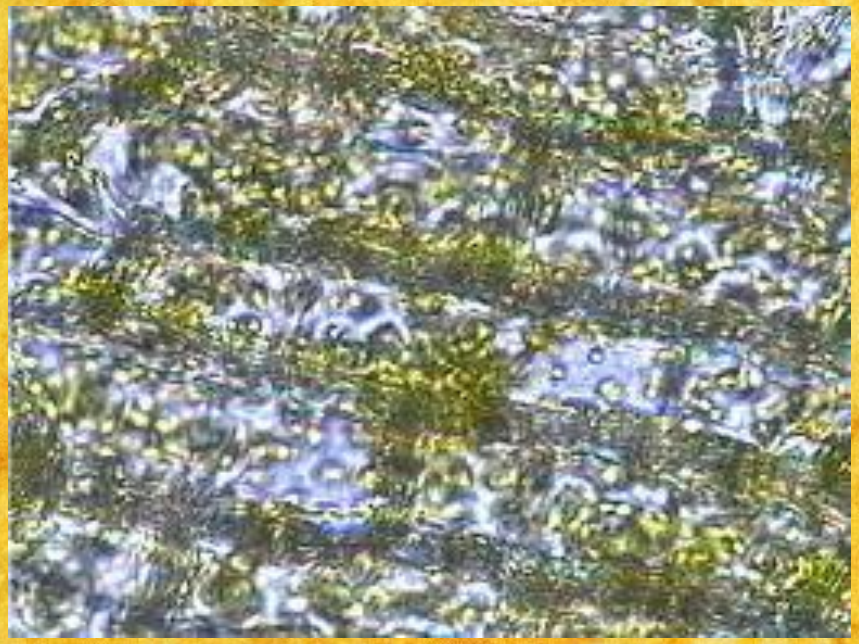
Cell Structure and Function

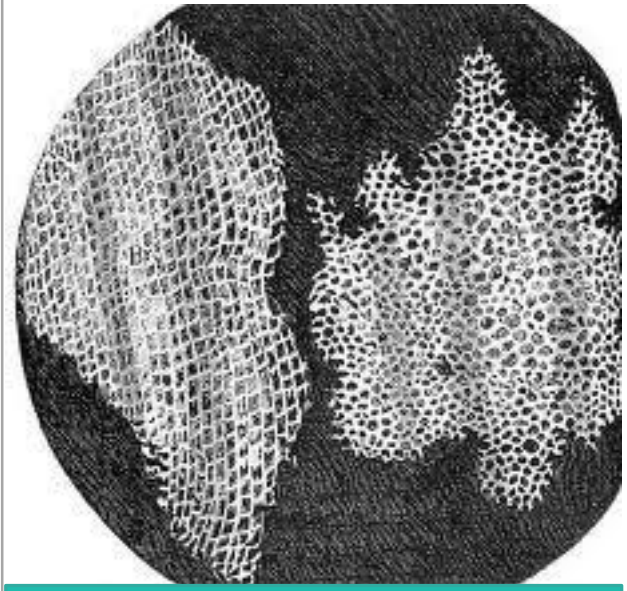
The Basic Unit of Life



The Discovery of the Cell

Robert Hooke

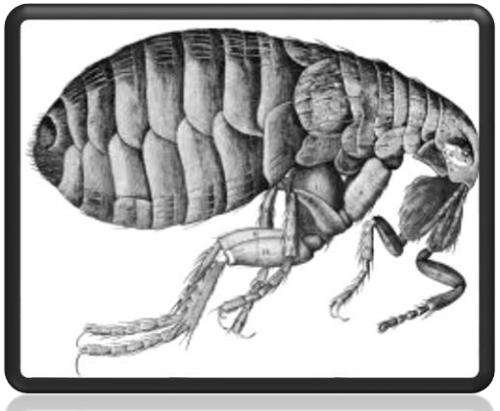
The word "cell" was first used in late 1665 by Robert Hooke. He looked at thin slices of cork (plant cells) under the microscope.



Cork seemed to be made of thousands of tiny, empty chambers.

Hooke called these chambers "cells" because they reminded him of the tiny rooms in which he lived in the monastery.

Today we know that cells are not empty chambers, but contain much living matter.



Anton van Leeuwenhoek – late 1600's

Leeuwenhoek made many simple microscopes to observe things in nature that interested him.

Leeuwenhoek Microscope (circa late 1600s)

He discovered the hidden world of microorganisms in a drop of water. He called them "little beasties".

He was the first to:

…. see and describe microorganisms under the microscope.

On the road to the cell theory….

Matthias Schleiden

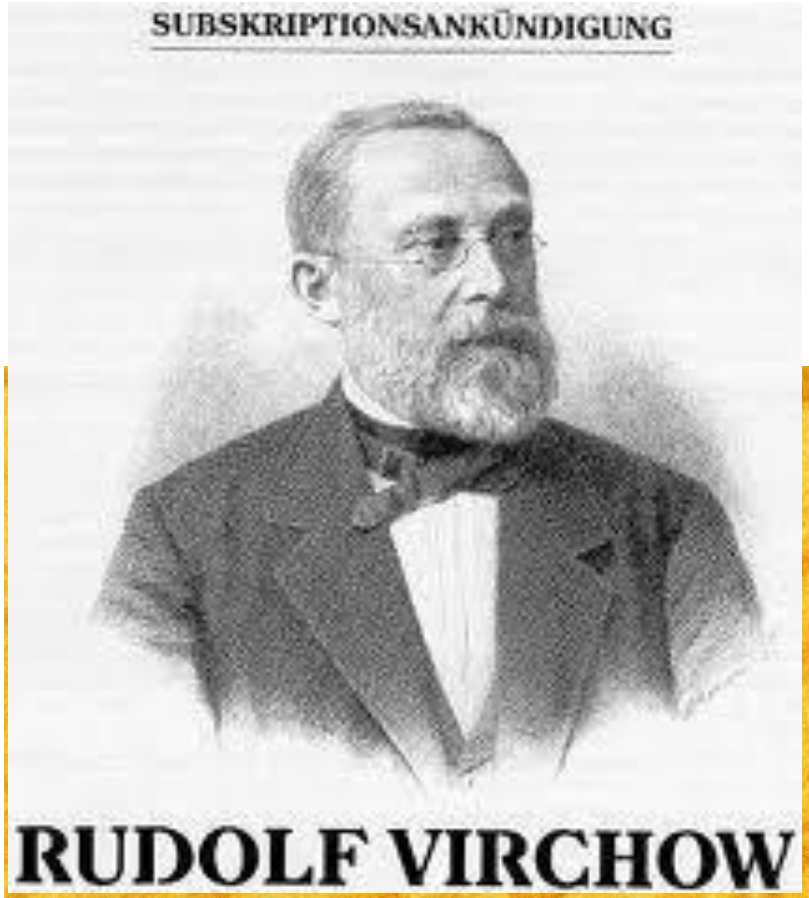
German botanist

Schleiden said that all plants are made of cells.

Theodore Schwann

Zoologist

Schwann said that all animals are made of cells.



Virchow

1858

In 1858, Rudolph Virchow said that cells could only arise from preexisting cells.

The Cell Theory

1. All living things are composed of cells.

2. Cells are the basic units of structure and function in living things.

3. New cells are produced from existing cells.

Energy Requirements of Living Organisms

Living organisms need a constant supply of energy to maintain themselves and to grow and reproduce.

Heterotrophs

Heterotrophs are consumers.

Heterotrophs cannot make their own food. They must get it from outside sources

Examples:
All Animals
The Fungi

Autotrophs

Autotrophs are producers.

Examples include:

All green plants, some protists, and some bacteria.

Autotrophs

can make their own food

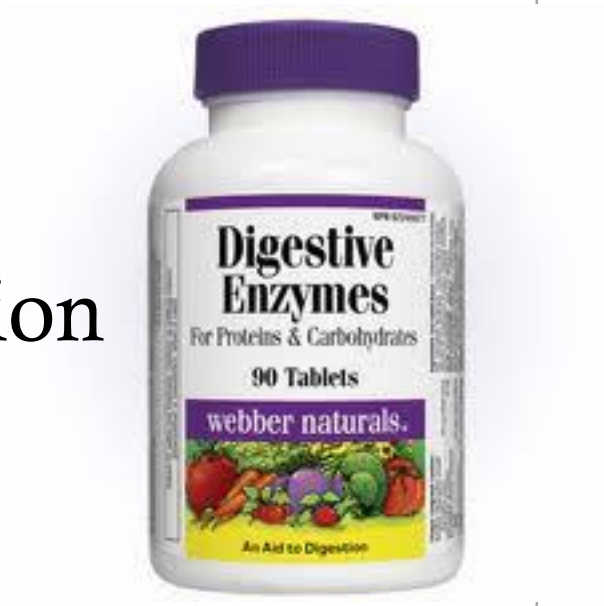
and are not dependent on outside sources for their food.

All cells must be able to perform the following functions.

Ingestion:

The taking in of food and water.

Digestion



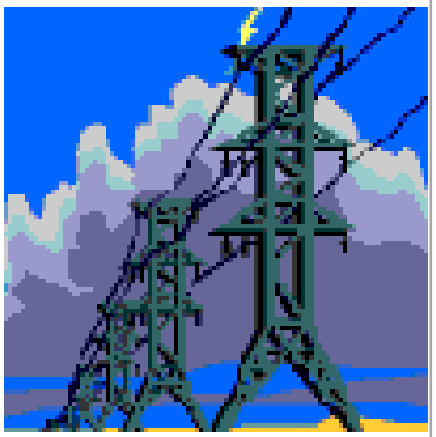
Breaking down food into small molecules that can be used by the cell.

Cyclosis:

The movement of materials inside a cell.

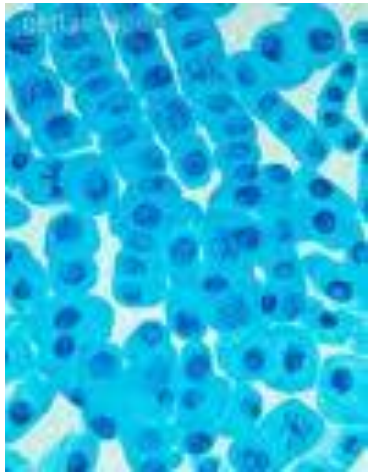
Respiration:

Burning food for energy; the release of energy from food.



Biosynthesis:

Using the energy from food for growth and repair.

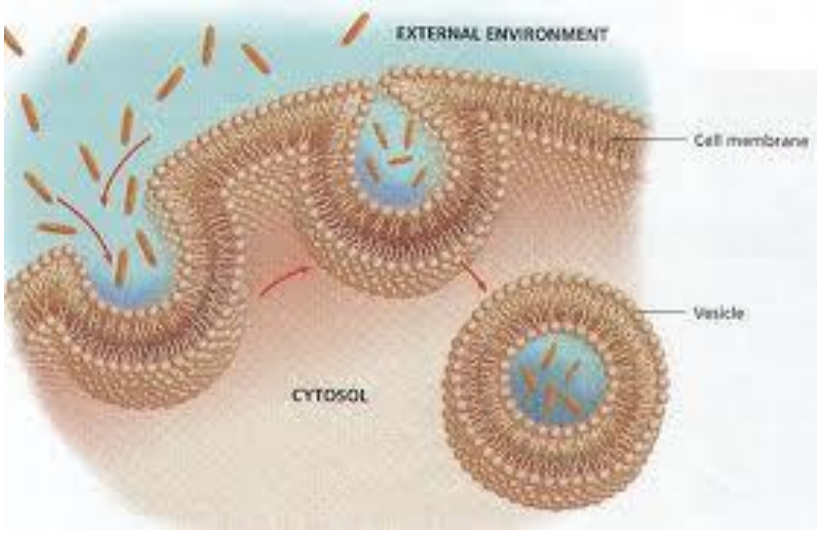


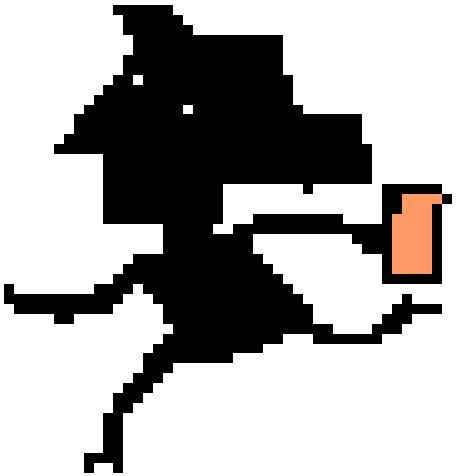
Excretion:

The removal of liquid waste from the cell.

Egestion:

The removal of solid waste from the cell.

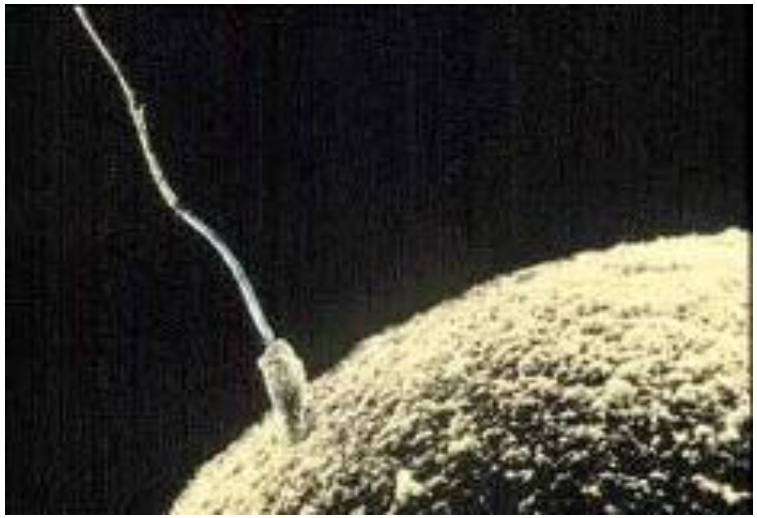




Movement:

Reproduction

May be sexual….



…or asexual.

