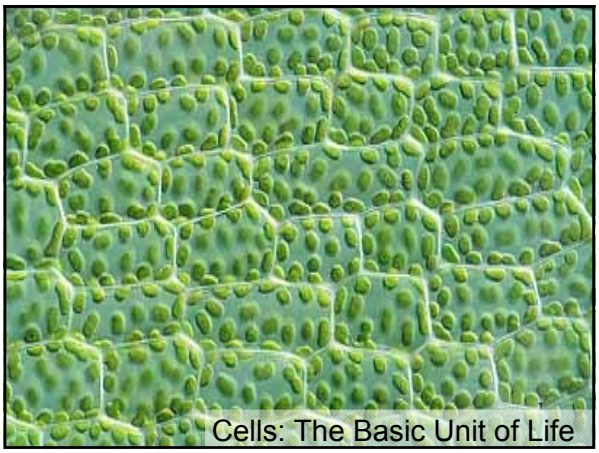


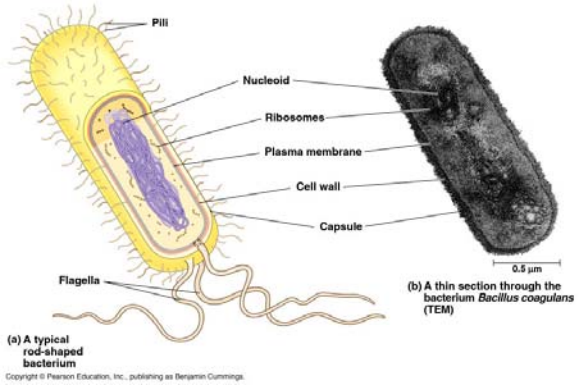
Cell Theory

1. **All living things are composed of one or more cells**
2. **Cells are the basic unit of structure and function of living things**
3. **All cells are produced from other cells**

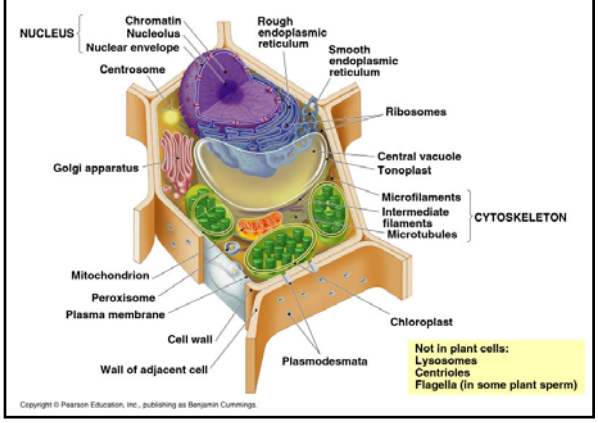
Two Types of Cells

- **Prokaryotic: Do not have a membrane enclosed nucleus**
  - **Example: bacteria and archae**
- **Eukaryotic: Have a membrane enclosed nucleus to protect their DNA**
  - **Example: Plants, Animals, Fungi, Protists**

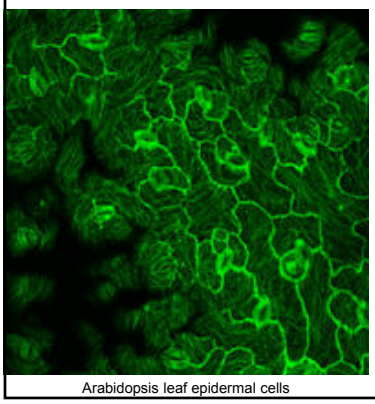
A prokaryotic cell



Overview of a plant cell



What we can see



Arabidopsis leaf epidermal cells

- Plant and animal cells can be easily seen using the compound light microscopes we have at school.

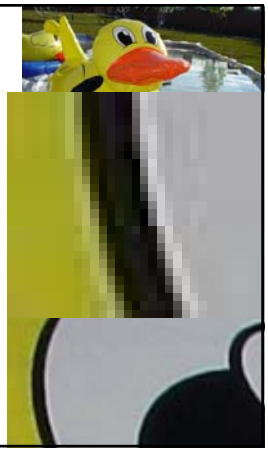
- Not all organelles are readily apparent using the light microscope.

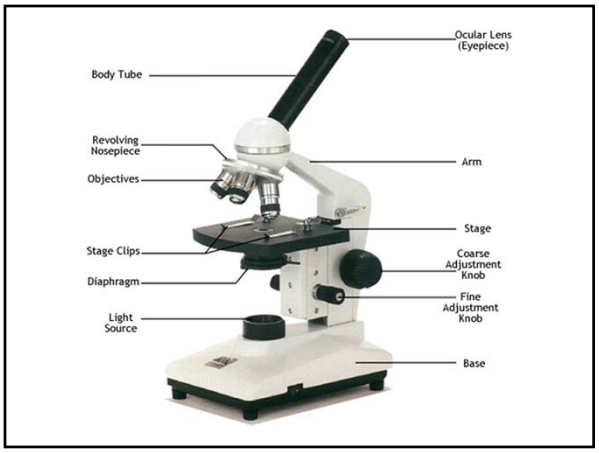
Compound Light Microscope

- The term light refers to the method by which light transmits the image to your eye.
- Compound deals with the microscope having more than one lens.
- Microscope is the combination of two words; "micro" meaning small and "scope" meaning view.

Microscopes

- The main function of a microscope is to magnify small objects.
- However, the clarity of what you see is just as important…the resolving power of a microscope is its ability to distinguish 2 closely positioned objects as being separate.

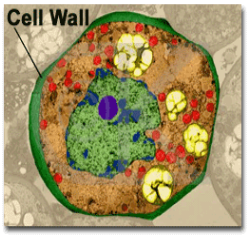




Electron Microscopes

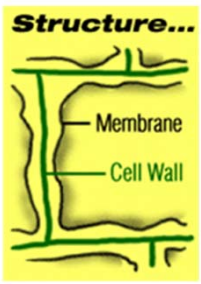
- It wasn't until the use of EM that biologist were able to study the insides of cells.
- Today we know that cells are made up of smaller parts called organelles

Cell Anatomy



- Cell Wall→
  - rigid layer of nonliving material
  - Provide protection & support
  - Found in plant, some bacteria, some protists and some, fungi

Cell Anatomy

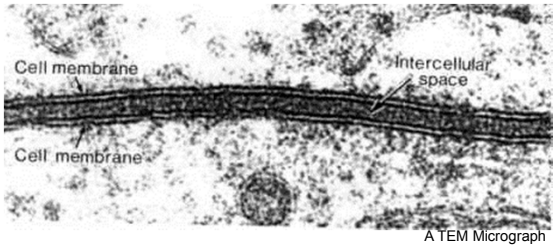


- Cell membrane
  - The outer layer of animal cells, found inside cell walls (if wall is present)
  - Controls what enters and leaves the cell
  - Most important organelle in terms of maintaining homeostasis

What is Homeostasis?

