Historical Development of the Cell Theory (p. 6-11)

Biology

- The study of life (living things).
- Living things are composed of units called cells.

Unicellular organism

- A one-celled organism.
    - Ex: paramecium, bacteria, amoeba

Multicellular organism

- Organisms with more than one cell.
    - Ex: cat, dog, worm, human

The Cell Theory

Contains four Statements: (First stated in 1858)

1. All living organisms are composed of one or more cells.
2. Cells are the basic unit of structure and function in all organisms.
3. All cells are derived from pre-existing cells.
4. In a multicellular organism, the activity of the entire organism depends on the total activity of its independent cells.

In the Beginning…

Spontaneous generation

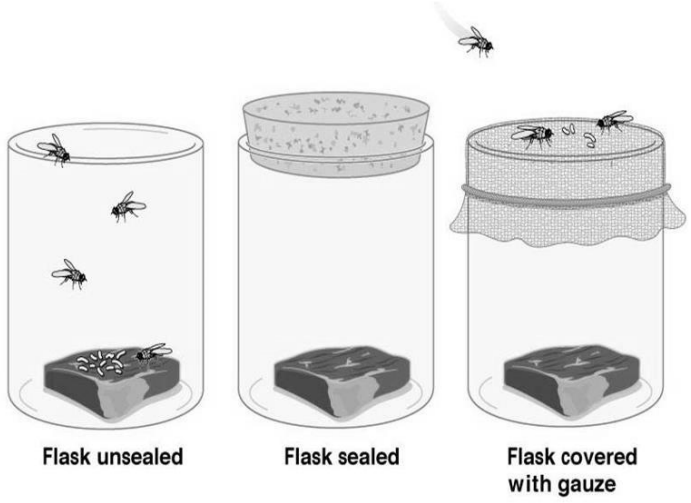
- Idea that living things come from non-living sources
    - Ex: maggots appear on meat if left out too long
    - Ex: After it rains — frogs
    - Ex: Insects and plants seem to come out of mud in ponds.
- In 1870 ***abiogenesis*** was used to describe spontaneous generation

Aristotle (334 BC)

- Put forward the idea of spontaneous generation.
- He classified all organisms as plants or animals.

Francesco Redi (l668)

- Challenged the idea of spontaneous generation.
- Helped proposed the idea known as ***biogenesis*** – Life comes from Life.
    - Did the first controlled experiment.
    - He hypothesized that if maggots come from fly eggs, then maggots will appear only in open jars where flies can deposit eggs on meat. When testing, he placed some meat samples in covered jars and some in uncovered jars. He found that maggots appeared only in uncovered containers. He tested many times and obtained the same results even with different meats.

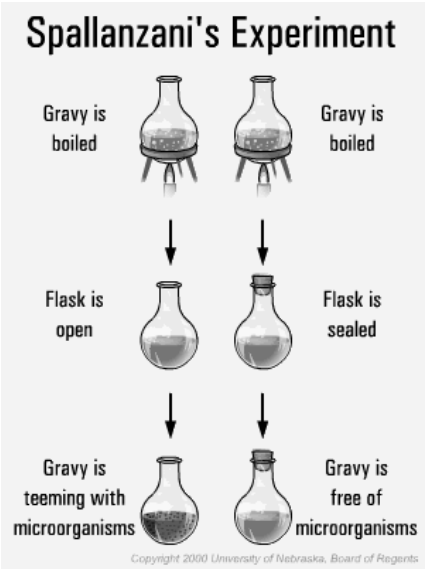


John Needham (1748)

- Performed an experiment similar to Redi's.
- He boiled a meat broth (to kill microbes); sealed one container (not airtight --- sterile) and left another open.
- The result was microbes were present.
- This supported spontaneous generation.

