Cells and Cell Theory

What are cells? … And how do we know cells exist?

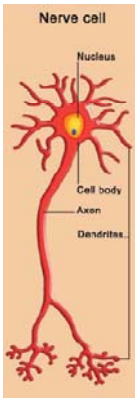
All living organisms are composed of cells, from just one to many trillions, whose details usually are visible only through a microscope.

Look at one square centimeter of the skin on your arm.

- That square centimeter contains about 100,000 skin cells.
- Cells are so small that they weren't even discovered until the invention of the microscope.

A cell is the basic unit of structure and function in a living thing.

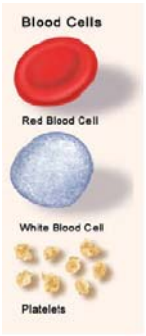
- Your body is composed of billions of cells.



Types of Cells

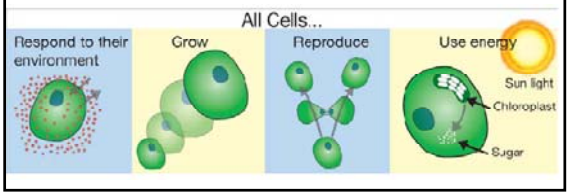
- You have nerve cells, skin cells, muscle cells, blood cells, and many other types as well.

These are some of the types of cells found in your blood.



Each cell in your body shares the characteristics of all living things.

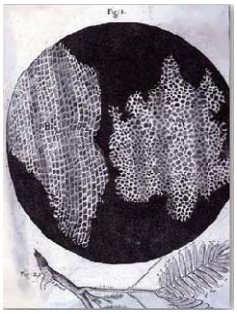
- Each cell can respond to changes in their surroundings in ways that keep them alive, grow, reproduce, and use energy.



We only began to learn about cells with the invention of the microscope in the late 1500s.

- It was English scientist, Robert Hooke (1635-1703), who first recorded his observations of cells.
- In 1663, he took a thin slice of cork and placed it under a microscope that he built himself.

Hooke called each of the square structures a cell because they reminded him of tiny rooms.



About that same, Anton van Leeuwenhoek (1632-1723), a Dutch craftsman who made lenses, used his lenses to build a simple microscope.

- With his microscope, he looked at pond water, blood, and scrapings from his teeth.
- He was the first to observe single-celled protists, blood cells, and bacteria.

Modern replica of van Leeuwenhoek's microscope.

As microscopes improved, scientists made more discoveries.

- In 1839, two German scientists, Matthais Schleiden and Theodore Schwann, viewed plant and animal tissues under a microscope.
- They concluded that all plants and animals were made up of cells.

Scientists knew that cells existed, but what they didn't know was where they came from?

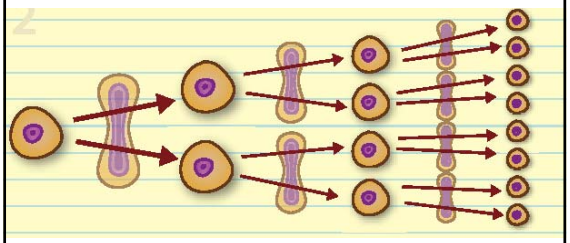
- In the 1800s it was believed that living things came from nonliving objects.
- Did cells come from some tiny, nonliving objects?
- In 1855, a German physician named Rudolf Virchow (1821-1902) proposed that cells can only come from other cells.

The Cell Theory

- The work of Hooke, Leeuwenhoek, Schleiden, Schwann, Virchow, and others led to an important theory in life science.
- The cell theory explains the relationship between cells and living things.

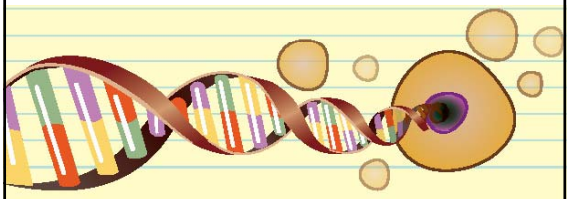
1. All living things are made of one or more cells.

2. Cells come only from existing cells.



3. All of an organism's life functions occur within cells.

4. Cells contain the hereditary information necessary for regulating cell functions and transmitting information to the next generation of cells.