Homeostasis = Maintaining a Balance

- Cells must keep the proper concentration of nutrients and water and eliminate wastes.
- The cell membrane is selectively permeable – it will allow some things to pass through, while blocking other things.

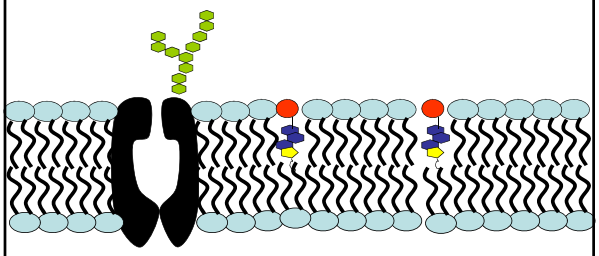


A TEM Micrograph

The cell membrane is made up of two layers of molecules called phospholipids

The job of the cell membrane is to regulate the movement of materials into and out of the cell.

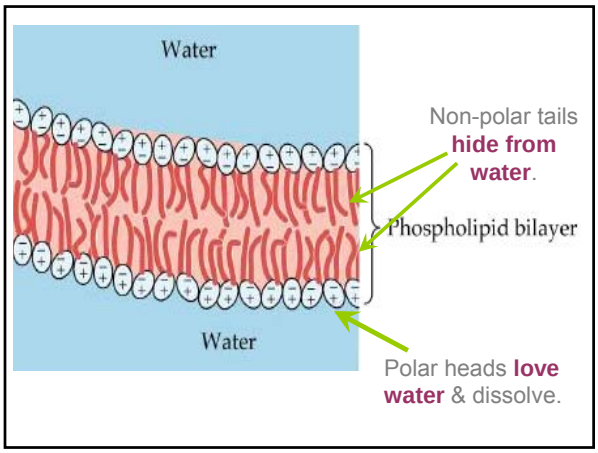
The Cell Membrane is described using the fluid mosaic model



What is a Phospholipid?

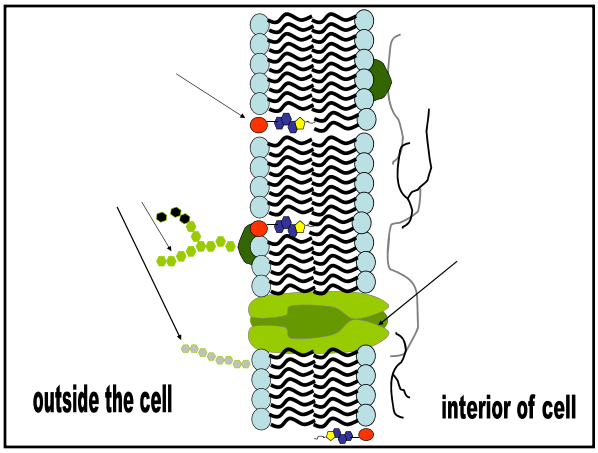
What's a Phospholipid?

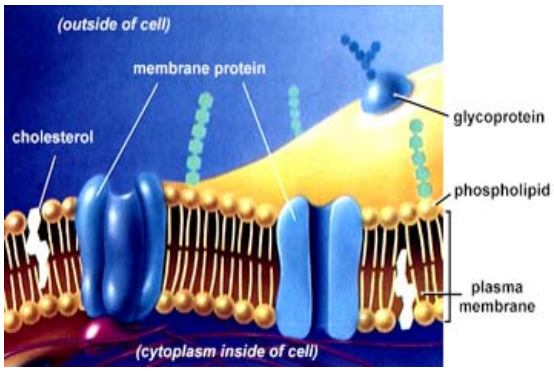
- It's a pair of fatty acid chains and a phosphate group attached to a glycerol backbone.
  - Polar heads (water-loving) face out and the
  - **nonpolar fatty acid tails** hang inside.



Membrane Proteins

- Determine what particles can pass through the membrane.
- Serve as enzymes (speed up reactions).
- Act as markers that are recognized by chemicals and molecules from the inside and the outside of the cell (the immune system).





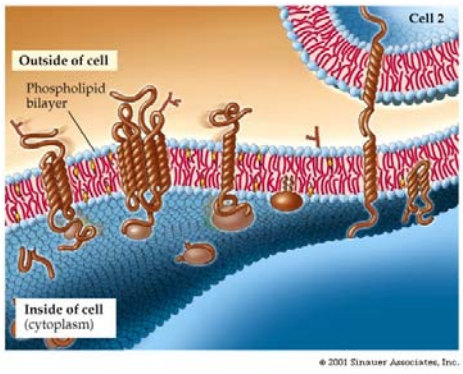
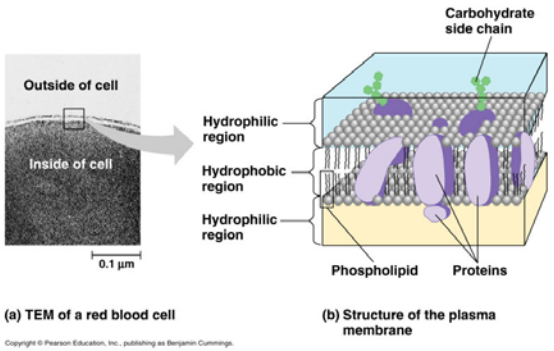
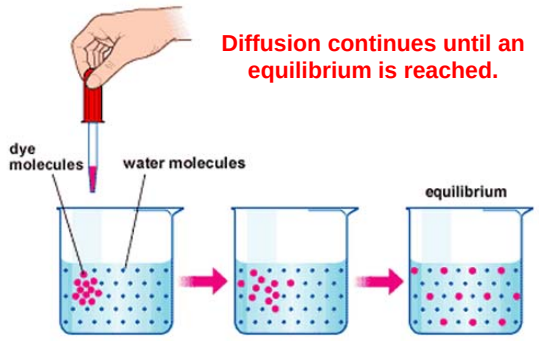


Figure 7.6 The plasma membrane



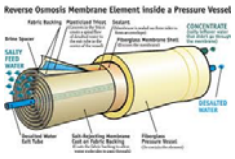
Diffusion

- The movement of particles from an area of high concentration to an area of low concentration caused by kinetic energy.
  - Kinetic Energy (movement of particles because of the movement of their atoms).