Lorenzo Spallanzani (1776)

- Repeated Needham's experiment.
    - He boiled the containers for one hour; then, sealed the flasks tightly.
    - No microbes were present.
    - The microbes appeared hours after the seals were broken.
    - He believed that microorganisms were carried in air and multiplies when they had a food supply.



Louis Pasteur (1861)

- Repeated Spallanzani's work.
    - He used S - shaped necked flasks (heat flask and bend into an S-shaped curve) which allowed air and microbes in.
    - When he boiled the solution in the base of the flask this created steam which condensed and formed water droplets which trapped microbes in the neck of the flask. The broth remained clear. He broke the necks of the flasks. The broth turned cloudy. Flasks were tipped and the microbes mixed with the broth. The broth turned cloudy. Some of his flasks (on display) are still sterile today.

Early Microscopes and Cells

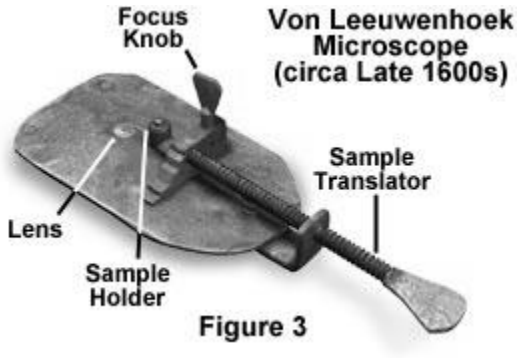
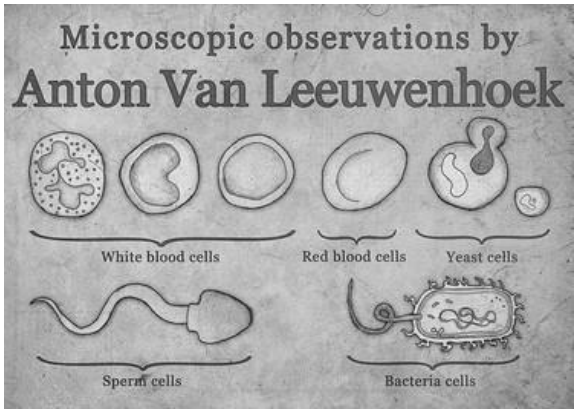


Figure 3

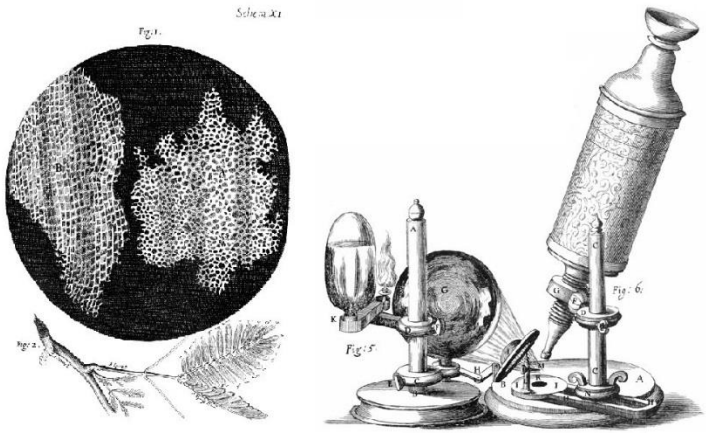
Leeuwenhoek (1675)

- Invents the simple (single lens) microscope.
    - Considered the Father of the Microscope
- Using his microscope, he sees microorganisms.



Robert Hooke (1665)

- Studied slices of cork and saw hollow sacs he called "Cells".



Contributions to the Development of the Cell Theory

Schleiden (1838)

- Cells were present in plant tissue.

Schwann (1839)

- Cells were present in animal tissue.

This suggested that all organisms were composed of one or more cells.