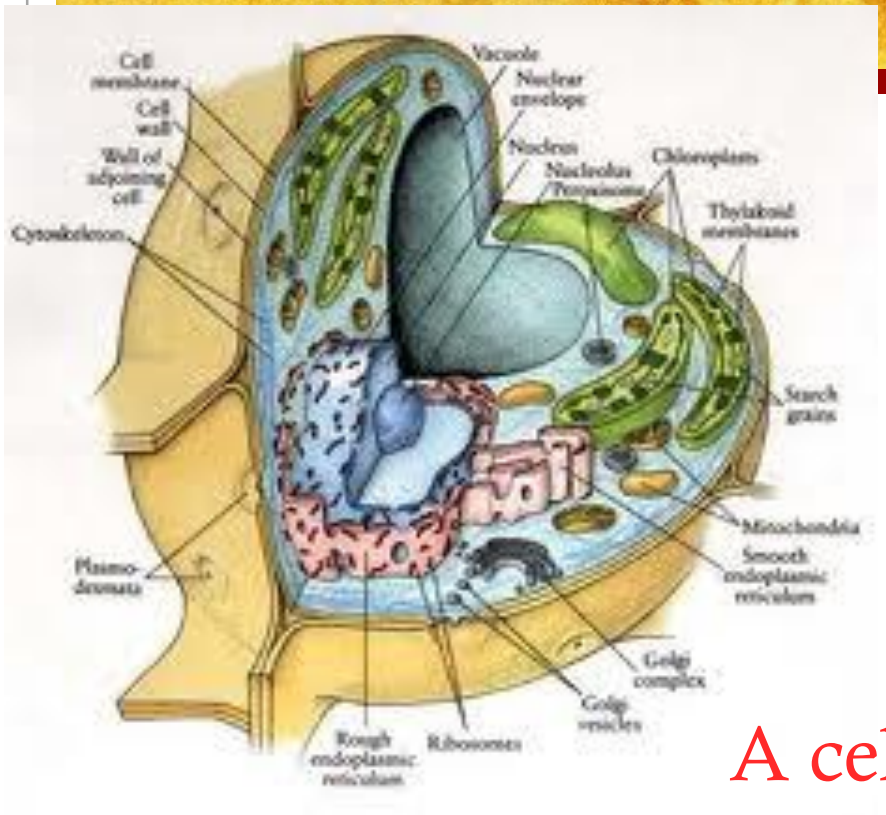
Irritability:

Responding to a stimulus

A substance made in one place, but used in another place

Secretion:

Structures of Animal Cells



Organelles are the <u>specialized structures found within a cell.</u>

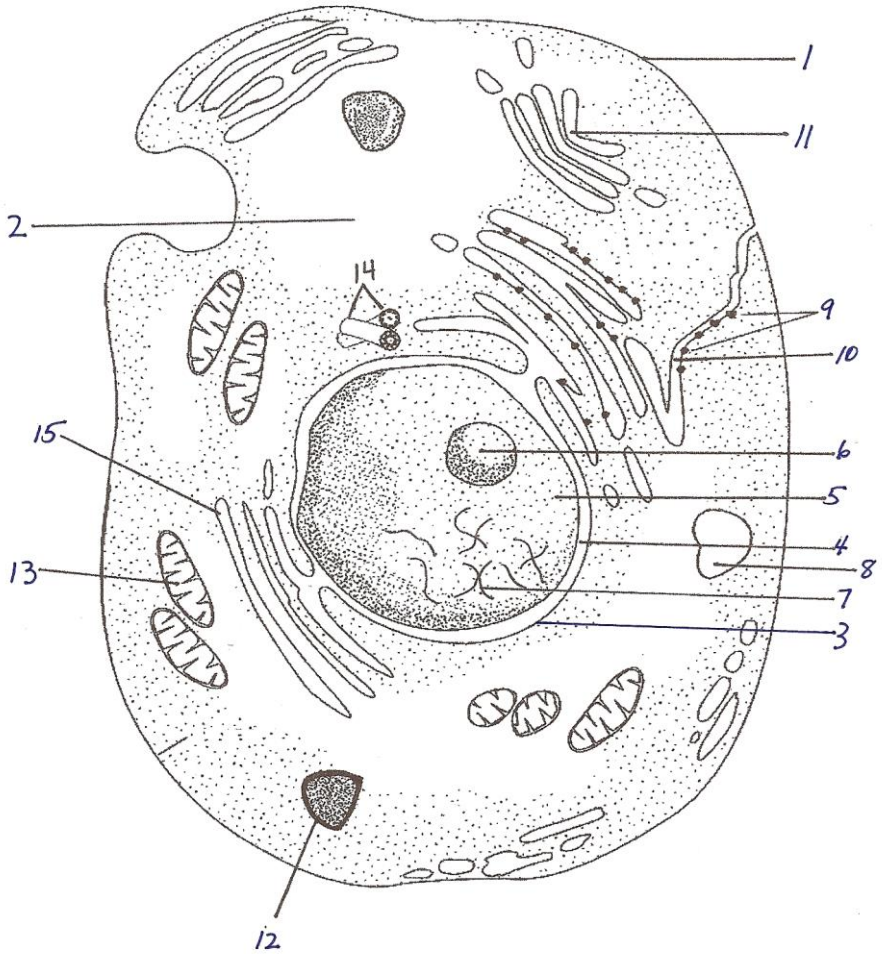
Each organelle has a specific job or function.

A cell is divided into 2 parts:

Nucleus: The control center of the cell.

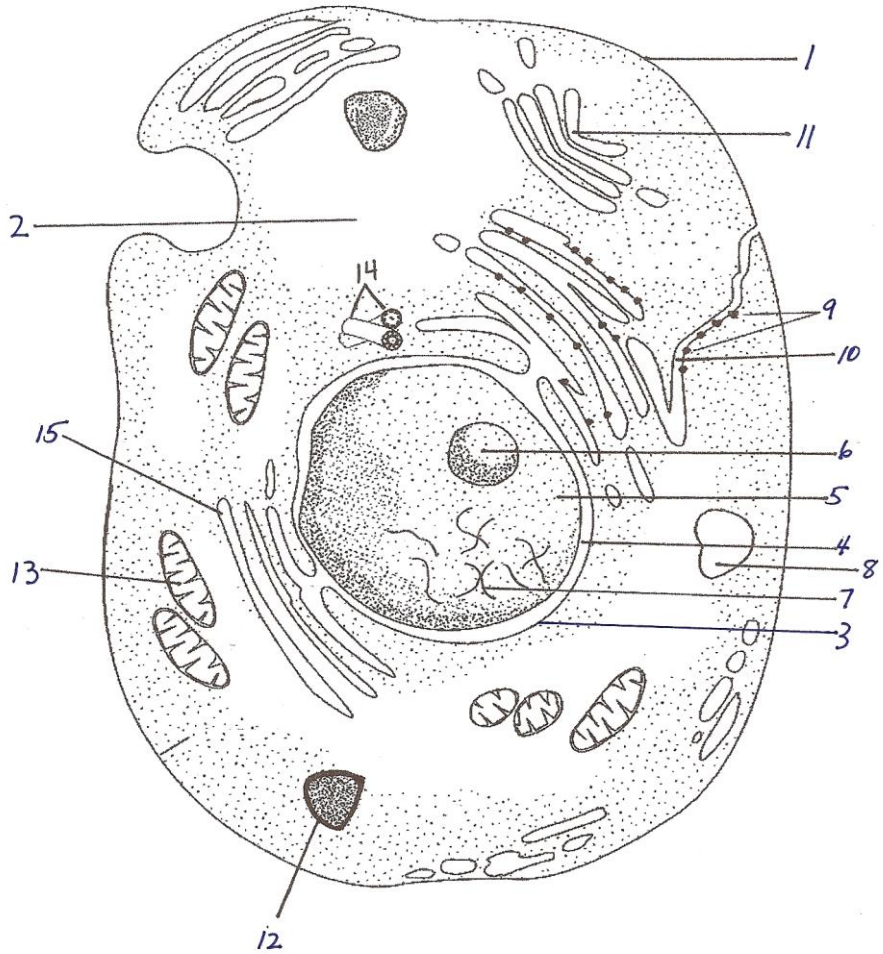
Cytoplasm: The portion of the cell outside of the nucleus.

Organelles Found in a Generalized Animal Cell



1. Cell Membrane
2. Cytoplasm
3. Nucleus
4. Nuclear Membrane
5. Nucleoplasm
6. Nucleolus
7. Chromosomes
8. Vacuole
9. Ribosomes
10. Rough Endoplasmic Reticulum

Organelles Found in a Generalized Animal Cell



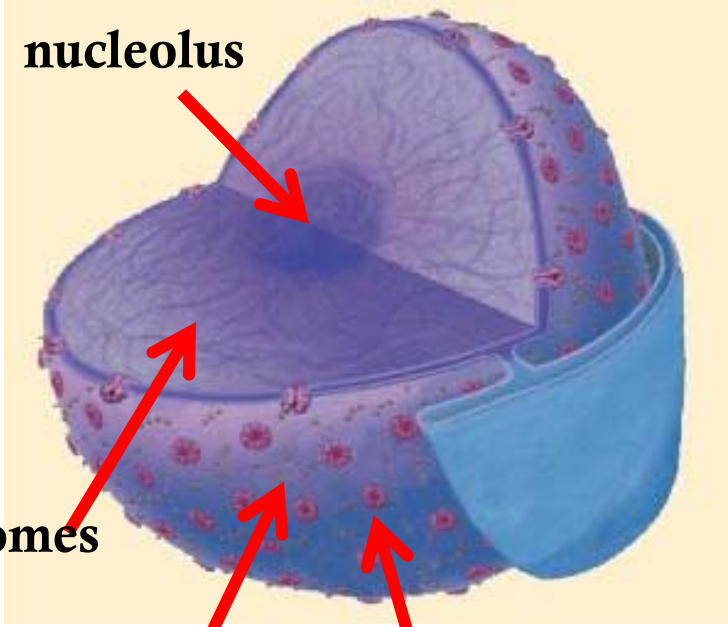
11. Golgi Apparatus
12. Lysosome
13. Mitochondria
14. Centrioles
15. Smooth Endoplasmic Reticulum

The Nucleus

The nucleus is the control center of the cell.

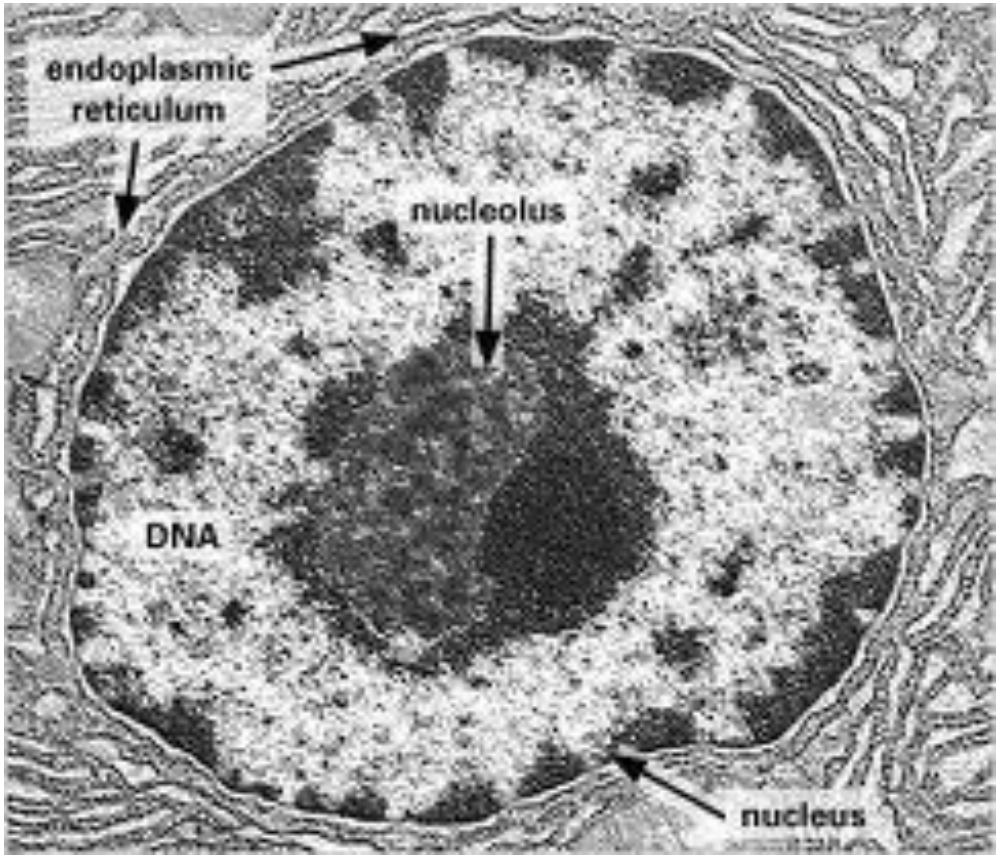
The nucleus contains nearly all of the cell's DNA.

The DNA has the instructions for making proteins and other important molecules.



The nucleus is surrounded by a nuclear membrane.

The nuclear membrane is a double membrane that is dotted with thousands of pores. These pores allows materials to move into and out of the nucleus.

