from existing cells.**

Parts of the Cell

Cell structure is one way in which organisms differ from each other. For example, animal cells have things in them that plant cells do not, and muscle cells have structures in them that aren't found in blood cells. But there are certain features that are common to most cells.

I. Cell Membrane:

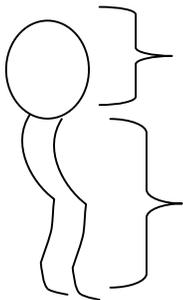
A. **cell membrane: a thin layer of lipids and proteins that separates the cell's contents from the outside environment**

→ very thin: 10,000 stacked = thickness of a page

1. **function: controls what enters and leaves the cell**

1. **composition: mostly phospholipids and some proteins**

B. **Phospholipids look like this:**



phosphate head is hydrophilic ("water loving")

lipid tails are hydrophobic ("water fearing")

C. **Cell membranes consist of 2 phospholipid layers, called a *bilayer*. The phosphate heads face the watery fluids inside and outside of the cell. The lipid tails are sandwiched inside the bilayer.**

D. Embedded in this bilayer are 3 different kinds of proteins.

- 1. channel protein: allows some molecules to pass through the membrane**
→ shaped like a doughnut; only certain molecules are able to go through
- 2. receptor proteins: transfer information from the world outside the cell to the inside of the cell**
→ look like boulders

How do they work? The end of the receptor protein that sticks out from the cell surface has a special shape that will hold only one particular type of molecule. When a molecule of the right shape comes along, it causes changes at the other end of the protein, which causes other responses inside the cell.

- 3. marker proteins: act as name tags for cells which can be used for identification and organization**
→ long, thin proteins often with carbohydrates on their surfaces

**The cell membrane is very complex. It is fluid (flows like a liquid). And you know it's made of different pieces that can move around in the membrane. These properties have given this view of the cell membrane's structure a certain name:
the fluid mosaic model**

II. The Nucleus

- A. **function: control center of the cell; surrounded by a membrane called the nuclear membrane**
→ *Most* (but not all) cells have a nucleus, some cells even have more than one.

NB: ALL cells contain DNA, but the DNA isn't always located in a nucleus.

- B. **The nucleus contains DNA (deoxyribonucleic acid), which carries all of the instructions for cell activity.**
- Usually the DNA is in a long strand called *chromatin*.**
 - However, during cell division, the chromatin coils into thick *chromosomes*.**
- C. **A nucleus (plural = *nuclei*) usually contains a nucleolus (plural = *nucleoli*). The nucleolus makes ribosomes (which are small parts of the cell that make proteins).**
- D. **The nucleus is used to classify cells into 2 types:**
- prokaryotic cells: cells that never contain a nucleus**
→ still have DNA but it's not in a special compartment like the nucleus
→ organisms whose cells are prokaryotic are called prokaryotes
 - eukaryotic cells: always or usually contain a nucleus**
→ organisms whose cells are eukaryotic are called eukaryotes

**BACTERIA & THEIR RELATIVES ARE PROKARYOTES.
ALL OTHER ORGANISMS ARE EUKARYOTES.**

III. Cytoplasm

A. cytoplasm: everything inside the cell membrane except the nucleus (in eukaryotic cells) or the DNA (in prokaryotic cells)

1. made of 2 things: cytosol and organelles

cytosol: jellylike mixture that consists mostly of water, along with proteins, carbohydrates, and other organic compounds

organelles: structures that work like miniature organs, carrying out the specific functions in the cell

→ In eukaryotic cells, most organelles are surrounded by membranes. In prokaryotic cells, there are no membrane bound organelles (with one exception - ribosomes).

IV. Cytoskeleton

- A. Definition: a network of protein filaments within some cells that helps the cell maintain its shape and is involved in many forms of cell movement**
- B. Two main parts of cytoskeleton – microfilaments and microtubules**
 - 1. Microfilaments: threadlike structures made of a protein called actin**
 - a. Microfilaments form extensive networks and produce a tough, flexible framework that supports the cell.**
 - b. They also help cells to move – assembly and disassembly of microfilaments is responsible for cells being able to crawl along surfaces**
 - 2. Microtubules: hollow structures made up of proteins called tubulins**
 - a. Microtubules help the cell maintain its shape.**
 - b. They are very important in cell division (form the mitotic spindle).**
 - c. They also help to build projections on the cell surface like cilia and flagella, which are used to move the cell.**
 - d. In ANIMAL CELLS ONLY, microtubules form centrioles. Located near the nucleus, the centriole helps to organize cell division.**