Osmosis

- Diffusion of water across a selectively permeable membrane.
- Occurs until water is balanced on both sides of the membrane.



Solute: A solute is a substance that is dissolved in a solvent.

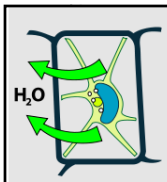
For example, when sugar (solute) is dissolved in water (solvent).

Solvent: **A solvent** (from the Latin solvō, "loosen, untie") **is a substance that dissolves a solute** resulting in a solution.

Solution: A homogeneous mixture of two or more substances.

Cell Concentrations

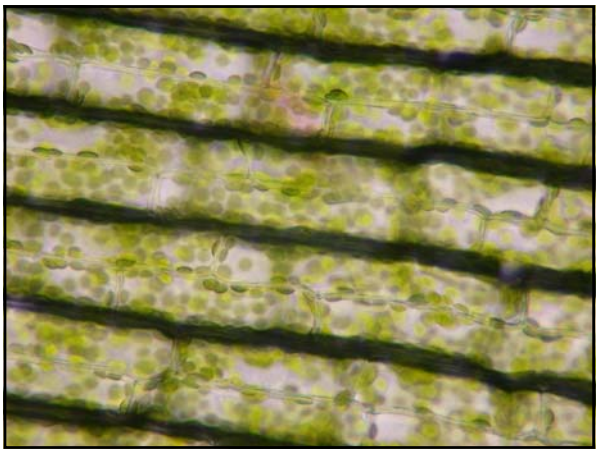
- Hypertonic solutions – when one solution has more dissolved solute (less % of water).
- Hypotonic solutions – the solution with a lower concentration of dissolved solute (more % of water).
- Isotonic solutions – the same concentration of dissolved solute.

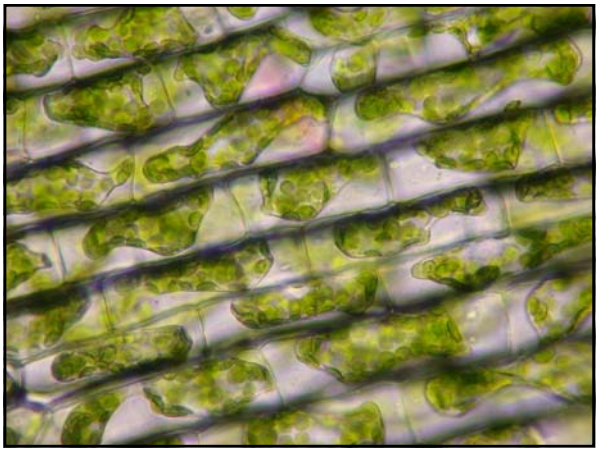


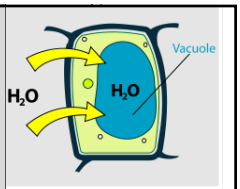
Hypertonic Environment

When plant cells are placed in a Hypertonic solution – the cells will have more water than the environment (the cell's internal fluid is hypotonic to the environment). The water inside the cell will then move outwards to reach equilibrium. This will cause the cell to shrink as it loses water.

The cell membrane will SHIRNK



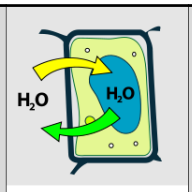




Hypotonic Environment

When plant cells are placed in a Hypotonic solution – the cells will have more water than the environment (the cell's internal fluid is hypertonic to the environment). The water **outside** the cell will then move **inwards** to reach equilibrium. This will cause the cell to swell as it gains water.

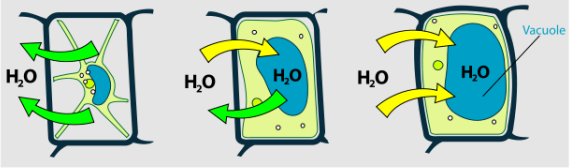
The cell membrane will SWELL. Luckily the cell wall will then prevent the membrane from growing so large that it bursts.



Isotonic Environment

When plant cells are placed in a **Isotonic solution** – the cells will have more water than the environment (the cell's internal fluid **is** Isotonic to the environment). The water **outside** the cell will then move **inwards** while the water inside the cell moves **outwards.**

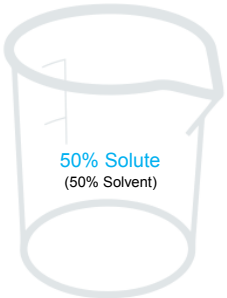
The Cell will stay the same



Hypertonic Environment	Isotonic Environment	Hypotonic Environment
Hypotonic Cell	Isotonic Cell	Hypertonic Cell
Cell will lose water and shrink	Cell will stay the same	Cell will gain water and swell

If a red blood cell is placed within a solution containing 50% solute what will be the effect of diffusion on the cell if the cell membrane is impermeable to the solute?

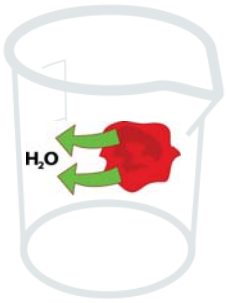
5% Solute
(95% Solvent)



50% Solute
(50% Solvent)

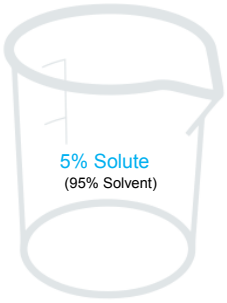
If a red blood cell is placed within a solution containing 50% solute what will be the effect of diffusion on the cell if the cell membrane is impermeable to the solute?

Since the Solute cannot exit the cell (the membrane is impermeable to solute) the red blood cell will lose water to the beaker as the solvent flows out to reach equilibrium.