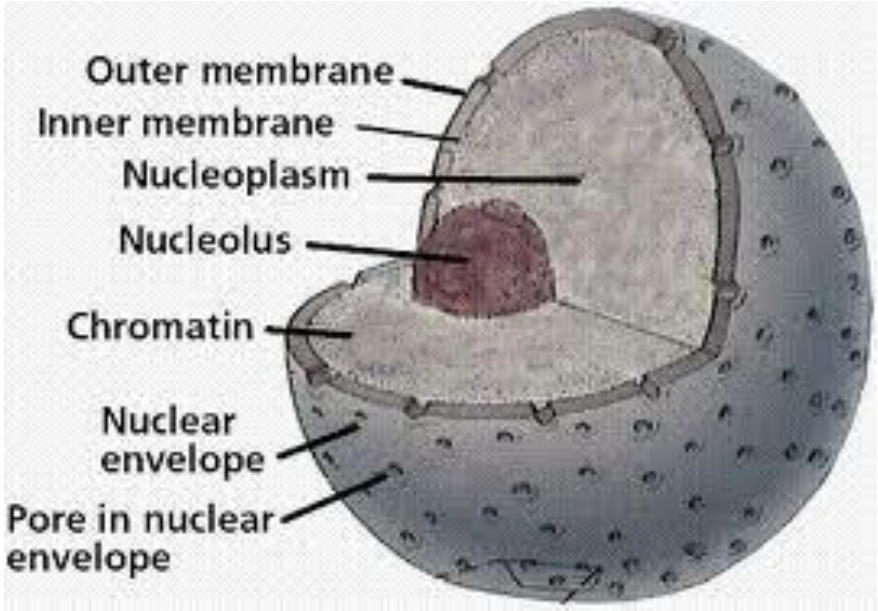


The chromosomes are made of DNA and have two functions:

To contain the genetic information that is passed from one generation to the next.

To control the cell's activities.

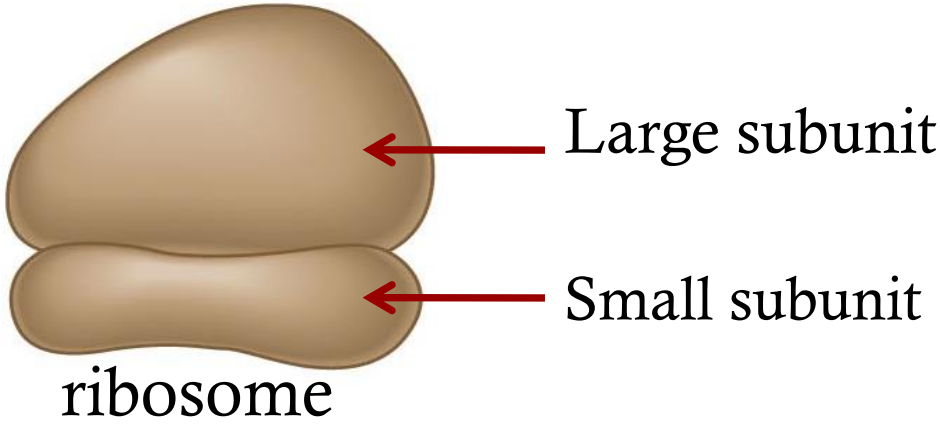
The Nucleoplasm is the semi-liquid portion inside the nucleus.



Nucleolus

The nucleolus manufactures the subunits that make up ribosomes.

There are 2 subunits – the large subunit and the small subunit.



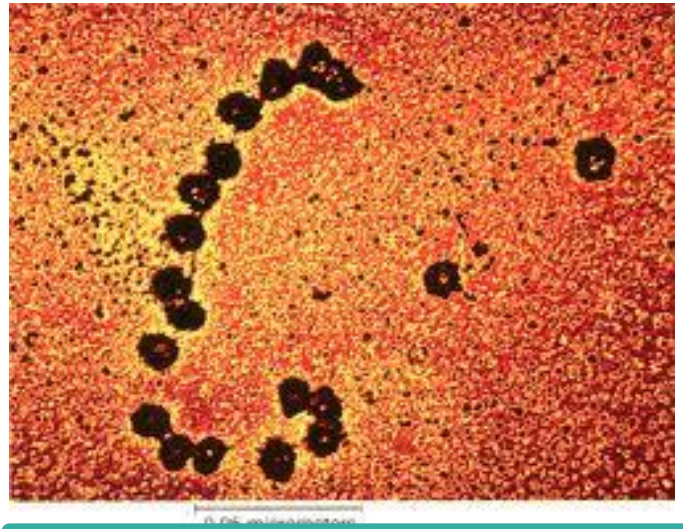
These subunits then pass through the pores of the nucleus to the cytoplasm where they combine to form ribosomes.

Functions of the Nucleus

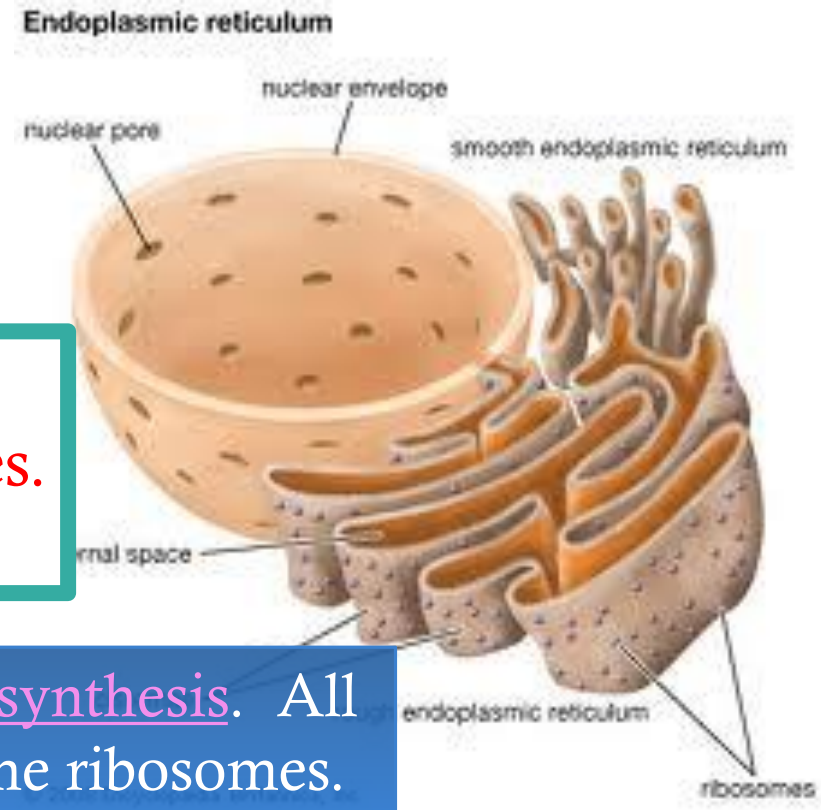
The nucleus is the carrier of the genetic information because this is where the genes are found.

The nucleus controls the reproduction of the cell.	**The nucleus controls all of the activities of the cell.**	**The nucleus directs protein synthesis by sending messages out to the ribosomes.**

Ribosomes may be found free floating in the cytoplasm, or they may be found attached to the endoplasmic reticulum.



Ribosomes



Ribosomes are the most numerous of the cell's organelles.

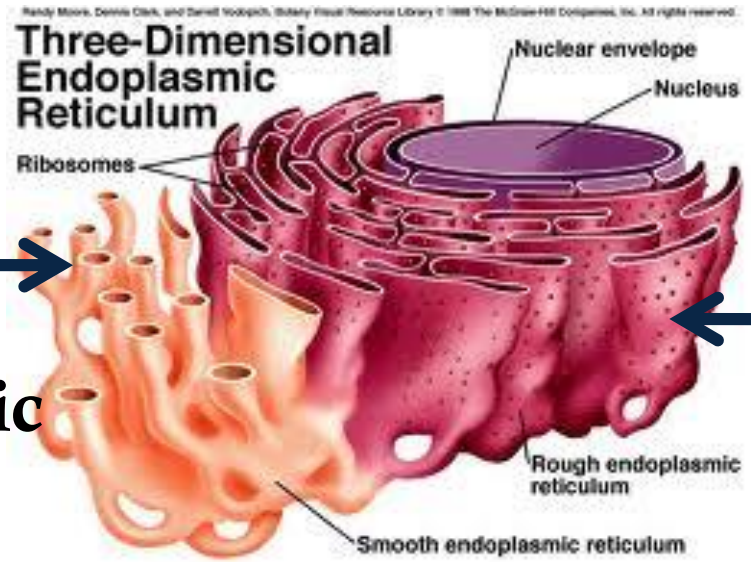
Ribosomes are the site of protein synthesis. All proteins of the cell are made by the ribosomes.

Endoplasmic Reticulum

The internal membrane system of a cell is known as the endoplasmic reticulum.

This system of membranes is so extensive throughout the cell that it accounts for more than half the total membrane in a cell.

It connects the nuclear membrane to the cell membrane.



Smooth endoplasmic reticulum

Rough endoplasmic reticulum

The rough endoplasmic reticulum has ribosomes attached to it.

This type of endoplasmic reticulum is involved in the making of proteins.

The smooth endoplasmic reticulum has no ribosomes. The function of the smooth endoplasmic reticulum is to make:

lipids that will be used in the cell membrane.

Newly made proteins leave the ribosome and are inserted into **spaces of the endoplasmic reticulum** where they are **modified and shaped** into a functioning **protein**.

Golgi Apparatus

Proteins ___ that were produced in the rough endoplasmic reticulum now move to the Golgi apparatus.

The Golgi apparatus appears as a stack of loosely connected membranes.

The function of the Golgi is to modify, sort and package the proteins that have arrived from the endoplasmic reticulum.

These proteins will either be stored inside the cell or be secreted to the outside of the cell.

The finishing touches are put on proteins here before they are shipped off to their final destinations.

Lysosomes

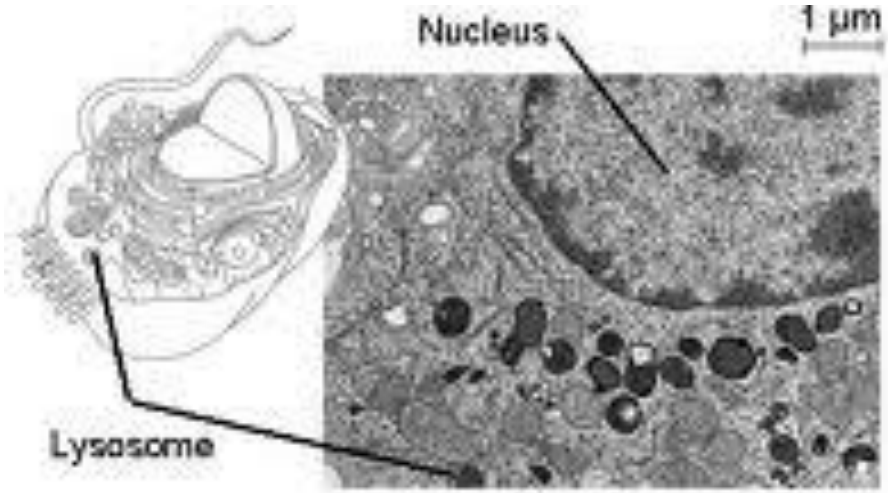
Lysosomes are filled with:
very strong digestive enzymes.

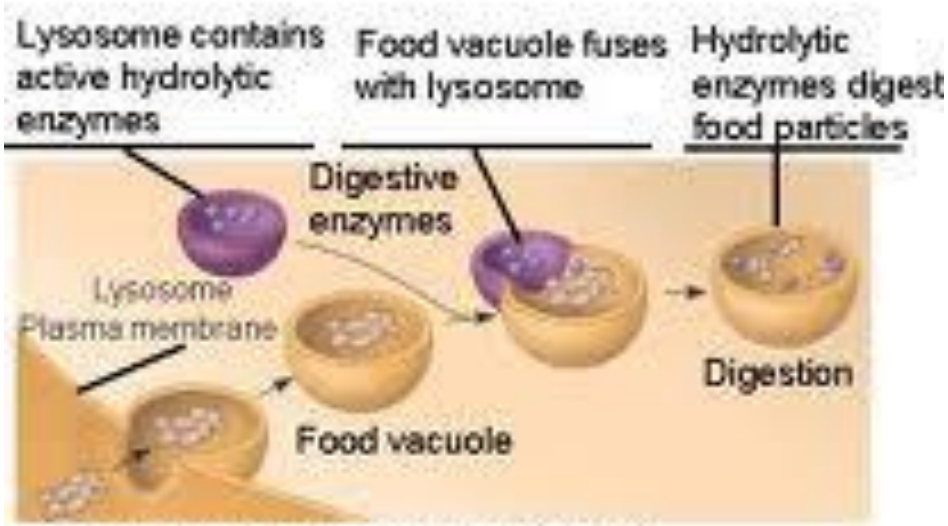
One function is the:

digestion of carbohydrates, proteins, and lipids into small molecules

that can be used by the rest of the cell. They recycle the cell's own organic materials, breaking them down into their building blocks, and returning them to the cytoplasm to be used again.

Lysosomes are responsible for destroying old organelles that can no longer carry out their function.





Phagocytosis: lysosome digesting food

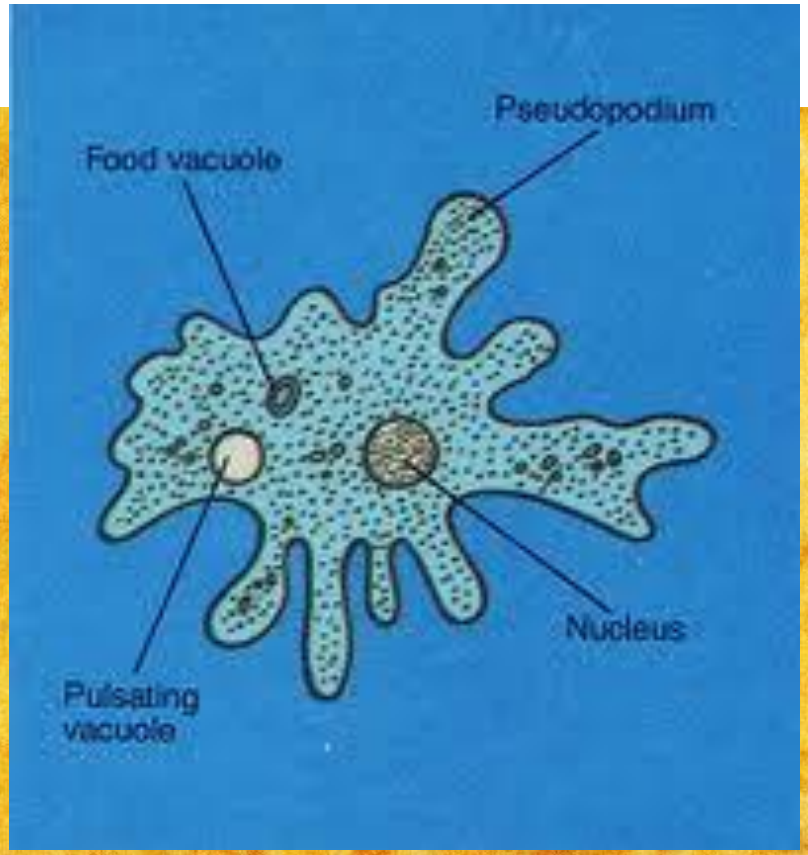
Lysosomes help to "clean up" or destroy any debris that might build up inside the cell.