Organelles of Eukaryotic Cells

1. **mitochondria**: the “powerhouse” of the cell
function: . release the energy in food by breaking down food molecules
2. **endoplasmic reticulum (ER)**: the “highway” of the cell; it’s a system of membranes used to transport materials around the cell and to process certain macromolecules
There are 2 types of ER:
 - a. rough ER: has ribosomes attached to it
 - b. smooth ER: does not have ribosomes attached
3. **ribosomes**: structures where proteins are made; can be attached to the ER or free floating in cytoplasm
4. **Golgi Apparatus**: the “post office” of the cell; it’s a series of membranes stacked like pancakes
function: adds the finishing touches on newly made molecules and then packages those molecules and sends them out into the cell
5. **lysosomes**: small sacs that contain enzymes used to digest food particles
6. **chloroplasts**: make food from sunlight, water, and carbon dioxide through photosynthesis
→ **CHLOROPLASTS ARE ONLY FOUND IN THE CELLS OF GREEN PLANTS AND ALGAE!!!**

7. vacuoles: membrane bound spaces that hold or store wastes, water, and nutrients

→ very large in plant cells, small or not found in animal cells

The 7 organelles just described are found only in eukaryotic cells, with the exception of ribosomes. Ribosomes are found in both eukaryotic and prokaryotic cells. All other organelles are found **ONLY in eukaryotic cells.**

Kinds of Eukaryotic Cells: Animal Cells vs. Plant Cells

**Plant cells have a few extra organelles and structures:
chloroplasts, large vacuoles, and the cell wall**

**cell wall: extra layer that lies outside the cell membrane;
made mostly of cellulose (a type of sugar)**

function: gives strength and rigidity to the cell

In addition to plants, the cells of algae, fungi, and some bacteria have cell walls.

Comparing Prokaryotic and Eukaryotic Cells

Structure	Prokaryotic		Eukaryotic	
	Bacteria & Relatives	Plant Cell	Animal Cell	
Cell Membrane				
Cell Wall				
Nucleus				
DNA				
Ribosomes				
Endoplasmic Reticulum				
Golgi Apparatus				
Lysosomes				
Vacuoles				
Mitochondria				
Chloroplasts				

ENDOSYMBIOTIC THEORY

How did eukaryotic cells develop?

This was a question that was on the minds of many scientists.

Over 100 years ago, the idea of endosymbiotic theory was proposed. But it wasn't until Lynn Margulis of Boston University championed the theory in the 1960's that it became mainstream thinking.

Endosymbiotic theory: theory that eukaryotic cells formed from a symbiosis among several different prokaryotic organisms

Symbiosis: any relationship in which two species live together closely

As scientists studied eukaryotic cells, they noticed a few things:

- 1. some organelles had membranes just like prokaryotes (mitochondria, chloroplasts)**
- 2. some organelles had their own DNA that was very similar to prokaryotic DNA**
- 3. some organelles had their own ribosomes whose size and structure closely resemble those of prokaryotes**
- 4. some organelles divided separately from the rest of the cell (used same way to divide as prokaryotes)**

They came up with the idea that a much larger cell had engulfed (surrounded) a bacterium and instead of being digested as food, that bacterium remained inside the cell.

Eventually, these engulfed bacteria lost their ability to live on their own and became organelles within the larger cell. The result was a eukaryotic cell.

Size of Cells

If you compare cells from an elephant with cells from a mouse, they are very much alike in shape, structure, and size. Almost all eukaryotic cells are about 10 μm to 100 μm big. (μm = micrometer)

Size often depends on the cell membrane. Cells obtain nutrients and get rid of wastes through the cell membrane.

- The bigger the cell, the more membrane that is needed.

Problem: As cells get bigger, there is less surface area of the cell (where the membrane is) for each part of volume (where the cytoplasm with the organelles is located).

As cells increase in size, their volume increases more rapidly than the surface area does. With a really big volume, it's very hard for the cell to transport things in and out of the cell fast enough.

Another factor is the nucleus. The nucleus can only control so much cytoplasm and keep up with the cell's activities.

So the cell has to stay small to survive.