If a red blood cell is placed within a solution containing 5% solute what will the effect of diffusion be on the cell if the cell membrane is impermeable to the solute?

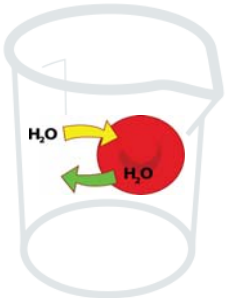
5% Solute
(95% Solvent)



5% Solute
(95% Solvent)

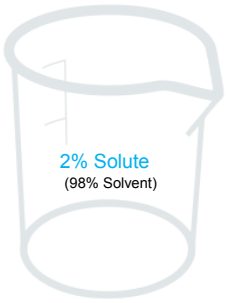
If a red blood cell is placed within a solution containing 5% solute what will the effect of diffusion be on the cell if the cell membrane is impermeable to the solute?

Since the amount of solvent is equal both inside and outside the red blood cell the amount of solvent entering will be equal to the amount of solvent exiting



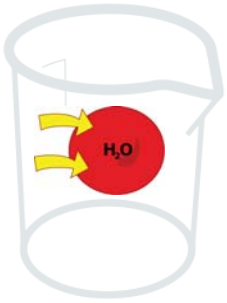
If a red blood cell is placed within a solution containing 2% solute what will the effect of diffusion on the cell if the cell membrane is impermeable to the solute?

5% Solute
(95% Solvent)



If a red blood cell is placed within a solution containing 2% solute what will the effect of diffusion on the cell if the cell membrane is impermeable to the solute?

Since the Solute cannot exit the cell (the membrane is impermeable to solute) the red blood cell will gain water to the beaker as the solvent flows into the cell as it tries to reach equilibrium.

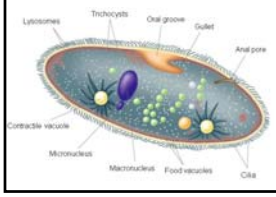


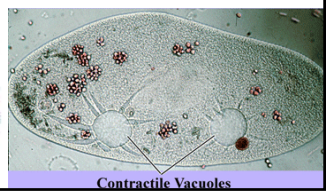
Cell Concentrations

- Hypertonic solutions – when one solution has greater concentration of impermeable solutes (less water).
- Hypotonic solutions – the solution with a lower concentration of impermeable solutes (more water).
- Isotonic solutions – the solution has the same concentration of impermeable solute.

Overcoming Osmosis

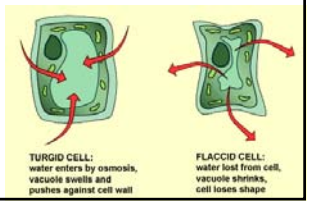
- Contractile vacuoles – expel excess water from paramecium that live in fresh water.
  Uses energy to pump water out.





Overcoming Osmosis

- Turgor pressure – water pressure pushing out on cell wall.
- Loss of turgor pressure causes wilting (plasmolysis).
- Only in plants



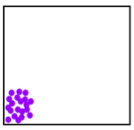
Cellular Transport

- Passive transport – no energy is needed to move particles.
  1. Diffusion
  2. Facilitated diffusion
  3. Osmosis

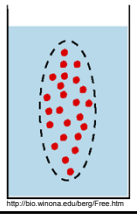
Diffusion is a type of Passive Transport

1. **Diffusion**: <u>random</u> movement of particles **from an area of high concentration to an area of low concentration**.

   (***High to Low***)

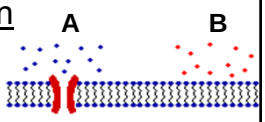


- Diffusion continues until all molecules are evenly spaced (**equilibrium** is reached)-
- ***<u>Note:</u>*** molecules will still move around but stay spread out.



Passive Transport: <u>Facilitated Diffusion</u>

2. **Facilitated diffusion**: diffusion of specific particles **through transport proteins** found in the membrane
   a. Transport Proteins are <u>specific</u> – they "select" only certain molecules to cross the membrane
   b. Transports larger or charged molecules



Facilitated diffusion

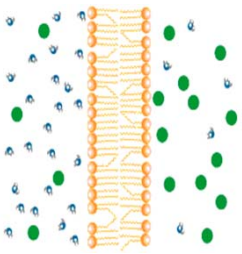
Solute uses the Channel Protein to enter cell)

Diffusion

Solute or more likely solvent moves between the Lipid Bilayer

Passive Transport: **Osmosis**

- **Osmosis**: diffusion of *water* through a selectively permeable membrane
- Water moves from high to low concentrations



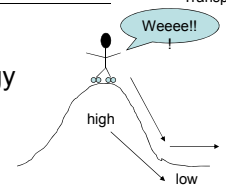
•Water moves freely through pores.

•Solute (green) is too large to diffuse across.

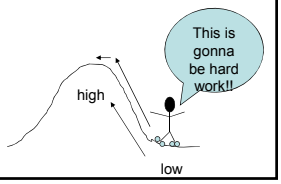
Types of Cellular Transport

•Animations of Active Transport & Passive Transport

- **Passive Transport**
  cell doesn't use energy
  1. Diffusion
  2. Facilitated Diffusion
  3. Osmosis



- **Active Transport**
  cell does use energy
  1. Protein Pumps
  2. Endocytosis
  3. Exocytosis



Cellular Transport

- Active transport – energy is needed to move particles.
  - Carrier proteins – embedded proteins change shape to open and close passages across the membrane.
  - Endocytosis – taking something into the cell.
  - Exocytosis – expelling something from the cell.

Types of Endocytosis

- **Phagocytosis- "Cell eating"** when the membrane is used to surround a large food particle (that is so big it can't fit into a transport protein)
- **Pinocytosis- "Cell Drinking"** when the membrane is used to surround a liquidy food particle (that is so big it can't fit into a transport protein)

Cytoplasm

- contains the organelles
- allows for the transport of substances within the cell;
- provides an environment in which chemical reactions can occur;
- helps to support the cell.

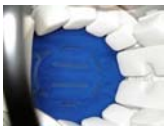
Cytoplasm

Cytoplasm is all of the liquidy stuff inside a cell

Cytoplasm is a colloid (A substance in between a solution and a suspension)

Fog

Jell-O



The gel like consistency of the cytoplasm supports and holds the organelles in place while providing some protection from impact

Cytoplasm

- Cytoplasm is separated from nucleus by the nuclear envelope and from the external environment by the plasma membrane.
- Dissolved in the cytoplasm are salts, minerals and organic molecules (like glucose).