Lysosomes are surrounded by a thick membrane, because the cell would be destroyed if the enzymes were released.

Vacuoles

A vacuole is a <u>storage area inside a cell</u>.

A vacuole may store water, salts, proteins, and carbohydrates.



Mitochondria

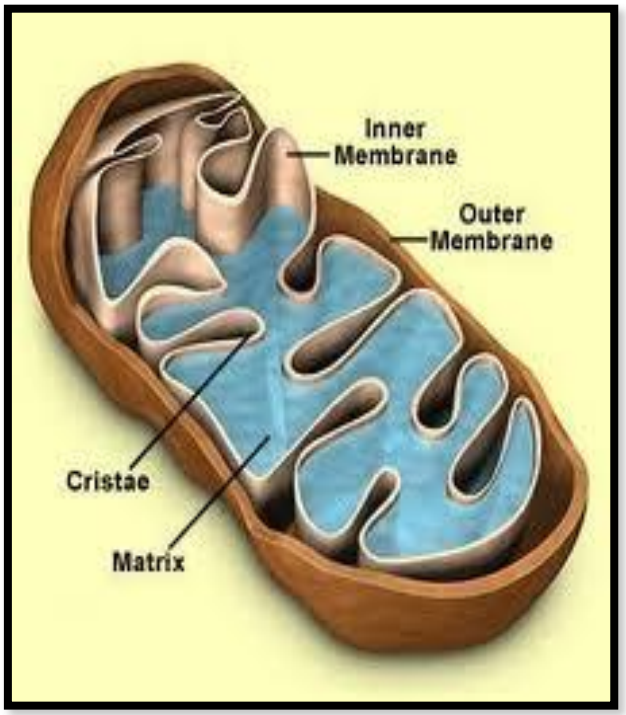
The mitochondria is the "powerhouse" of the cell.

The purpose of the mitochondria is:

cellular respiration.

$$C_6H_{12}O_6 + 6O_2 + 6H_2O \longrightarrow 6CO_2 + 12H_2O + \text{ATP energy}$$

Cellular respiration is the process of converting glucose or sugar molecules into a usable form of energy for the cell.



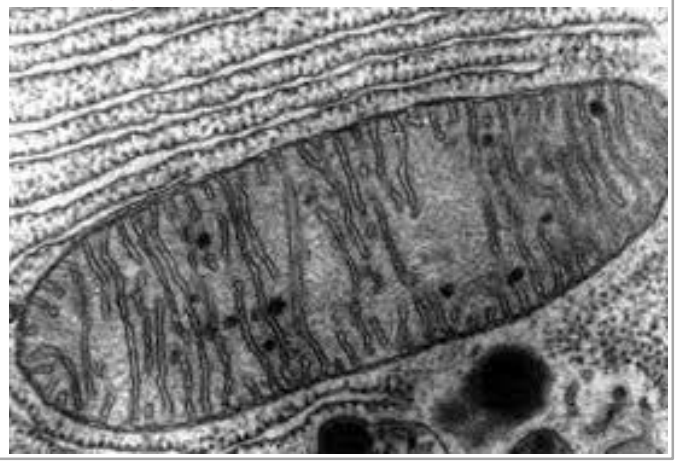
Mitochondria have an inner membrane and an outer membrane.

The folds on the inner membrane are known as cristae.

The cristae…

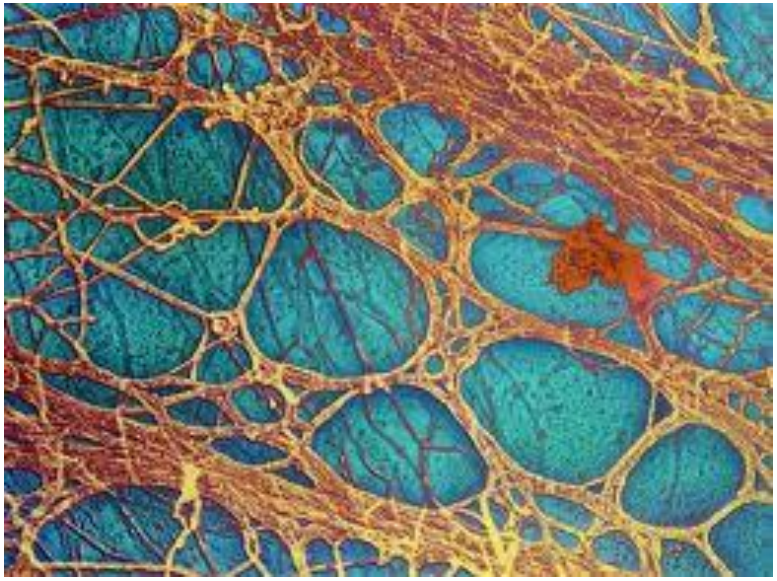
…increase the surface area for respiration.

100's or 1000's may be found in a cell.



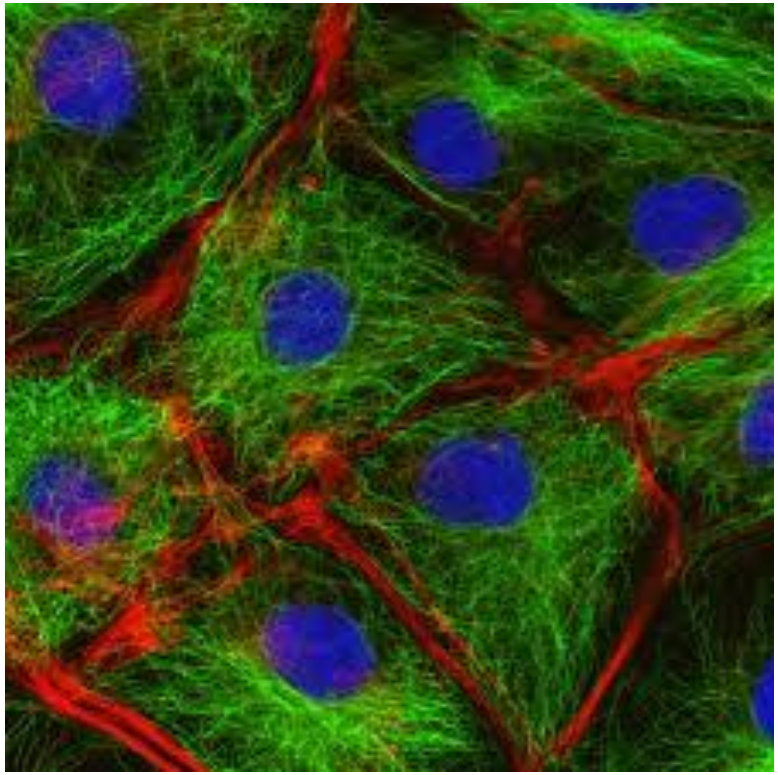
The Cytoskeleton

The organelles of a cell do not float freely in the cytoplasm.

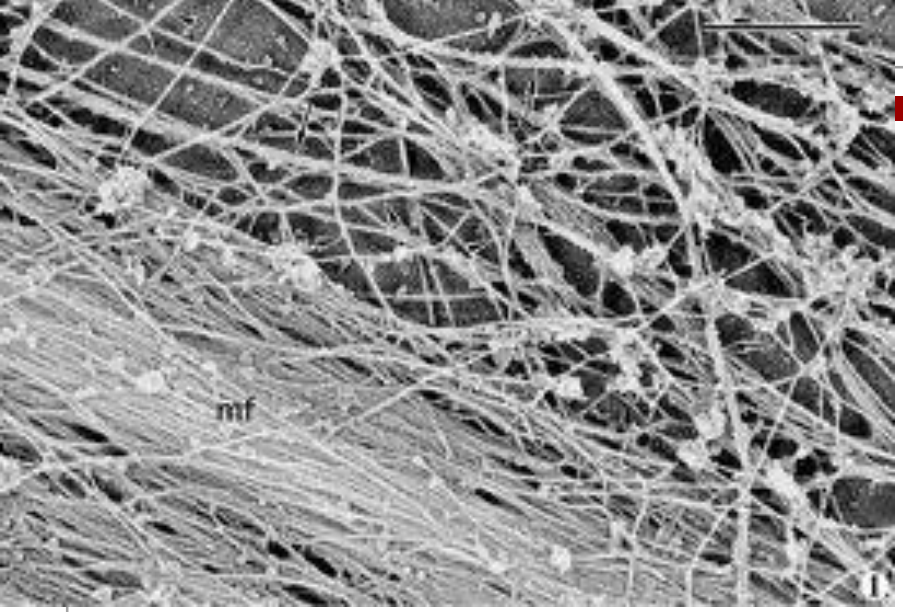


- Cells must have an internal framework and **support system** to give **shape** and organization to a cell.

The cytoskeleton is a network of protein tubes and fibers that helps the cell to maintain its shape.



- The cytoskeleton is also involved in movement.
- Two of the types of fibers found in the cytoskeleton are microfilaments and microtubules.



Microfilaments

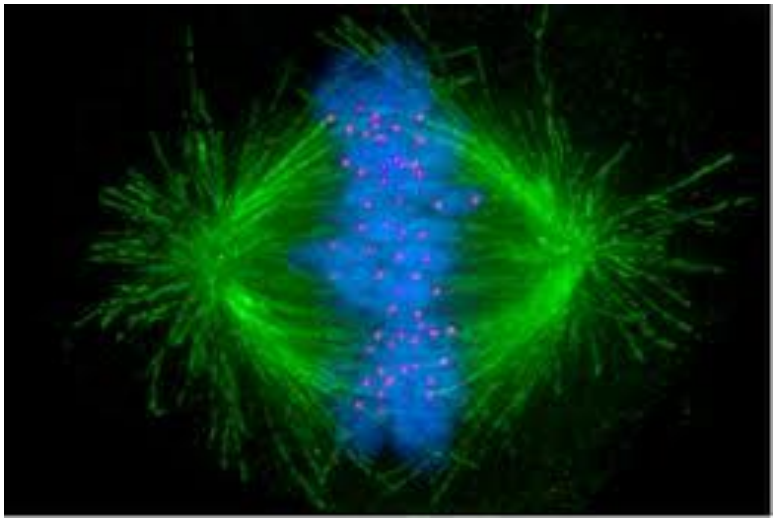
Microfilaments are …

…solid, threadlike, protein structures.

Microfilaments form extensive frameworks inside the cell to give support to the cell. They help to bear mechanical stress.

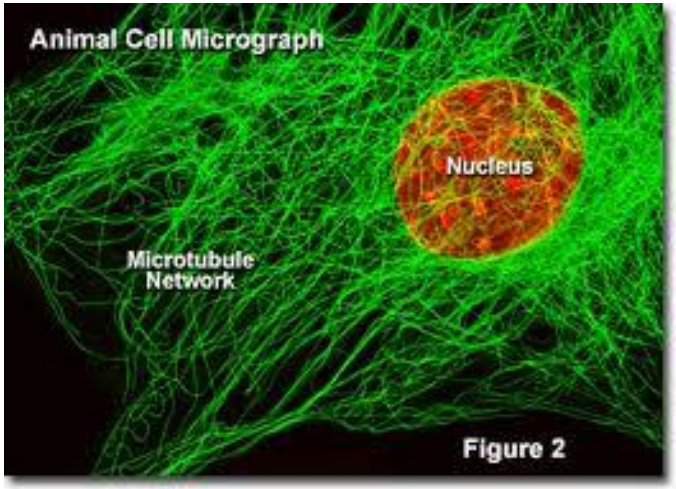
Microfilaments also help cells to move. They can assemble and disassemble rapidly causing movement.

Microtubules are hollow structures. Functions include:



- The separation of chromosomes during cell division

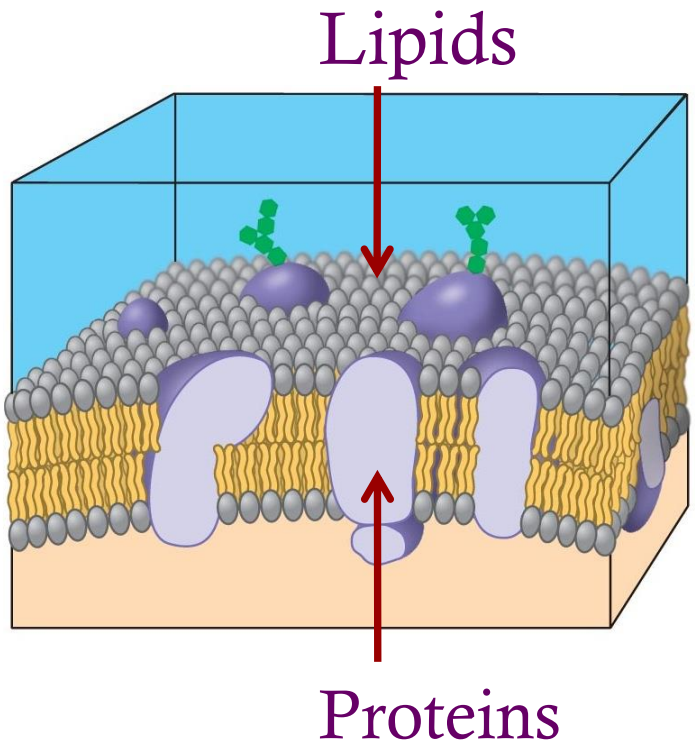
- Cell Shape



- The formation of cilia and flagella

The Cell Membrane

- Also called the plasma membrane.
- Maintains the shape of the cell.
- Separates one animal cell from the next.
- Regulates the passage of materials into and out of the cell.