Cell Cycle

Cell Cycle

Cells divide to increase their numbers through a process of mitosis, which results in two daughter cells with identical sets of chromosomes.

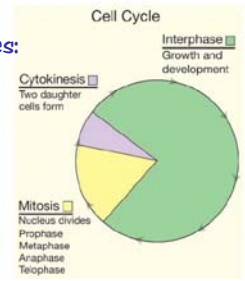
As you grow from an infant to an adult, you pass through different stages of your life cycle.

- Similarly, a cell passes through different stages of its life.
- The life cycle of a cell is called the cell cycle.

The cell cycle is the period of time from the beginning of one cell division to the beginning of the next.

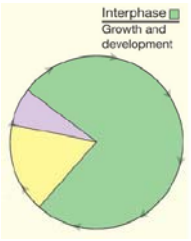
It consists of three stages:

1. interphase
2. mitosis
3. cytokinesis



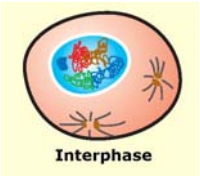
The longest stage of the cell cycle is called interphase.

- Interphase is the stage that occurs in between cell divisions.
- During interphase, the cell grows and develops and performs its functions.



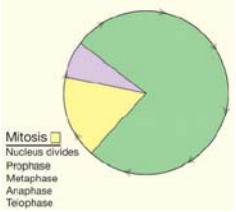
Toward the end of interphase (just before the cell begins to divide), the amount of DNA doubles.

- Organelles of the cytoplasm (like mitochondria) also double in number.

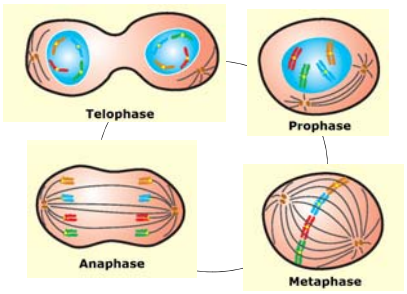


The second stage of the cell cycle is called mitosis (splitting of the nucleus).

- Mitosis is the process in cell division where the nucleus divides into two nuclei, each with an identical set of chromosomes.
- Mitosis is divided into four phases: prophase, metaphase, anaphase, and telophase.

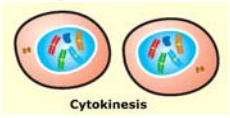


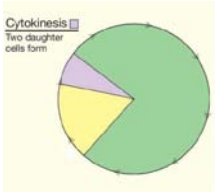
Mitosis



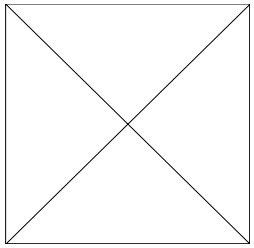
The shortest stage of the cell cycle is called cytokinesis (division of the cytoplasm).

- In cytokinesis, the cytoplasm and its organelles divide into two daughter cells.
  - Each daughter cell contains a nucleus with an identical set of chromosomes.
- The two daughter cells then start their own cycles, beginning again with the interphase stage.

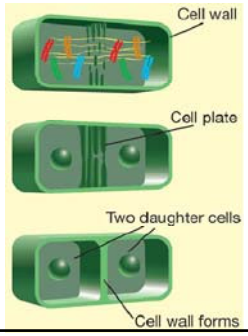




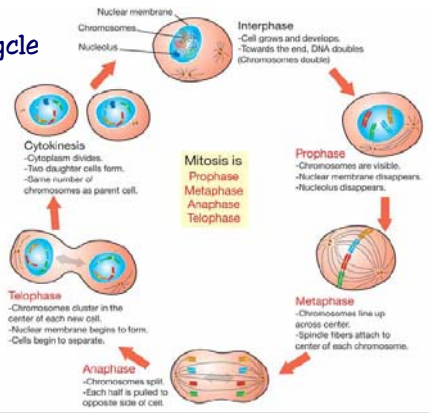
Mitosis Video Clip



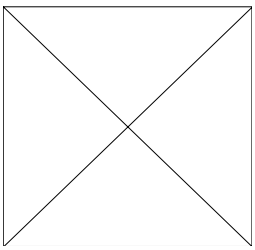
Cytokinesis in plant cells is different because a cell plate forms.