Nucleus

- Nucleus→
  - Stores the recipes for making proteins
  - Contains DNA found on **chromatin** strands
  - Materials pass in and out through nuclear pores in the double layered nuclear membrane

Nucleus

The nucleus controls and regulates the cell's activities by transmitting genetic information during cell division; and by providing instructions for protein synthesis.

It is made up of the following components

•A double membrane-enclosed sac containing:
•Chromatin fibers (which comprise DNA and proteins)
•Nucleoplasm (a gel-like fluid)
•and the nucleolus.

The nucleolus (a dense sphere made of RNA and proteins) makes ribosomal RNA.

Why is the Nucleus more like a library then a brain?

Libraries store information just like the nucleus stores DNA. DNA on it's own does not actually do anything. The information stored within the molecule is what is important.

Brains on the other hand are used to make decisions and actively participate in the running of the organisim.

Figure 7.9 The nucleus and its envelope

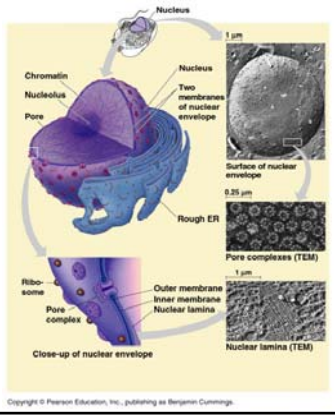
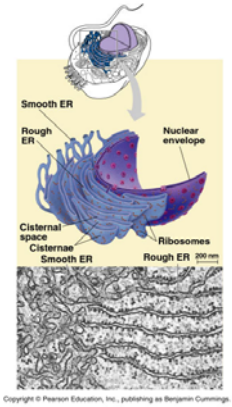
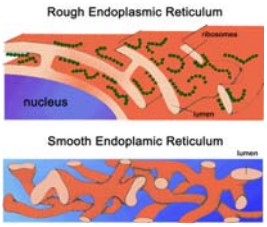


Figure 7.11 Endoplasmic reticulum (ER)



Cell Anatomy



- Endoplasmic Reticulum→ (ER)
  - Carry proteins and other materials through the cell

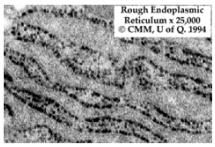
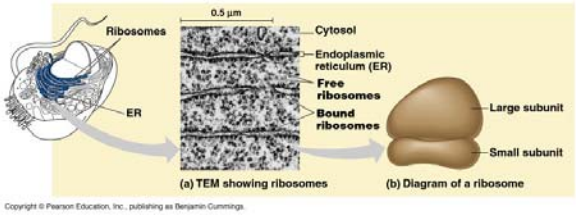
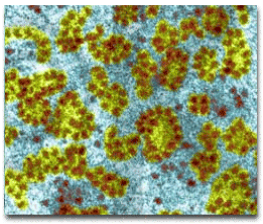


Figure 7.10 Ribosomes

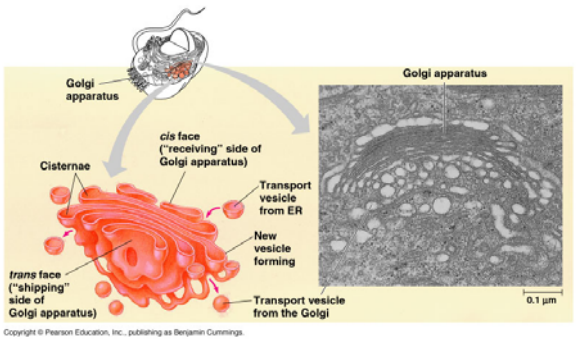


Cell Anatomy



- Ribosome→
  - Found on ER or in the cytoplasm
  - Produce protein for the cell

Figure 7.12 The Golgi apparatus



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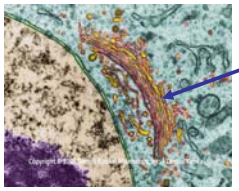
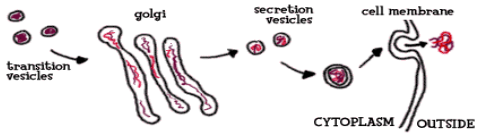
Cell Anatomy

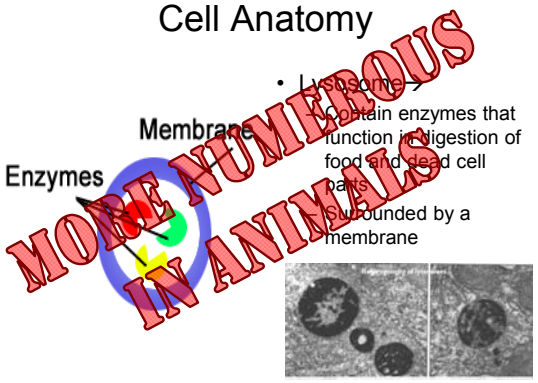


- Golgi Body→
  - Flattened sacs
  - Receive proteins and other material, package them and ship them out



The Golgi apparatus is the FedEx of the cell because it packages proteins and ships vesicles throughout the cell

Cell Anatomy



- Lysosome→
  - Contain enzymes that function in digestion of food and dead cell parts
  - Surrounded by a membrane

Figure 7.14 The formation and functions of lysosomes (Layer 1)

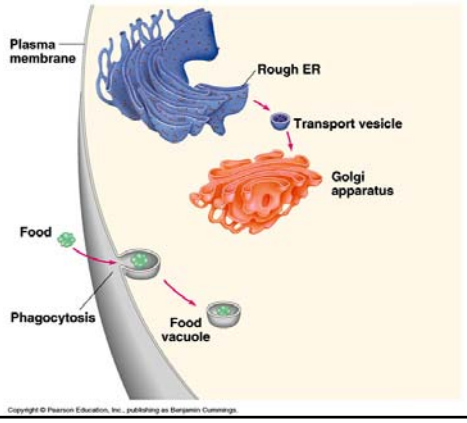


Figure 7.14 The formation and functions of lysosomes (Layer 2)