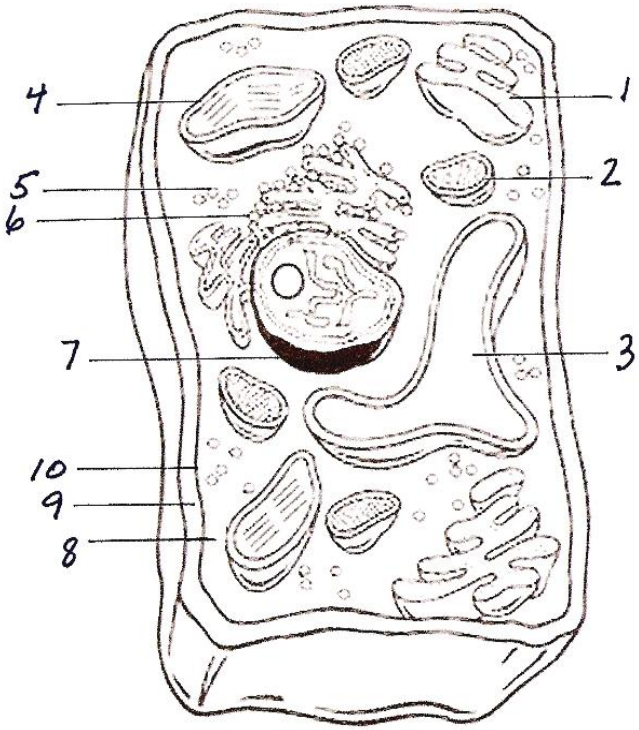


- Made mostly of lipids and proteins.

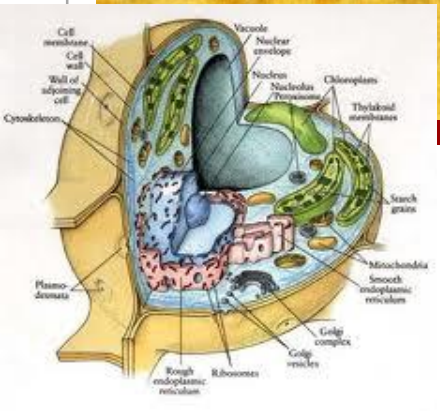
A plant cell has many of the same parts found inside an animal cell, but there are a few organelles that are only found in plant cells.

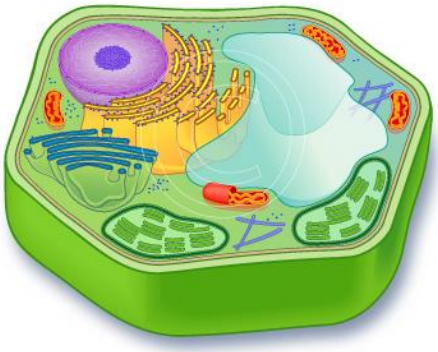
The Plant Cell

- 1 – Golgi Apparatus
- 2 – Mitochondria
- 3 – Central Vacuole
- 4 – Chloroplasts
- 5 – Ribosomes
- 6 – Endoplasmic Reticulum
- 7 – Nucleus
- 8 – Cytoplasm
- 9 – Cell Wall
- 10 – Cell Membrane



Differences Between Plant and Animal Cells





Structures never found in plant cells:

- Lysosomes
- Centrioles
- Flagella

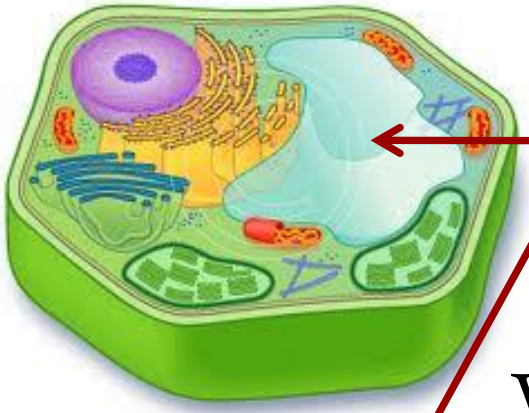
Animal Cells

Plant Cells

Structures never found in animal cells:

- Plastids (Chloroplasts)
- Central Vacuole
- Cell Wall

Large, Central Vacuole



Central Vacuole

A central vacuole is a very large vacuole found in mature plant cells.

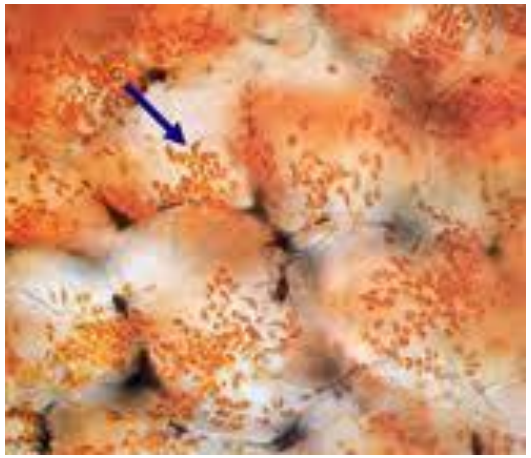
When filled with water, it creates turgor pressure to give strength and support to the cell. This allows the plant to support heavy structures such as flowers and leaves.

It can also serve as a storage area for organic compounds

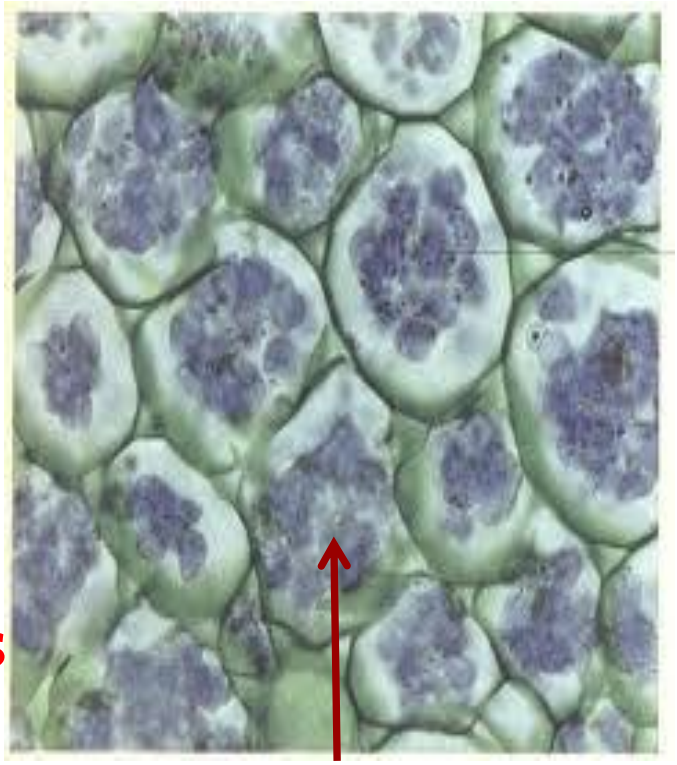
There are three types of plastics found in plant cells:

Plastids

← Chloroplasts



← Chromoplasts



Leukoplasts

Chloroplasts

thylakoids

Chloroplasts are only found in plant cells and other unicellular organisms that do photosynthesis.

A chloroplast is where photosynthesis takes place.

$$6CO_2 + 6H_2O + \text{☀} \rightarrow C_6H_{12}O_6 + 6O_2$$

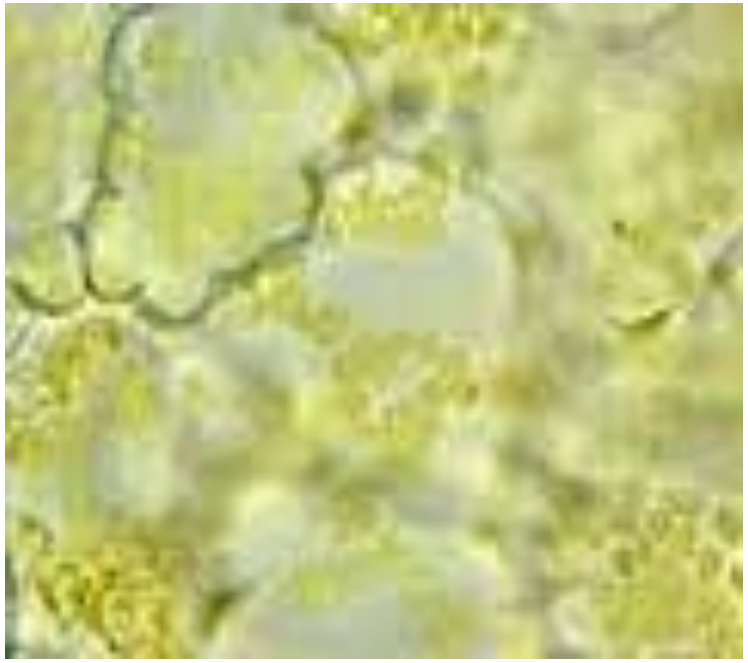
Chloroplasts absorb the energy from the sun and convert it to the chemical energy of a molecule of glucose or sugar.

Chloroplasts are surrounded by an outer and an inner membrane.

A chloroplast is similar to a solar power plant.

Inside the chloroplast are large stacks of other membranes called thylakoids. These thylakoids contain the green pigment chlorophyll which is required for photosynthesis.

Chromoplasts



"Chromo" means color.

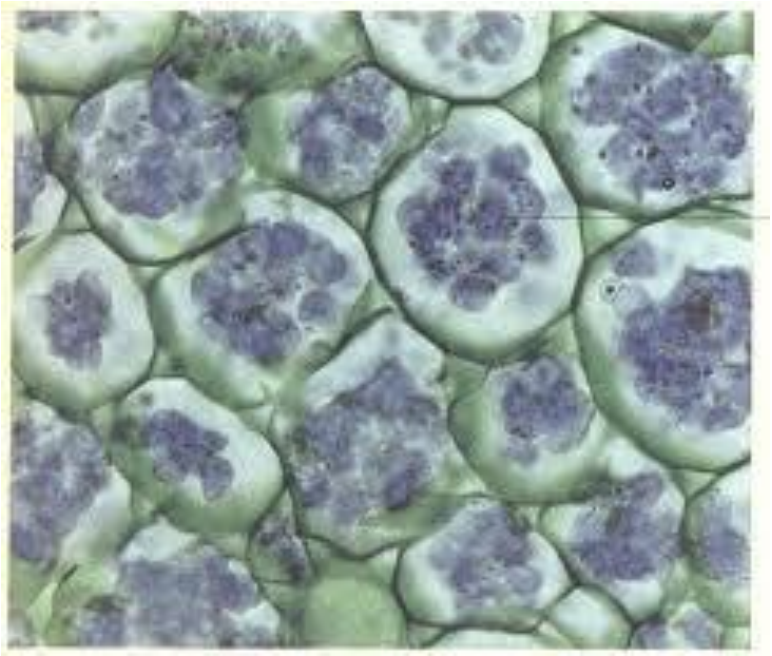
Chromoplasts contain pigments of all colors except green.

Chromoplasts give fruits and flowers their colors.

Flowers need color to attract insects for pollination.

Fruits need color to attract animals for seed dispersal.

Leukoplasts



- Leukoplasts have no color.
- This is an area of starch storage inside a cell.

Cell Wall

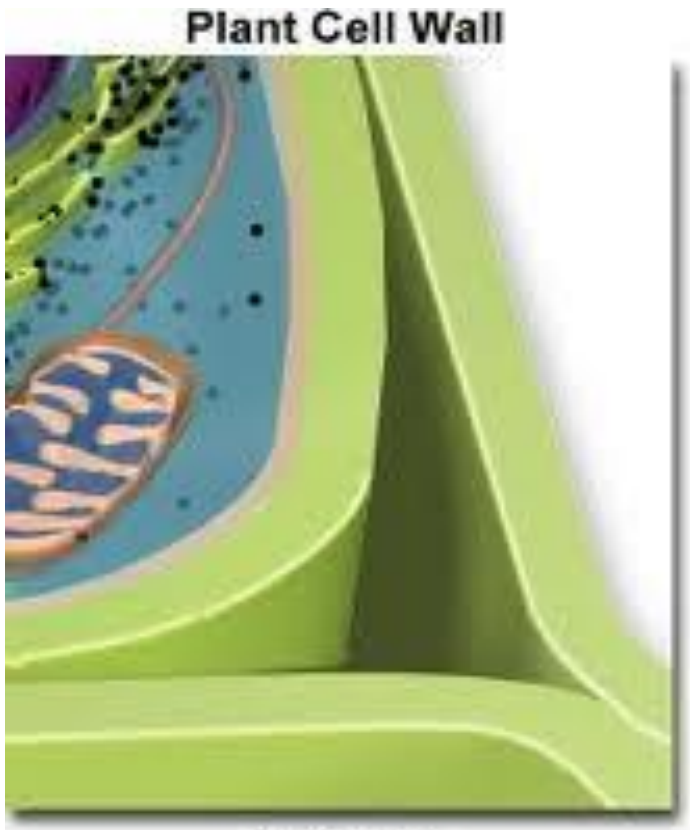
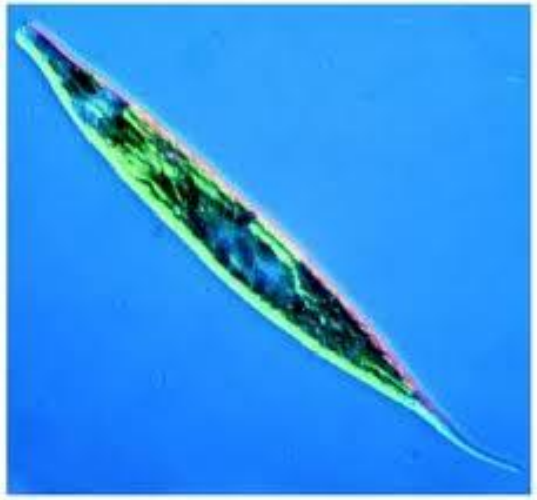


Figure 1

- The cell wall is a supporting structure found in the cells of plants and fungi.
- The main function of the cell wall is to provide support and protection for the cell.
- The cell wall is composed mostly of cellulose, a tough carbohydrate fiber.