Cell Cycle



Mitosis



Cellular Respiration

Cellular Respiration

Mitochondria liberate energy for the work that cells do, and chloroplasts capture sunlight energy for photosynthesis.

We already learned that plants make their food during photosynthesis.

Animal cells get the energy they need from the food the animal eats.

- The digestive system breaks down the food into molecules.
- The cells then convert those molecules into a form of energy they can use.

So how do plants and animals convert those food molecules into a form of energy they can use?

Through a chemical process called cellular respiration.

As you know, respiration is the process of breathing.

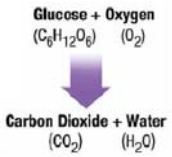
- Cellular respiration is not the same thing as breathing, but they are closely related.
- When you breathe in, you take in the oxygen your cells need for cellular respiration.
- When you breathe out, you get rid of the carbon dioxide that your cells produce during cellular respiration.

Try breathing onto a mirror or glass surface.

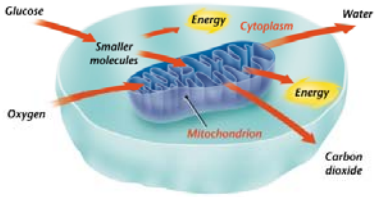
Can you see evidence of another product of cellular respiration?

This cellular respiration is carried out by every cell in both plants and animals and is essential for daily living.

- Cells use glucose and oxygen to produce carbon dioxide, water, and energy.



In cellular respiration, the carbohydrates from food are disassembled into glucose molecules.



- Then, this glucose is used to produce energy-rich ATP molecules.

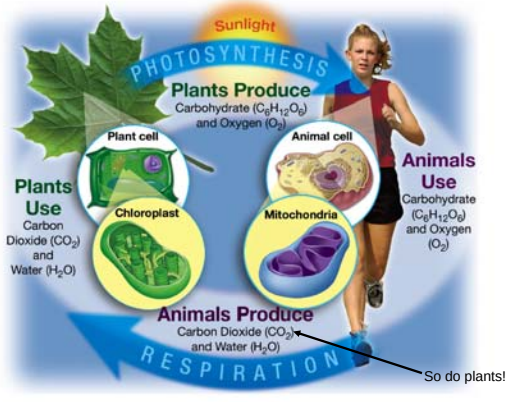
In most eukaryotic organisms, cellular respiration takes place in the mitochondria of cells.

During cellular respiration, some energy is stored in ATP and some is released as heat.

- ATP is a molecule that stores and transfers chemical energy within cells.
- ATP is used to power cell functions such as muscle contractions, nerve impulses, and molecule-building.

The chemical equations of photosynthesis and respiration have an interesting relationship.

- The reactants in photosynthesis are the products in cellular respiration!
- The reactants in cellular respiration are the products in photosynthesis!



Fermentation is the breakdown of sugars to make ATP in the absence of oxygen.

- When no oxygen is present, muscles cells use fermentation to make ATP from sugar.
- Lactic acid is also produced and causes the muscles to "burn" when exercising.

A second type of fermentation occurs in yeast & in certain types of bacteria.

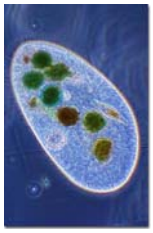
- First life forms used fermentation to gain energy.
- When the Earth was young, its atmosphere lacked oxygen.
- After organisms evolved the ability to photosynthesize, about 3 BYA, the oxygen they produced was added to the atmosphere.

Cell Similarities

Cells are different, yet they have many similarities.

Cells function similarly in all living organisms.

Cells may differ in their number.



- Some organisms are made of only a single cell.
- Other organisms are made of billions of cells.

Paramecium

Raccoon

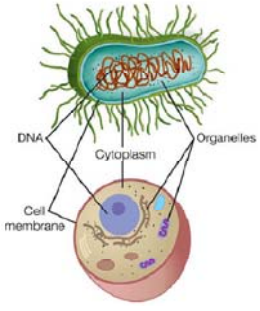
Specialized Cells

- In multicellular organisms like you, there are many different types of *specialized* cells.
- About 200 different types of specialized cells make up the tissues and organs of your body.

For example, the cells that line the retina of your eye have a structure and function that is very different from your skin cells.