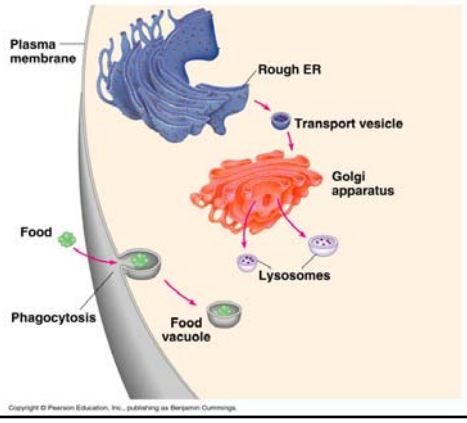


Figure 7.14 The formation and functions of lysosomes (Layer 3)

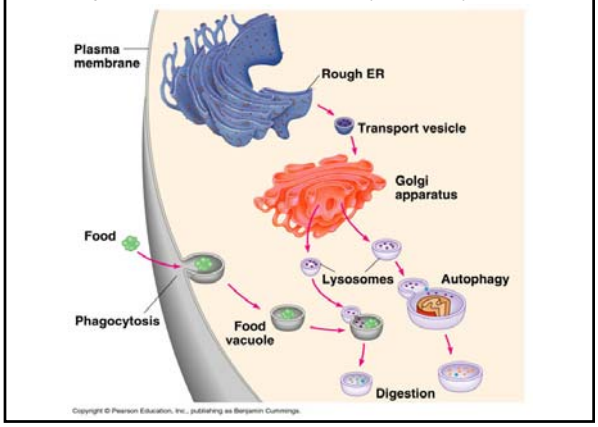
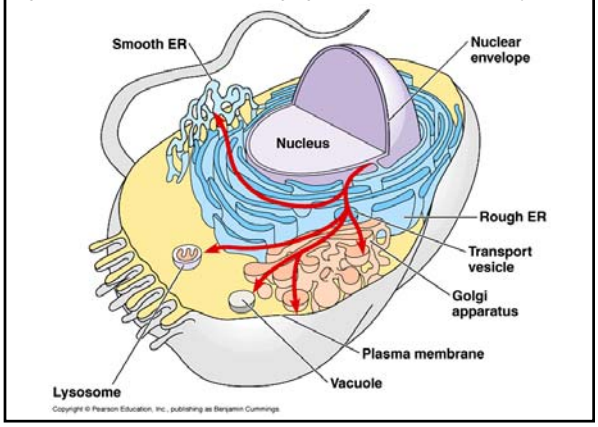


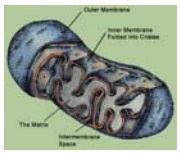
Figure 7.16 Review: relationships among organelles of the endomembrane system



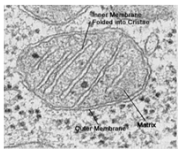
Why is the inside of the Mitochondria highly folded?

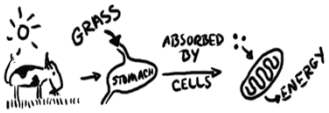
The cristae is the highly folded inner membrane of the mitochondria. It is folded to allow for greater surface area thus creating more room for making ATP

Cell Anatomy

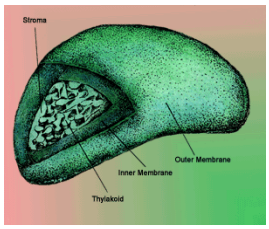


- Mitochondria→
  - Rod-shaped
  - Release energy for the cell from food (sugar)
  - Do Cellular Respiration

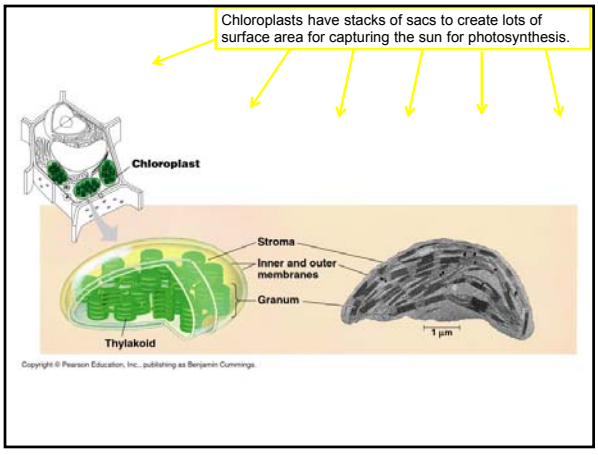




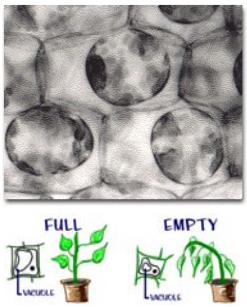
Cell Anatomy



- Chloroplast→
  - Turn the Sun's energy into food (sugar) through photosynthesis
    - They do not make energy, they convert it



Cell Anatomy



- Vacuole→
  - Store food, water and other materials
  - Small in animal cell
  - Large in plants
    - Store H_2O
    - Help keep the plant upright

Figure 7.15 The plant cell vacuole

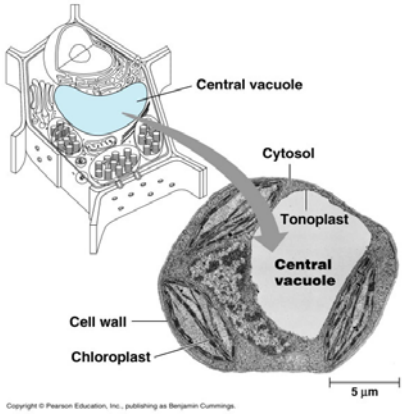


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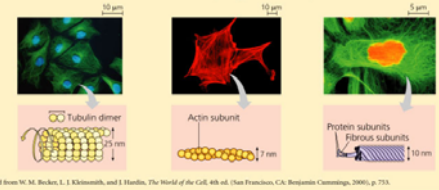
Table 7.2 The structure and function of the cytoskeleton

Table 7.2 The Structure and Function of the Cytoskeleton

Property	Microtubules	Microfilaments (Actin Filaments)	Intermediate Filaments
Structure	Hollow tubes; wall consists of 13 columns of tubulin molecules	Two intertwined strands of actin	Fibrous proteins supercoiled into thicker cables
Diameter	25 nm with 15-nm lumen	7 nm	8–12 nm
Protein subunits	Tubulin, consisting of α-tubulin and β-tubulin	Actin	One of several different proteins of the keratin family, depending on cell type
Main functions	Maintenance of cell shape (compression-resisting "girders") Cell motility (as in cilia or flagella) Chromosome movements in cell division Organelle movements	Maintenance of cell shape (tension-bearing elements) Changes in cell shape Muscle contraction Cytoplasmic streaming Cell motility (as in pseudopodia) Cell division (cleavage furrow formation)	Maintenance of cell shape (tension-bearing elements) Anchorage of nucleus and certain other organelles Formation of nuclear lamina



SOURCE: Adapted from W. M. Becker, L. J. Kleinsmith, and J. Hardin, *The World of the Cell*, 4th ed. (San Francisco, CA: Benjamin Cummings, 2000), p. 733.