The different levels of cellular organization include:

Unicellular



Colonial

Multicellular

Unicellular Organisms

A unicellular organism is composed of a single cell.

Examples: bacteria, yeast, ameba

Colonial Organisms

1. Unicellular organisms that live together in groups.
2. The cells have no relationship to each other.
3. There is no specialization or differentiation.

Multicellular Organisms

1. A multicellular organism is a group of cells that live and work together in one organism.

2. There is differentiation and cell specialization.
3. Advantage of having cell specialization:

   A cell that only has to do one function can be much more efficient at that one job.

4. Disadvantage of cell specialization:

   The cells are dependent upon one another. If one group of cells fails to do its job, the other cells will perish.

Levels of Organization

1. Cell : A cell that becomes specialized for just one function

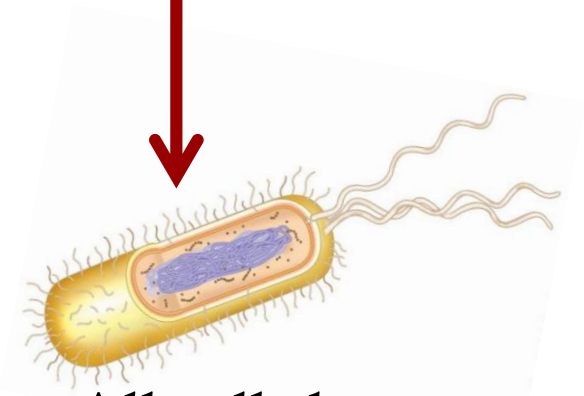
2. Tissue: A group of similar cells all performing a similar activity

3. Organ: A group of several tissues functioning as a unit and performing the same function.

4. Organ System: Organs work together to form systems.

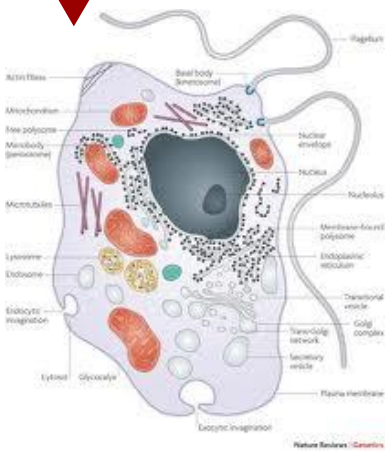
5. Organism: Various systems work together to form a multicellular organism.

Prokaryotic and Eukaryotic Cells



All cells have two characteristics in common:

- They are surrounded by a barrier called a cell membrane.
- They contain DNA.



All cells fall into two broad groups, depending on whether or not they contain a nucleus.

- Prokaryotic Cells
- Eukaryotic Cells

Prokaryotic Cells

Prokaryotic cells lack…

… a nucleus and membrane-bound organelles.

Prokaryotic cells have genetic material (DNA) that is not contained inside a nucleus. No membrane separates this from the rest of the cell.

Prokaryotic cells are generally smaller and simpler than eukaryotic cells.

Prokaryotic cells have a cell wall.

Prokaryotic cells have cell membranes and ribosomes.

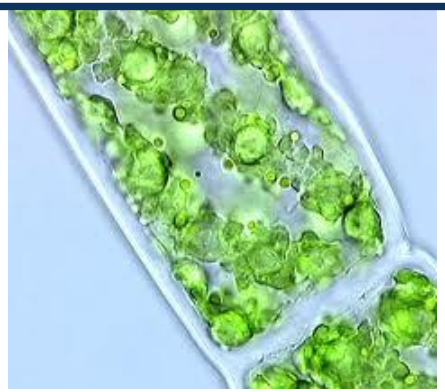
Bacteria are prokaryotic cells.

Eukaryotic Cells

Eukaryotic cells are generally larger and much more complex than prokaryotic cells.

Eukaryotic cells have:

A true nucleus and membrane-bound organelles.



Plants, animals, protists, and fungi all have eukaryotic cells.

Eukaryotic cells contain a <u>nucleus</u> which is kept separate from the rest of the cell.

Structure of the Cell Membrane

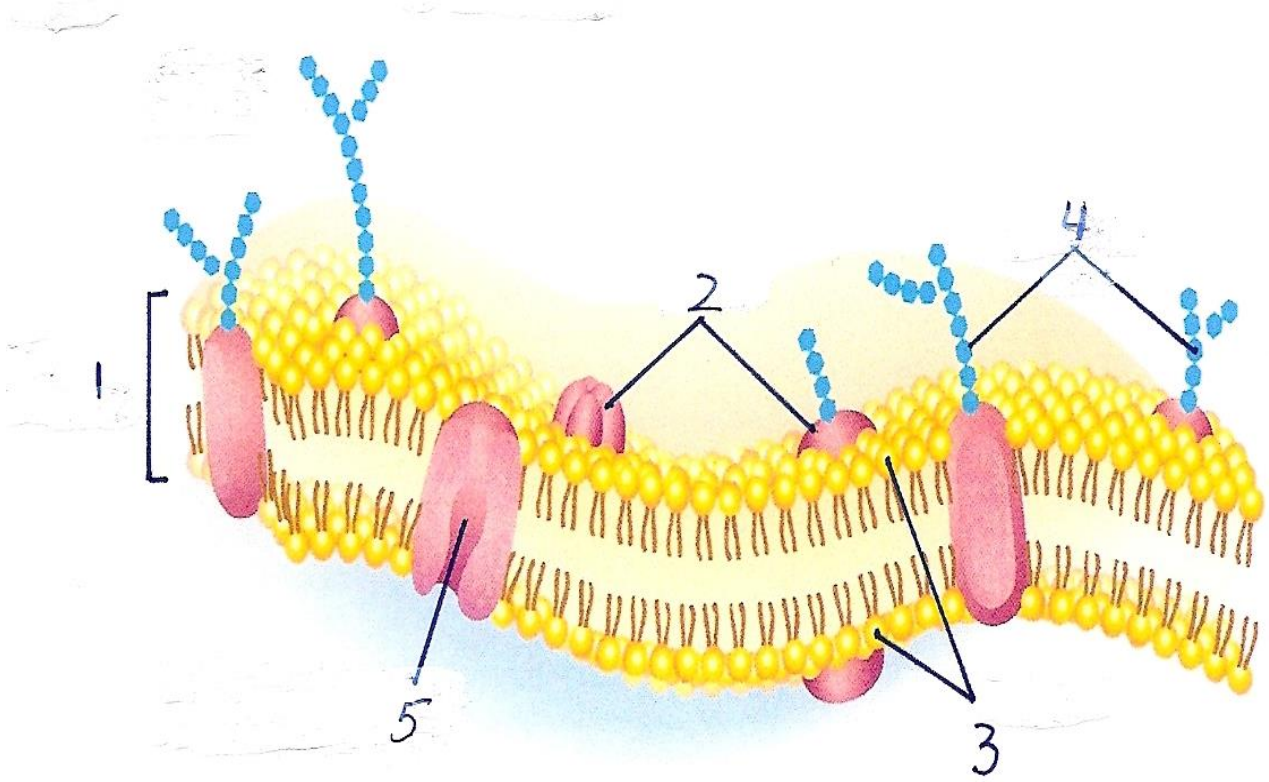
1 Cell Membrane

2 Proteins

3 Lipid Bilayer

4 Carbohydrates

5 Transport Proteins



The cell membrane regulates what enters and what leaves the cell.

It also provides protection and support to the cell.

The membrane consists of a lipid bilayer (double layer) in which proteins are embedded. The lipid bilayer gives the membrane a flexible structure that forms a strong barrier between the inside and the outside of the cell.

Many of the proteins form channels and pumps to help move materials across the membrane.

The carbohydrates serve as identification markers to help individual cells to identify one another.

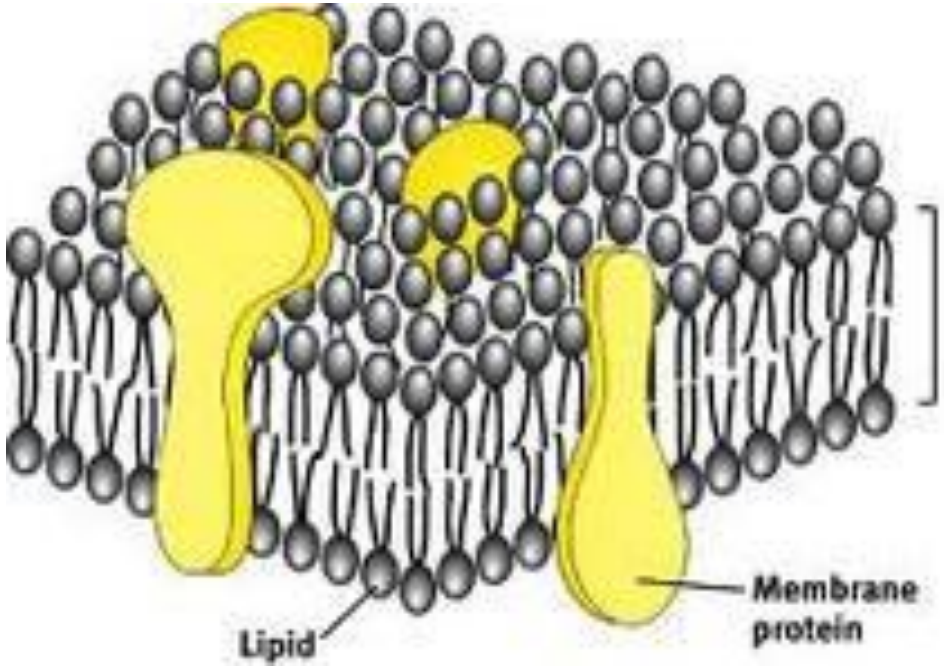
Homeostasis

…. is a balance that organisms maintain through self-regulating adjustments.

It requires self-regulation of materials coming into the cell and going out of the cell.

The cell is an open system: it requires the constant inflow of matter and energy and the constant out flow of waste.

Permeability of the Membrane



The cell membrane is called a selectively permeable membrane or a semipermeable membrane.

It has the ability to let one substance pass through more readily than others; some materials are not allowed to enter at all.

It can control the speed at which molecules are allowed to enter.

The Concentration Gradient

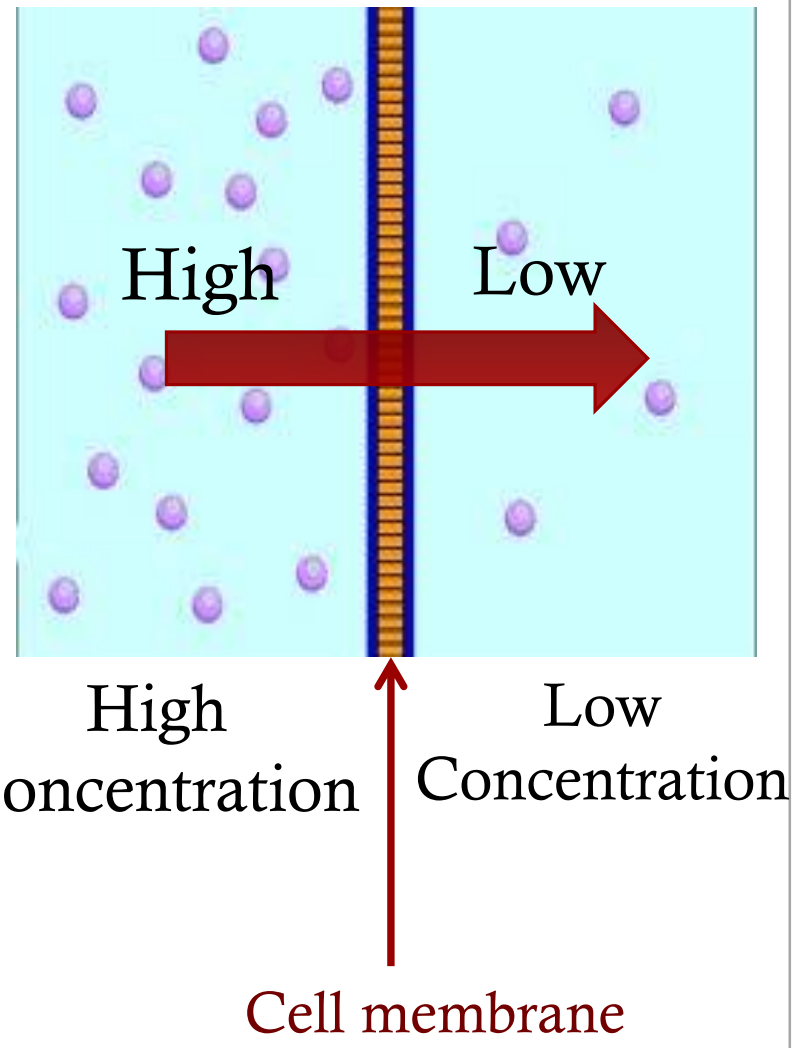
In the absence of other forces, materials will tend to …

… move from an area of high concentration to an area of lower concentration.

Label the area of higher concentration.