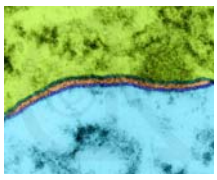
Even though there are many different types of cells, they all share similar characteristics.

- All cells have a cell membrane, organelles, cytoplasm, and DNA.



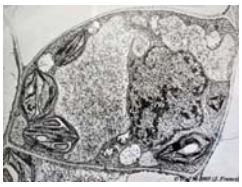
1. All cells are surrounded by a cell membrane.

- The cell membrane is a barrier between the inside of the cell and its environment.
- It also controls the movement of materials into and out of the cell.



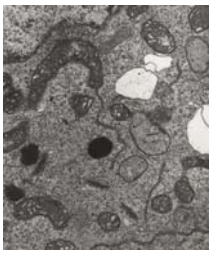
2. All cells contain organelles.

- An organelle is a structure inside of a cell that helps the cell perform its functions.
- Although all cells contain organelles, they don't all contain the same kinds.



3. All cells contain cytoplasm.

- The cytoplasm is a fluid mixture that contains the organelles.
- It also contains the compounds cells need to survive such as water, salts, enzymes, and other carbon compounds.

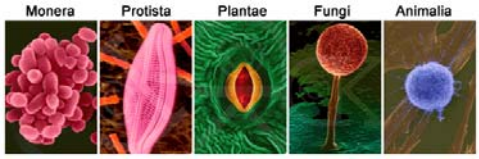


4. All cells contain DNA.

- The cell theory states that all cells come from other cells.
- When cells reproduce, they make copies of their DNA and pass it on to the new cells.
- DNA contains the instructions for making new cells and controls all cell functions.

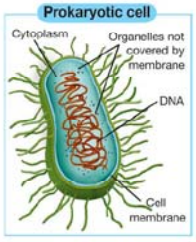
Based on the organization of their structures, all living cells can be classified into two groups: prokaryotic and eukaryotic.

- Animals, plants, fungi, and protozoans all have eukaryotic cells.
- Only bacteria have prokaryotic cells.



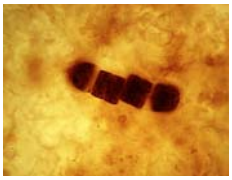
Prokaryotic cells do not have a nucleus.

- The word *prokaryotic* means "before nucleus" in Greek.
- Only bacteria have this type of cell.
- The DNA in a prokaryotic cell is bunched up in the center of the cell.
- The organelles are not covered with a membrane.



Scientists believe that all life on Earth came from prokaryotic cells.

- The oldest fossils of bacteria are estimated to be 3.5 billion years old.

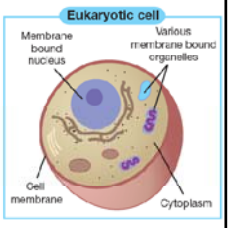


Eukaryotic cells

- Eukaryotic cells have a nucleus and membrane-covered organelles.
- The word *eukaryotic* means "true nucleus" in Greek.
- The oldest fossils of eukaryotic cells are about 2 billion years old.

Animals, plants, fungi, and protists all have eukaryotic cells.

- Eukaryotic cells have a nucleus and membrane-covered organelles.
- There is more DNA in these types of cells and it is found in the nucleus.
- They tend to be about ten times larger than prokaryotic cells.



Prokaryotic cells	Eukaryotic cells
Bacteria	All other cells
No nucleus	Nucleus
Organelles not membrane-covered	Membrane-covered organelles
DNA is bunched up in the center of the cell	DNA is found in the nucleus

Cell Structure and Function

Cell Structures & Functions

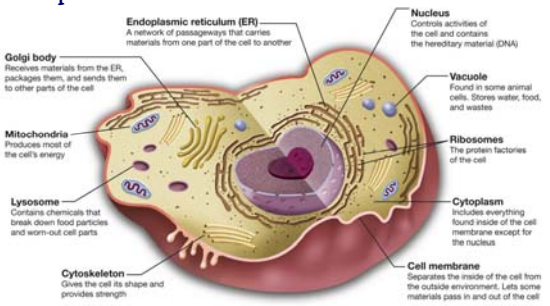
Cells function similarly in all living organisms.