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Figure 7.20 The cytoskeleton

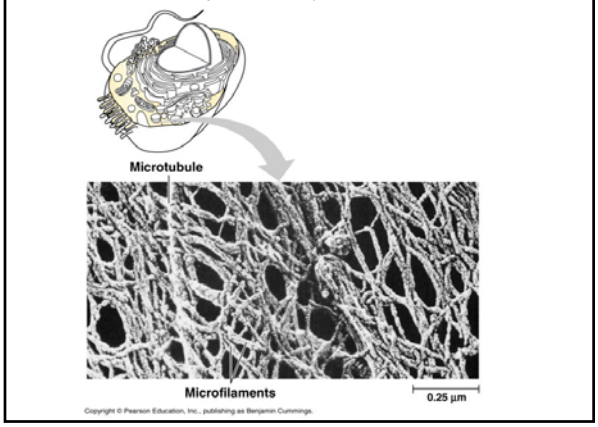


Figure 7.23 A comparison of the beating of flagella and cilia

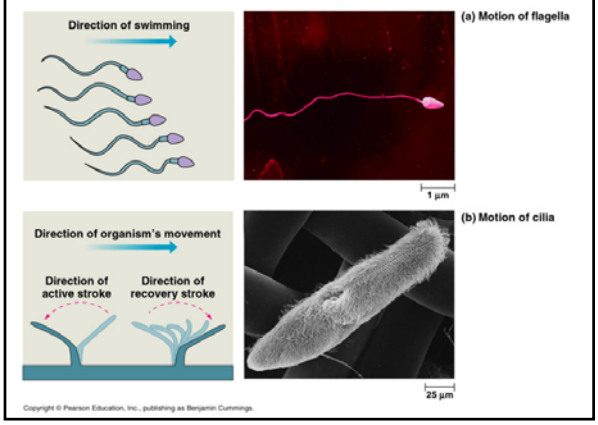


Figure 7.23 A comparison of the beating of flagella and cilia

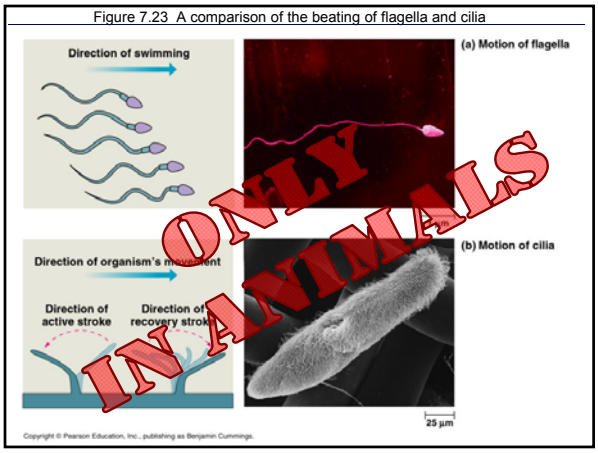
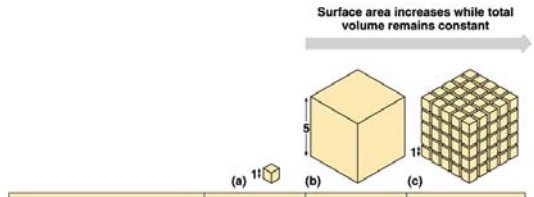


Figure 7.5 Geometric relationships explain why most cells are microscopic



Total surface area (height × width × number of sides × number of boxes)	6	150	750
Total volume (height × width × length × number of boxes)	1	125	125
Surface-to-volume ratio (area ÷ volume)	6	1.2	6

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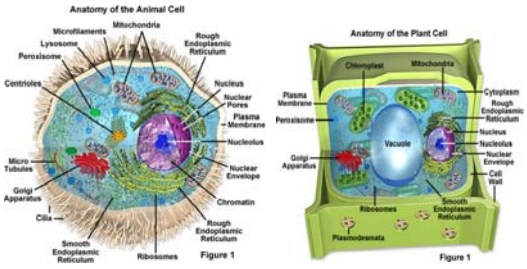
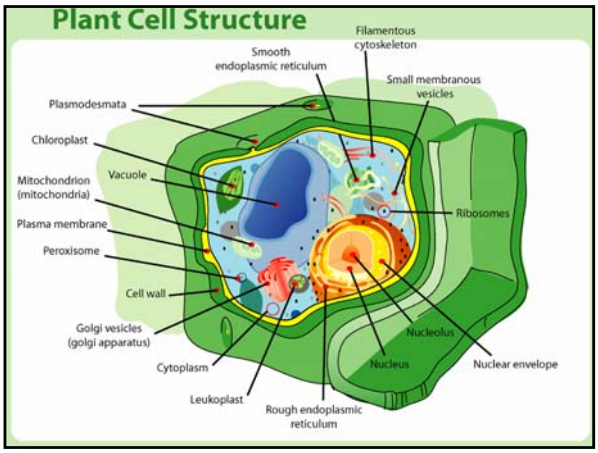
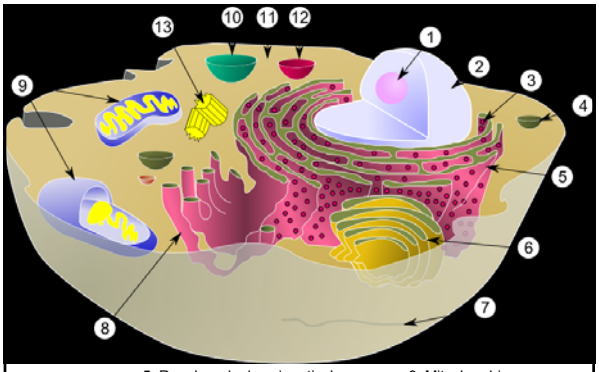
Animal vs. Plant