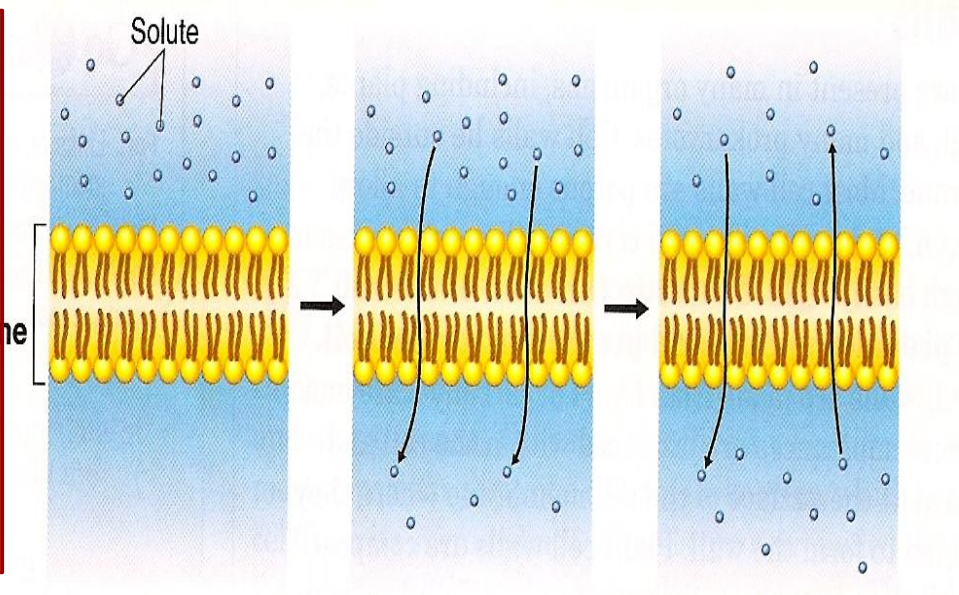
Label the area of lower concentration.

Draw an arrow on the drawing showing the direction of movement for this solute.



Describe what is happening in the drawing below.

A) There is a higher concentration of solute molecules on one side of the membrane.



A. **B.** **C.**

B. The solute molecules move from the side of higher concentration to the side of lower concentration. This movement will continue until the concentration is equal on both sides of the membrane.

C. Equilibrium has been reached; the concentration is equal on both sides of the membrane. There will still be movement in both directions, but the concentrations will remain equal.

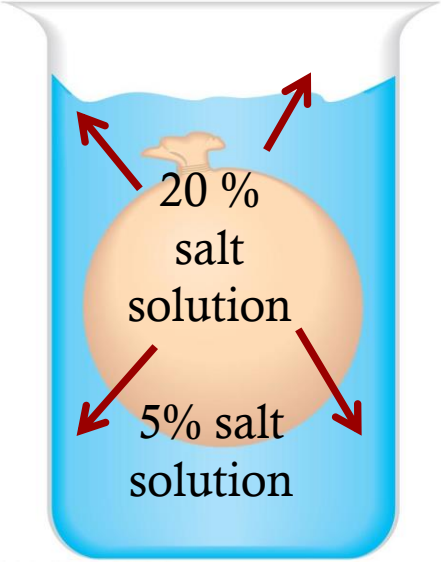
Types of Passive Transport

Passive transport means that …

… no energy is being used to move molecules across the membrane.

Diffusion is the spreading out of molecules from a region of high concentration to a region of low concentration.

In which direction will the salt molecules move?



The salt will move from the high side to the low side. The salt will move out of the bag and into the water.

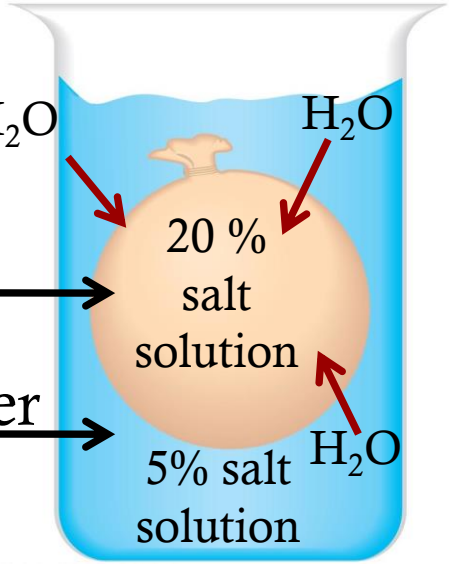
Osmosis

Osmosis is the movement of water across a membrane from a region of high concentration to a region of low concentration.

In which direction will the water molecules move?

The bag is 80% water

The solution is 95% water



The water will move from the high side to the low side. The water will move into the bag.

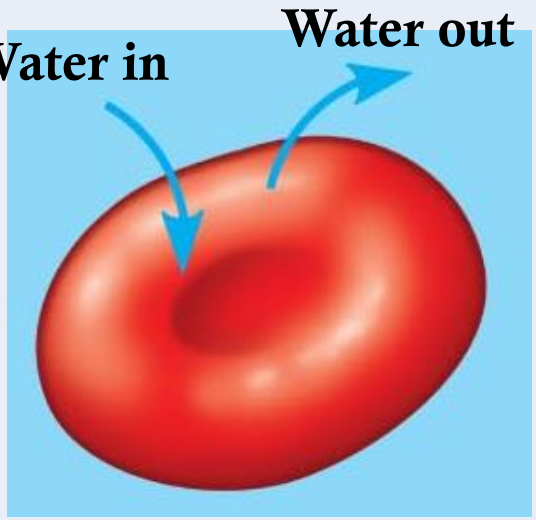
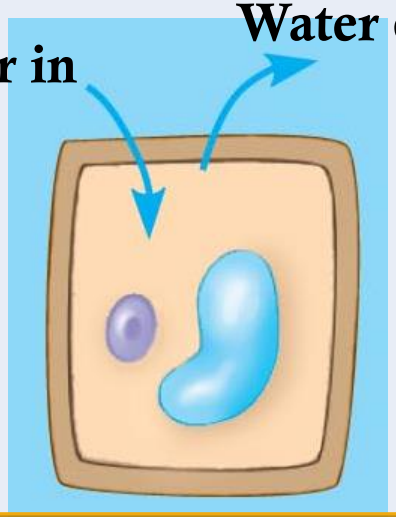
There are three types of water solution:

a)Isotonic Solution

a)Hypertonic Solution

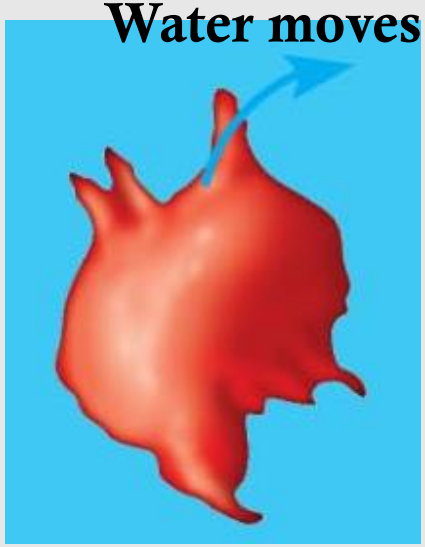
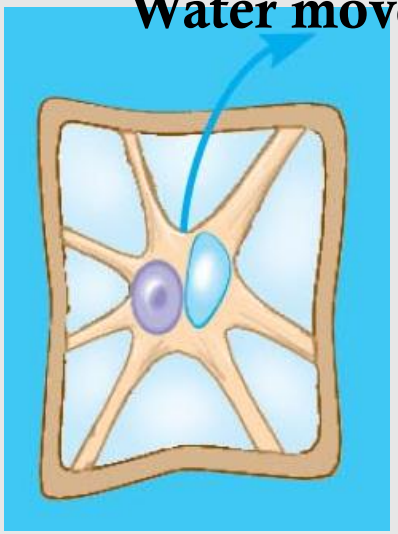
b)Hypotonic Solution

Types of Solutions: Isotonic

Isotonic	Animal Cell	Plant Cell
The amount of water is the same on the inside and the outside of the cell. Water will still flow back and forth across the membrane, but at the same rate in both directions.		

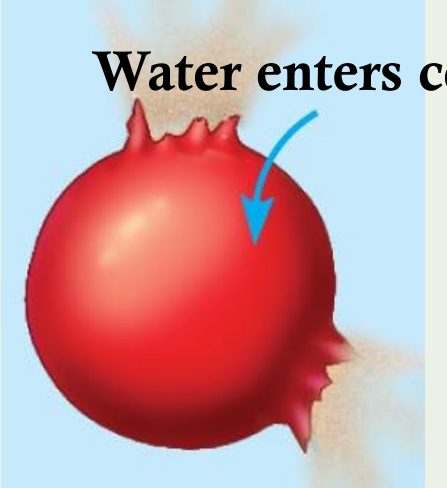
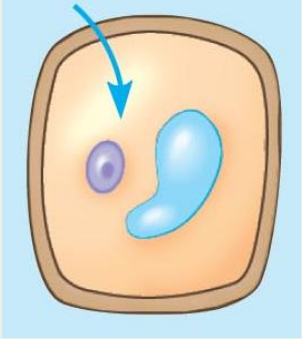
The concentration of water is equal on both sides of the membrane. Water moves in and out of the cell at the same rate.

Types of Solutions: Hypertonic

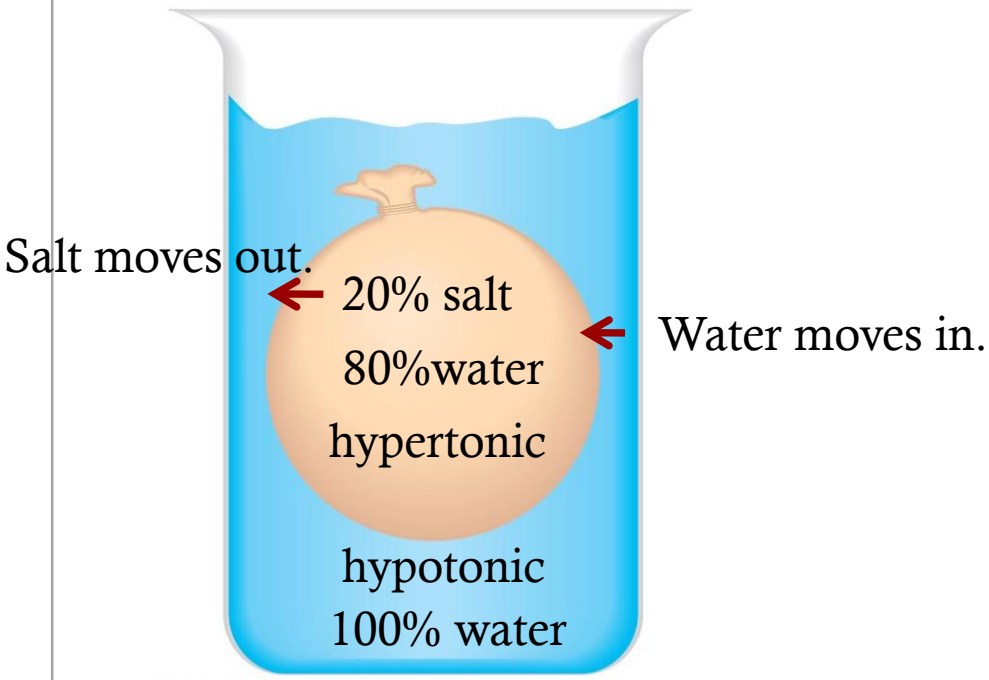
Type of Solution	Animal Cell	Plant Cell
If a cell is placed in a hypertonic solution, there is _more_ water on the _inside_ of the cell than on the _outside_ of the cell. There is a net movement of water _out_ of the cell.	**Water moves out.**  **Plasmolysis has occurred.**	**Water moves out.**  **Plasmolysis has occurred.**

Plasmolysis: Too much water moves out and the cell collapses.

Types of Solutions: Hypotonic

Type of Solution	Animal Cell	Plant Cell
If a cell is placed in a hypotonic solution, there is _more_ water on the _outside_ of the cell than on the inside of the cell. There is net movement of water _into_ the cell. Cytolysis: Too much water moves in & the cell membrane bursts because of the water pressure.	 **Cytolysis has occurred.**	**Water enters cell.**  In cells with a cell wall, cytolysis is not likely to occur. The central vacuole of a plant cell will become extremely full of water. Turgor pressure will increase. This helps to give structure and support to a plant cell.

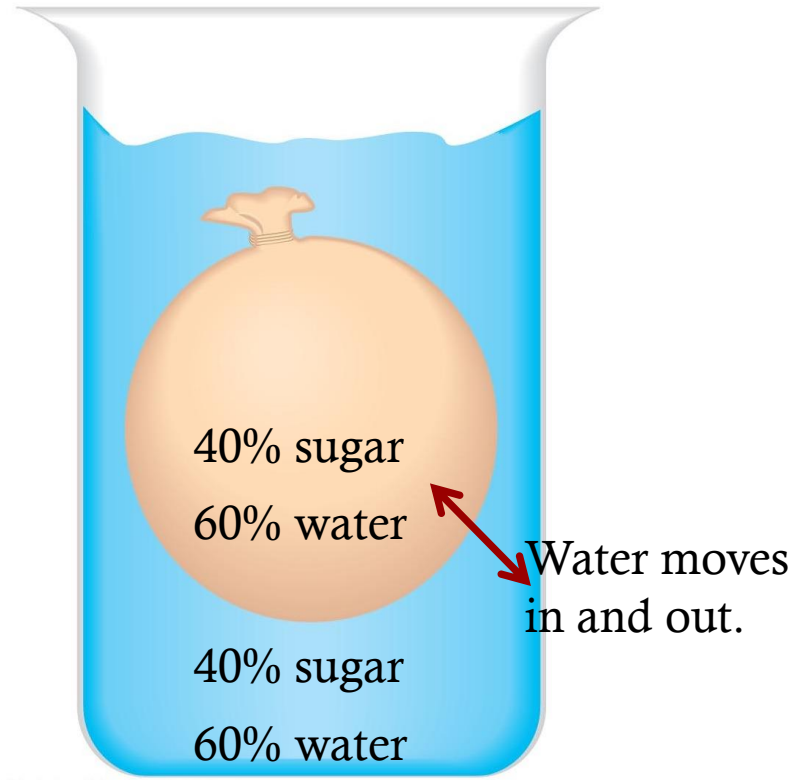
Label the drawing as we work through this.



Water always moves from an area of higher concentration to an area of lower concentration. In other words, water moves from the hypotonic side to the hypertonic side.