Characteristics distinguish plant cells from animal cells, including chloroplasts and cell walls.

Cells have many different functions and come in many shapes and sizes.

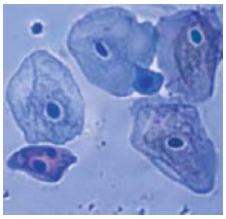
- But all cells have some parts in common:
  - All cells are surrounded by a cell membrane.
  - Cells have organelles, which are structures inside the cell that have specific jobs.

Here is a diagram of a typical animal cell and its parts.



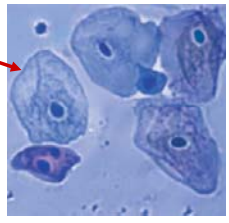
To make cell parts visible under a microscope, you can apply a stain to the cells.

- Methylene blue is a stain often used to look at animal cells.



Cell membrane

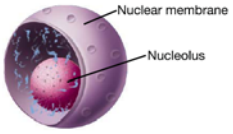
- The cell membrane is a thin layer that separates the inside of the cell from its outside environment.
- It keeps the cytoplasm inside while letting waste products out.



Can you identify the nucleus too?

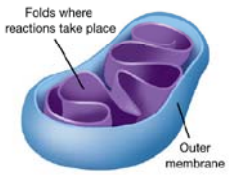
Nucleus

- The nucleus is covered with a membrane that allows materials to pass in and out.
- It's often called the "control center" of the cell because it contains DNA.
- The nucleolus acts as a storage area for materials.



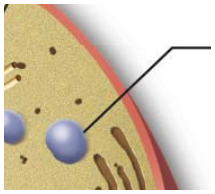
Mitochondria are called the "powerhouses" of cells.

- Mitochondria produce much of the energy a cell needs to carry out its functions.



A vacuole is the storage area of the cell.

- Vacuoles store water, food, and waste.

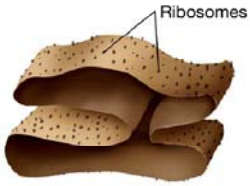


The endoplasmic reticulum (ER) is a series of tunnels throughout the cytoplasm.

- They transport proteins from one part of the cell to another.

Ribosomes are the protein factories of the cell.

- When ribosomes make proteins, they release them into the ER.

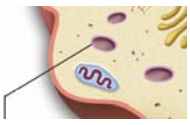


Golgi bodies receive proteins and other compounds from the ER.

- They package these materials and distribute them to other parts of the cell.

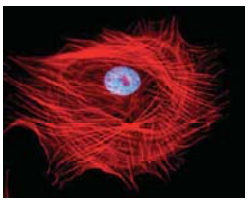
Lysosomes contain enzymes that can break things down.

- Lysosomes pick up bacteria, food, and old organelles and break them into small pieces that can be reused.

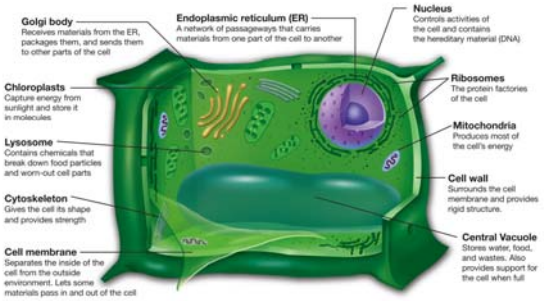


The cytoskeleton is a series of fibers made from proteins.

- It provides structure to the cell and gives it its shape.

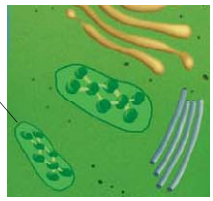


What organelles does this plant cell have in common with the animal cell?



How are plant cells different from animal cells?

- Plant cells have chloroplasts, but animal cells do not.
- A chloroplast is an organelle that contains a green pigment called chlorophyll.



Plant cells have a cell wall, but animal cells do not.

- The cell wall is made of a carbohydrate called *cellulose*.
- Cell walls provide structure and support for the plant.

Plant cells have a large central vacuole that stores cell sap.

When a plant needs water it wilts because the central vacuoles in its cells are empty.

- They no longer push against the cell walls to keep the plant upright.
- Watering the plant restores water in the central vacuoles.