Robert Brown (1831)

- Discovered the center of the cell. He called it the ***nucleus.***

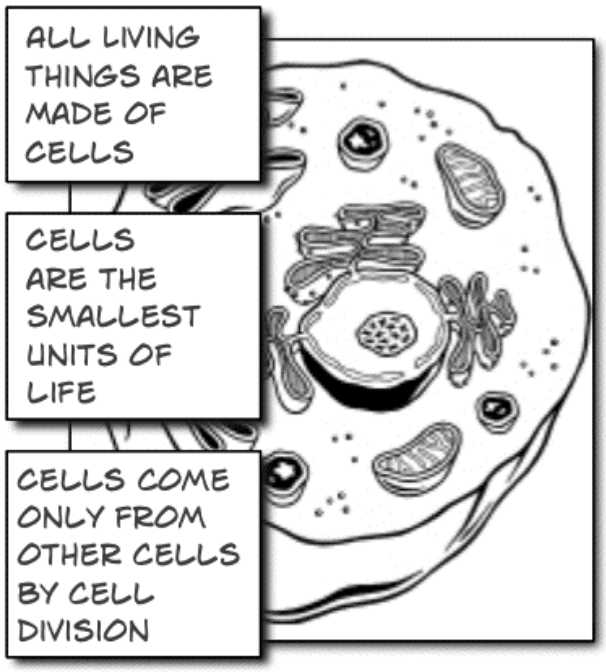
Virchow (1858)

- Observed dividing cells and concluded that ***cells can arise only from other cells***.

Braun (1845)

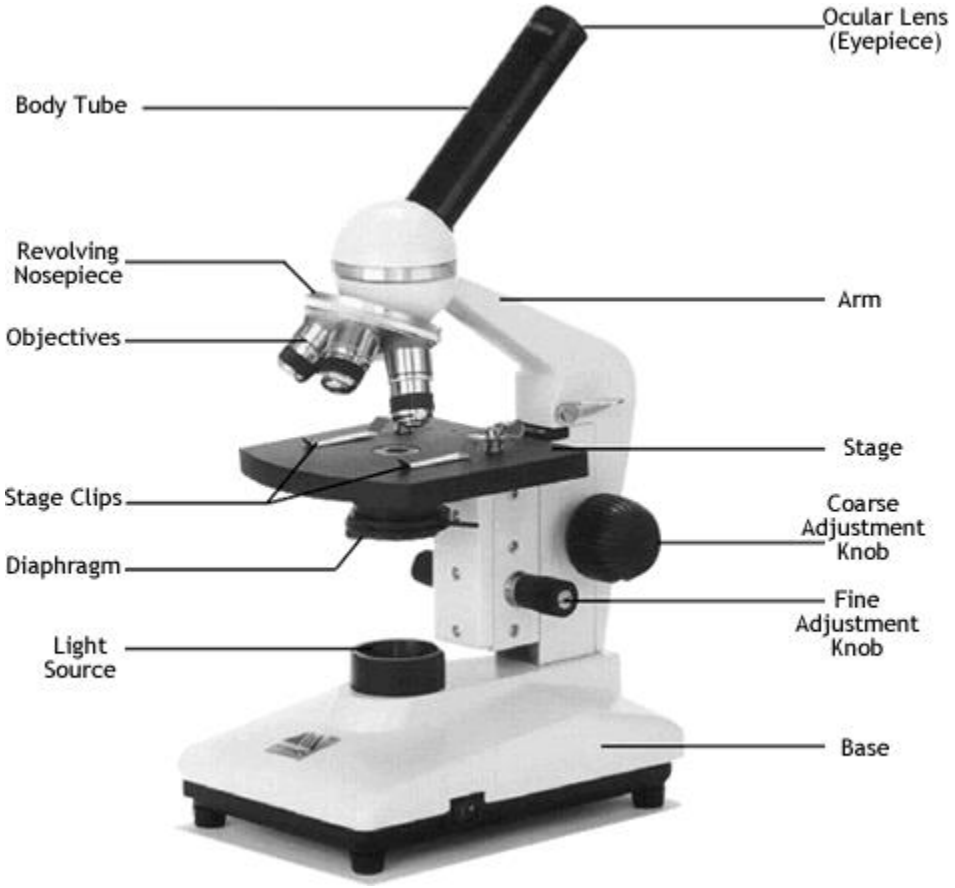
- "the cell is the basic unit of life"