Animal vs. Plant

1. Plant cells have chloroplasts
2. Plant cells have a cell wall
3. Plant cells have a large central vacuole
4. Animal cells have more lysosomes





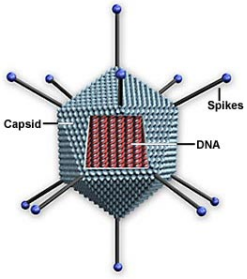
1. Nucleolus
2. Nucleus
3. Ribosome
4. Vesicle
5. Rough endoplasmic reticulum
6. Golgi apparatus (or "Golgi body")
7. Cytoskeleton
8. Smooth endoplasmic reticulum
9. Mitochondrion
10. Vacuole
11. Cytoplasm
12. Lysosome 13. Centriole

What About Viruses?

Viruses are NOT Organisms

Viruses are **not** plants, animals, or bacteria.
Although Viruses may seem like living organisms because of their prodigious reproductive abilities, viruses are not living organisms in the strict sense of the word.

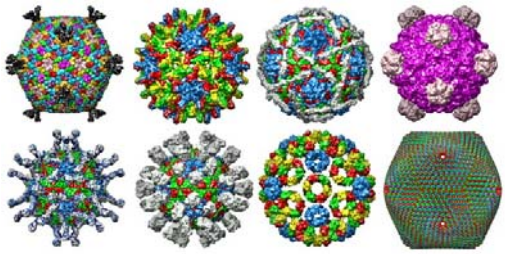
Animal Virus Structure



No cytoplasm
No organelles
No life

Without a host cell, viruses cannot carry out their life-sustaining functions or reproduce.

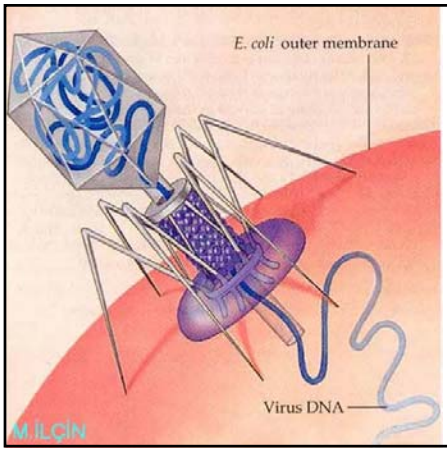
Viruses cannot synthesize proteins, because they lack ribosomes and must use the ribosomes of their host cells to translate viral messenger RNA into viral proteins.



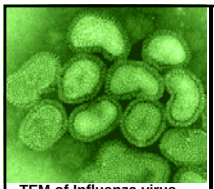
Viruses cannot generate or store energy in the form of adenosine triphosphate (ATP), but have to derive their energy, and all other metabolic functions, from the host cell.

They also parasitize the cell for basic building materials, such as amino acids, nucleotides, and lipids (fats).

Without a host cell, viruses cannot carry out their life-sustaining functions or reproduce.



A Virus replicates by entering a host cell and using this cell's resources to produce hundreds of copies of the viral DNA.



TEM of Influenza virus.

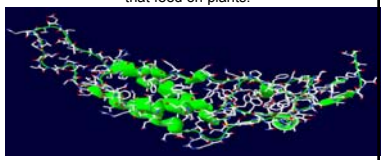
The Orthomyxoviridae are a family of RNA viruses which, so far as is known, infect mainly vertebrates.

It includes those viruses which cause influenza.

In 2010 the CDC ranked the flu as the 9th leading cause of death in the US following heart disease, cancer, stroke, accidents, and pulmonary disease

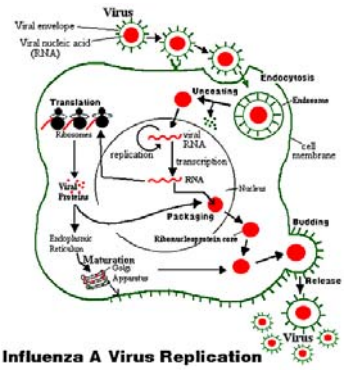
All viruses contain nucleic acids, either DNA or RNA (but not both), and a protein coat, which surrounds the nucleic acids. Some viruses are also enclosed by an envelope of slippery fat and protein molecules.

Viruses are generally classified by the organisms they infect, animals, plants, or bacteria. Since viruses cannot penetrate plant cell walls, virtually all plant viruses are transmitted by insects or other organisms that feed on plants.



The Tobacco mosaic virus (TMV) is an RNA virus that infects plants, especially tobacco and other members of the family Solanaceae, showing mottling and discoloration on the leaves.

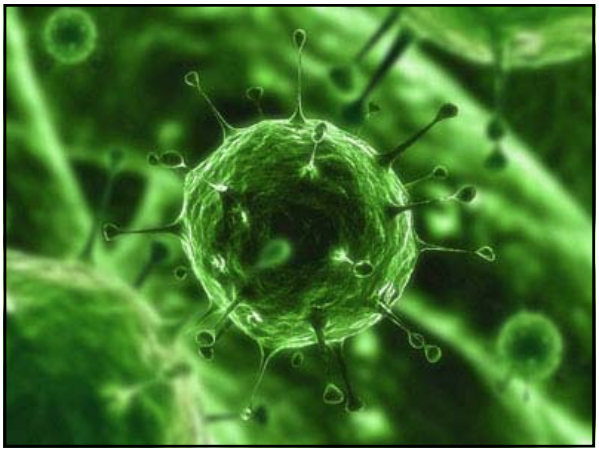
TMV was the among the first viruses to be discovered (1892).



Influenza A Virus Replication

The influenza virus is a class of viruses containing RNA as its hereditary material.

It replicates by entering a host cell and using this cell's resources to produce hundreds of copies of the viral RNA.

The virus attaches to the outside of the host cell and its RNA enters into the cell. The viral genes are transcribed and translated by the cell's enzymes and ribosomes. In this way, the virus takes over the cell's productivity.

Now, instead of producing only new cellular material, the cell produces hundreds of new virus particles. The new virus particles are eventually released from the cell and drift off, to land on a host cell of their own to pirate.