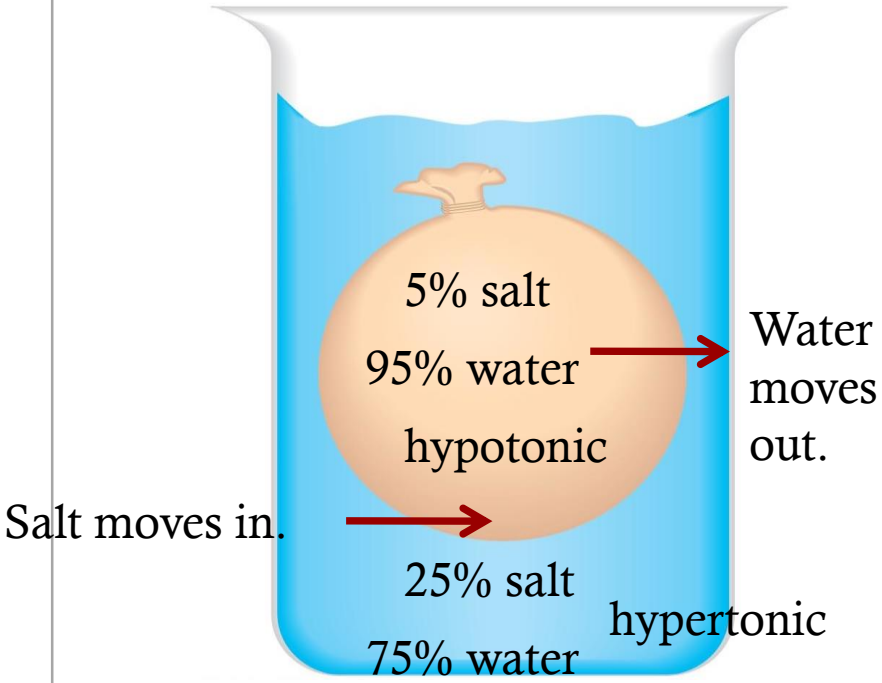
- 1. The bag contains a 20% salt solution.
- 2. The water surrounding the bag is pure (100%) water.
- 3. What is the concentration of water inside the bag? 80%water
- 4. Is the bag hypotonic or hypertonic to the water on the outside? hypertonic
- 5. Is the water on the outside hypertonic or hypotonic to the bag? hypotonic
- 6. In which direction will water move? Water moves in.
- 7. In which direction will salt move? Salt moves out.
- 8. What process might occur if too much water moves into the bag? cytolysis
- 9. The movement of the salt and the water will continue until??? Both sides are equal.
- 10. After equilibrium has been reached, what will happen to the movement of these molecules? Movement will continue in both directions, but the equilibrium will be maintained.

Label the drawing as we work through this.



- 1. The bag contains a 40% sugar solution.
- 2. The water solution surrounding the bag contains a 40% sugar solution.
- 3. What is the concentration of water inside the bag? 60% water
- 4. What is the concentration of water on the outside of the bag? 60% water
- 5. What type of solutions are these? isotonic
- 6. In which direction will water move? Water moves in and out.

Label the drawing as we work through this.



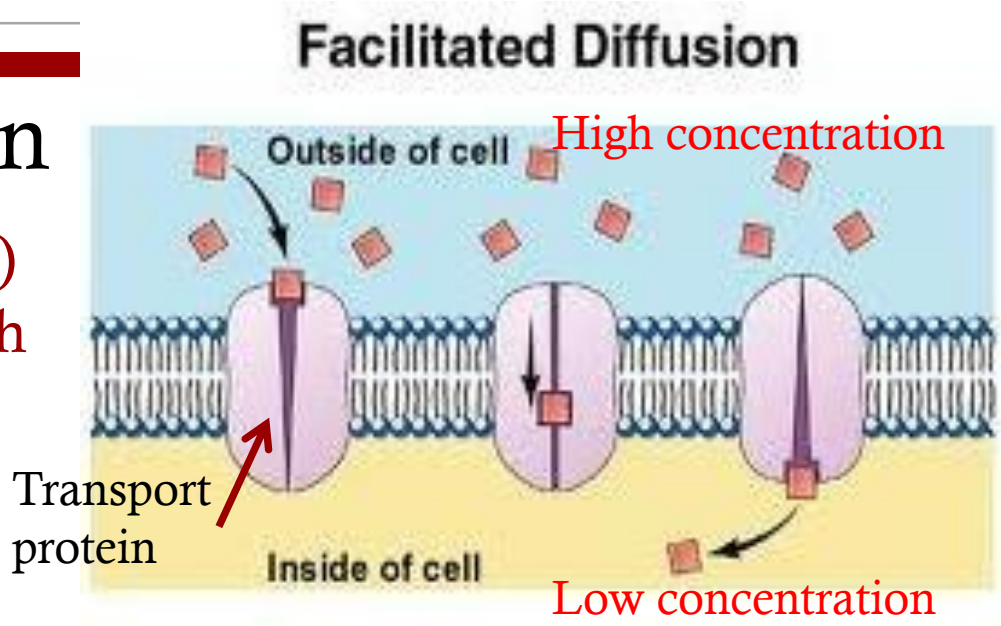
Water always moves from an area of higher concentration to an area of lower concentration. In other words, water moves from the hypotonic side to the hypertonic side.

- 1. The bag contains a 5% salt solution.
- 2. The water surrounding the bag contains a 25% salt solution.
- 3. What is the concentration of water inside the bag?
  95% water
- 4. What is the concentration of water outside the bag?
  75% water
- 5. Is the bag hypotonic or hypertonic to the water on the outside?
  hypotonic
- 6. Is the water on the outside hypertonic or hypotonic to the bag?
  hypertonic
- 7. In which direction will water move?
  Water moves out.
- 8. In which direction will salt move?
  Salt moves in.
- 9. What process might occur if too much water leaves the bag?
  plasmolysis
- 10. The movement of the salt and the water will continue until???
  Both sides are equal
- 11. After equilibrium has been reached, what will happen to the movement of these molecules?
  Movement will continue in both directions, but the equilibrium will be maintained.

Facilitated Diffusion

Polar molecules (water, glucose) have difficulty crossing through the lipid bilayer of the membrane.

Transport proteins help these molecules to pass through the membrane more easily.



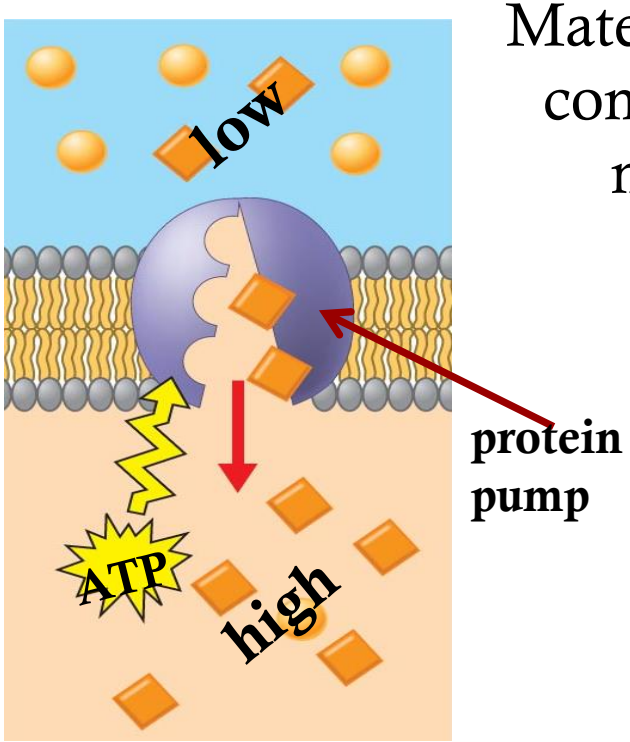
Polar molecules cross directly through the protein without coming into contact with the lipid bilayer.

This is known as facilitated diffusion because these proteins "facilitate or help" the diffusion of these molecules across the membrane.

Facilitated diffusion is considered passive transport because the solute is moving down its concentration gradient.

Facilitated diffusion speeds the passage of a solute by providing a passage through the membrane. It does not alter the direction of transport.

Active Transport



Materials must sometimes move against the concentration gradient. The cell must often move materials from an area of low concentration to an area of higher concentration.

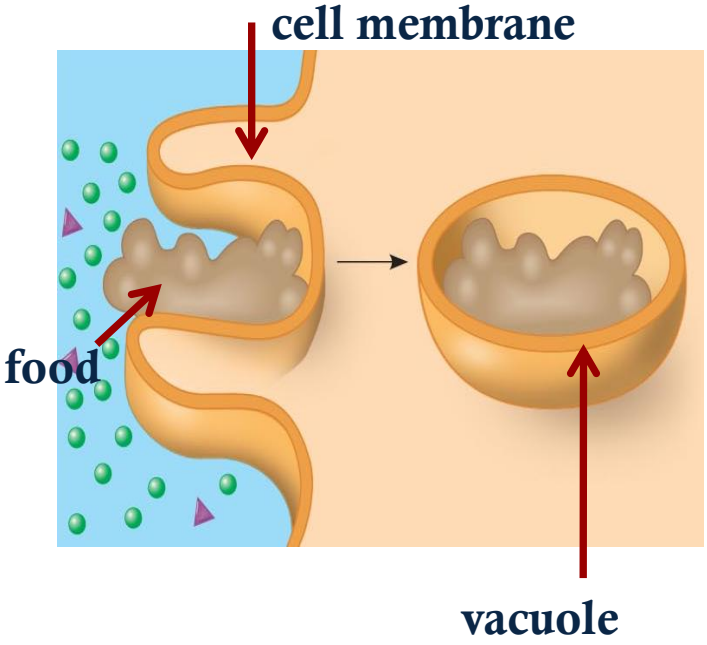
This is called…

…active transport, and the cell must expend energy to accomplish it.

If small molecules and ions need to be moved across the membrane against the concentration gradient, it will require the use of protein pumps that are embedded in the membrane. This use of protein pumps requires much energy.

Large molecules may have to be transported by a movement of the cell membrane.

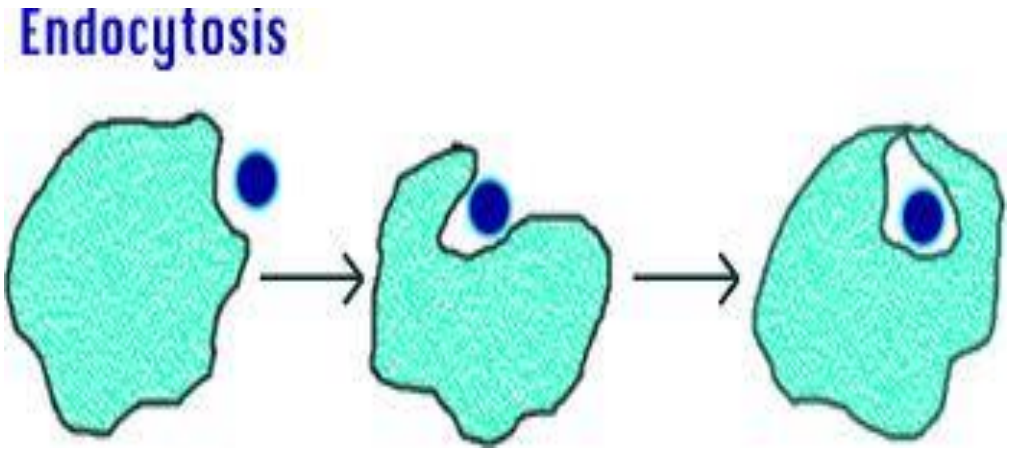
__Endocytosis__ is the process of taking material into the cell by means of infoldings, or pockets, of the __cell membrane__. The pocket that results breaks loose from the cell membrane and forms a __vacuole__ within the cytoplasm. Large molecules and clumps of food are taken up in this way.



This requires much energy.

Two types of endocytosis are:

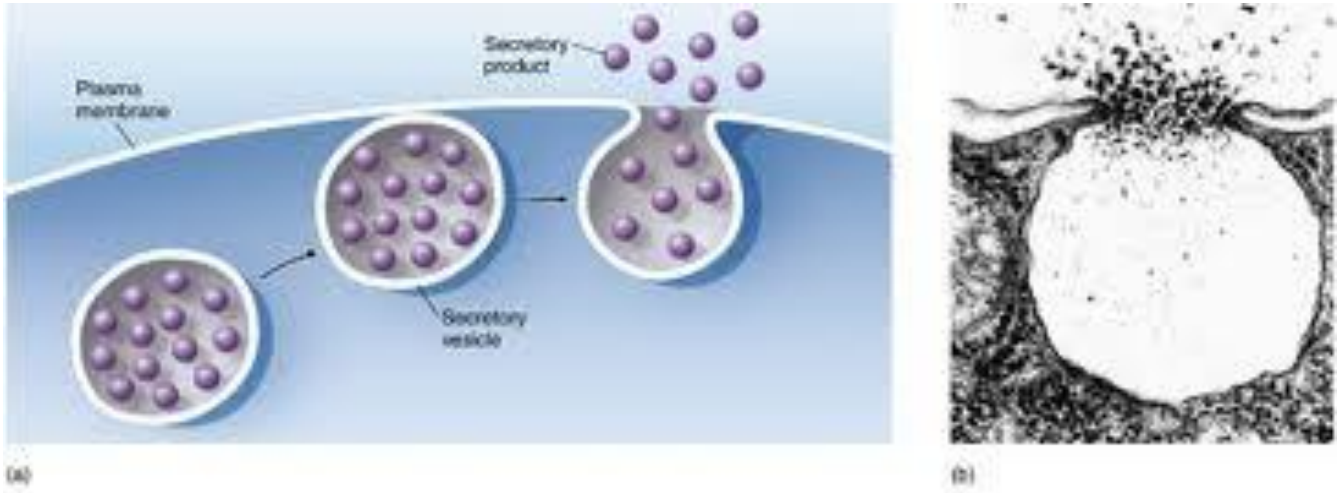
- Phagocytosis
- Pinocytosis



Phagocytosis is the engulfing of large food particles.

Pinocytosis is "_cellular drinking_". The cell surrounds and engulfs droplets of extracellular fluid. It is not the fluid that is needed, but the molecules dissolved in the droplets.

Exocytosis



Exocytosis is the release of large materials from the cell.

A vacuole fuses with the cell membrane, forcing the contents out of the cell.