CONCLUSION:



Crossword puzzle
Assignment: Create a Timeline
QUIZ – Scientists

Introducing the Compound Light Microscope (p. 15-19)



1. **Eyepiece**
   - The lens you look through. Usually 10x

2. **Arm**
   - Used for carrying the microscope.

3. **Objective Lens**
   - Lens that magnifies the object. Usually three on a typical microscope.
     - Low Power – 4x in magnification
     - Medium Power – 10x in magnification
     - High Power – 100x in magnification

4. **Stage**
   - Flat area where slide is placed
   - Contains a hole in the middle that allows light to pass through to illuminate the specimen

5. **Diaphragm**
   - Flat disc with holes in it just below the stage
   - Controls the amount og light reaching the object

6. **Light source**
   - Mirror or electrical light that illuminates the object being viewed

7. **Base**
   - Bottom of the microscope that provides support for the other parts.

8. **Coarse adjustment (focus) knob**
   - Knob which brings the object into focus quickly
   - Usually used only on low power.

9. **Fine adjustment (focus) knob**
   - Knob used for fine focussing of objects.
   - Used on medium and high power.

Using the Microscope

1. **Magnification**: The ratio of image size to actual specimen size.
   a. Calculating Magnification – Use the formula below.

      Magnification = objective lens X eyepiece

   Ex: Magnification = 40x (high power) X 10x (eyepiece) = 400x total magnification.

Note: *maximum magnification of a light microscope is usually 2000X*

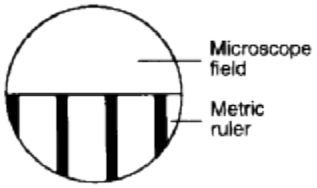
2. **Resolving Power:** The ability of a microscope to distinguish between two objects that are close together.

Note: *Maximum resolving power of Light microscope = 0.2 µm or 200nm*
Maximum resolving power of Electron Microscope = 0.2 nm

Remember:
Any light microscope with a resolving power LESS than 0.2 µm
you will not see the objects as distinct and separate.
They will appear as one object.

3. **Field of View:** The area you see as you look through the eyepiece. The area is round.

Determining the Size of the Field of View



a. Low Power → Measure using a mm ruler.
b. Medium and High Power → use the formula below

$$FOV_{med\ or\ high} = FOV_{low} \times \frac{Mag._{low}}{Mag._{med\ or\ high}}$$

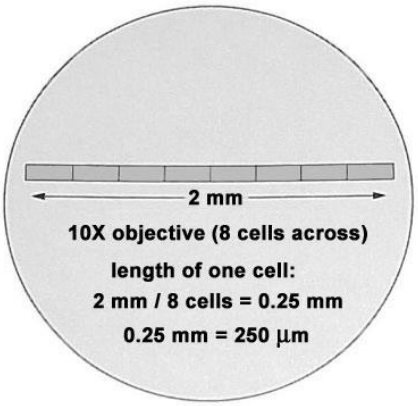
Ex: $FOV_{(med)} = 3.3\ mm \times \frac{40x}{100x}$

$FOV_{(med)} = 3.3\ mm \times 0.4$

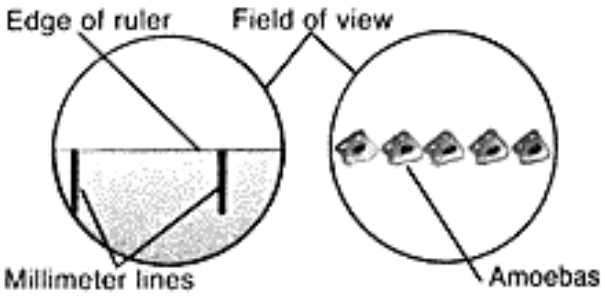
$FOV_{(med)} = 1.32 mm$

4. **Specimen Size:** The actual size of a specimen. Found by doing a calculation.

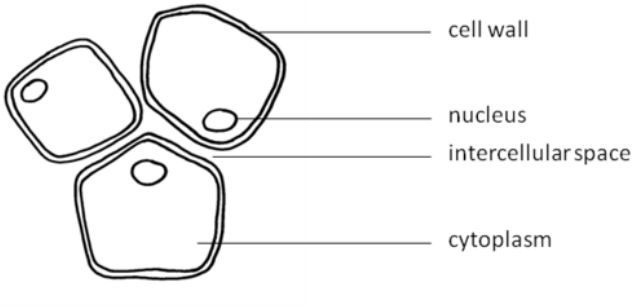
$$Specimen\ size = \frac{\text{Field of View}}{\text{\# specimens fitting across FOV}}$$

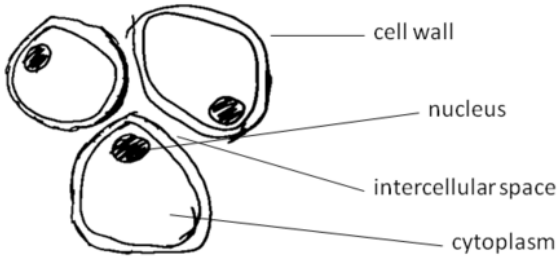


Practice:



5. Making a biological drawing





RULES:

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

Lab #1: Caring For and Using a Microscope

Follow your ***Lab Write-up Guidelines*** with these additional instructions.
Answer your 3 ***pre-lab questions*** first.
There is no need for a **HYPOTHESIS**.

We will do the lab in a different order (be sure to note this in your procedure)

- **Part A:** Becoming familiar with a compound microscope (done in a previous class)
- **Part F:** Preparing a wet mount of onion skin cells
    - Additional assessment will be for preparing a wet mount
- **Part B:** Calculating Field of View (misnamed in the text)
    - Magnification
    - Field of view
    - Specimen size
- **Part D:** Making scale drawings.
- **Part E:** Observing depth of field
- ∗ **Part C:** Omitted

Refer to MHR Biology for your **MATERIALS** and **PROCEDURE**.

Your **RESULTS** section will include the following:

- ✓ Calculation of the ***magnification*** for all three objective lenses.
- ✓ Calculation of the ***field of view*** for all three objective lenses.
- ✓ Calculation of your ***specimen size*** (in :m).
- ✓ A ***scale drawing*** of your specimen (see p. 742)

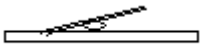
Answer the **post-lab questions** #s 1, 2, 3, 5, 6, 7 and 8.

In a **CONCLUSION**:

- ⓘ Answer the question in the problem
- ⓘ summarize your findings (how you found your specimen size and what it was)
- ⓘ include any sources of error
- ⓘ ways that your lab could be improved

Practical Assessment: Preparing a Wet Mount

1) Obtain a microscope employing good handling techniques and set it up at your work station
2) Prepare your wet mount using the following technique
    - Add <u>one</u> drop of water to a slide
    - <u>Carefully</u> use a razor blade and/ or forceps to obtain a sample of onion epithelium
    - Place the onion on the slide into the water drop
    - Apply the cover slip using the 45^{o} angle technique demonstrated in the previous laboratory exercise

A.  B.  C. 

    - Apply a single drop of stain in the center, on one edge of the cover slip

    - Using paper-towel or tissue paper, draw the stain into the wet mount by placing it on the opposite edge of the cover slip, as previously explained

A.  B. 

    - View specimen under low power on the light microscope.

3) Clean up your work station and return your microscope to the storage cabinet.

Advances in Microscope Technology

Light Microscope

- Uses light as a source of illumination for objects.
    - Simple Light Microscope -- Microscope composed of only 1 lens.
    - Compound Light Microscope – Microscope composed of 2 or more lenses.

Electron Microscope

- Uses Electrons as a source of illumination for objects.
    - *TEM* – Transmission Electron Microscope
        - Shoots a beam of electrons through specimen.
        - Produces a 2D micrograph (picture) of a specimen.
    - *SEM* – Scanning Electron Microscope
        - Shoots a beam of electrons at the *surface* of a specimen.
        - Produces a 3D micrograph.

Comparison of the light microscope with an electron microscope

Type of Microscope	Source of Illumination	Magnification	Resolution	Specimen Preparation
Light	visible light	up to 2000 x	about 0.2 um (200 nm)	usually killed, fixed and stained
Electron	electrons	TEM : typically 10 000 x to 500 000 x SEM : typically 1 000 x to 10 000 x	TEM : about 0.2 nm SEM : about 1 to 10 nm	usually killed, dried and fixed fixed, cleaned, and coated with metal

Microscope Comparison Chart

More About Cells

Cell

- Basic Structural Unit of Life.

Prokaryotic cells

- Cells that **DO NOT** contain a true membrane-bound nucleus;
- DNA is concentrated in an area called the nucleoid.
  1.
  2.
  3.
- Ex: ALL bacterial cells

Eukaryotic cells

- Cells that **DO** contain a true membrane – bound nucleus.
- The nucleus is an enclosed region that separates the DNA from the rest of the cell contents.
- Eukaryotes contain a number of specialized structures called **organelles**.
- There are TWO types of Eukaryotic Cells
  - Animal Cells
  - Plant Cells

Organelles

- Specialized structures within a Eukaryotic cell that carries out a specific function.
- Organelles work together to keep cell functioning.

Organelle name	Description of structure	Description of function	Plant or Animal or BOTH?
nucleus	round; occupies center of cell, largest	control center of the cell stores genetic info on DNA	
mitochondria	"peanut-shaped" Has 2 (double membranes	cellular respiration "powerhouse of cell"	

ribosome	little balls found on ER	protein synthesis with mRNA	
vacuole	round vesicle (large in plants, small in animals)	storage of food, wastes, water etc.	
chloroplast	"cucumber-shaped" Contains discs called Thylakoids. Thylakoids are in stacks called Grana	photosynthesis	
lysosome	round sac – contains digestive enzymes	Digestion Recycling materials	
nucleolus	An area of chromatin (uncoiled DNA) that produces ribosomes		
Golgi apparatus	stacked discs – like pancakes	vesicle formation, packages products for shipment to other cells	
Endoplasmic reticulum - 2 types Smooth – No ribosomes Rough – ribosomes	Folded long, thin membranes; thick structure surrounding	transport of materials	
cell wall	Made of chitin and cellulose	structural support	
cytoskeleton	thin, long structures 2 types: Microtubules- Hollow Microfilaments-Solid	skeletal support	
cell membrane	thin phospholipid bilayer separates the inside from the outside	controls entry/ exit of materials	

Cytoplasm	Fluid of cell Gel-like	Site of many reactions.	
Vesicle			
Cilia			
Flagella			

Complete above chart with colored diagrams and types of cells where found (Plant/Animal/BOTH?)

Label the plant and animal cell diagrams

QUIZ - Organelles

Cellular Processes (p. 50-64)

Cell Membrane

- controls what enters and leaves the cell to maintain ***homeostasis.***
- transports raw materials into the cell
- transports created materials and waste out of the cell
- Prevents unwanted material from entering the cell.
- Prevents escape of materials from cell needed for cell functions.

Homeostasis

- The process of maintaining a stable internal environment.

Fluid Mosaic Model

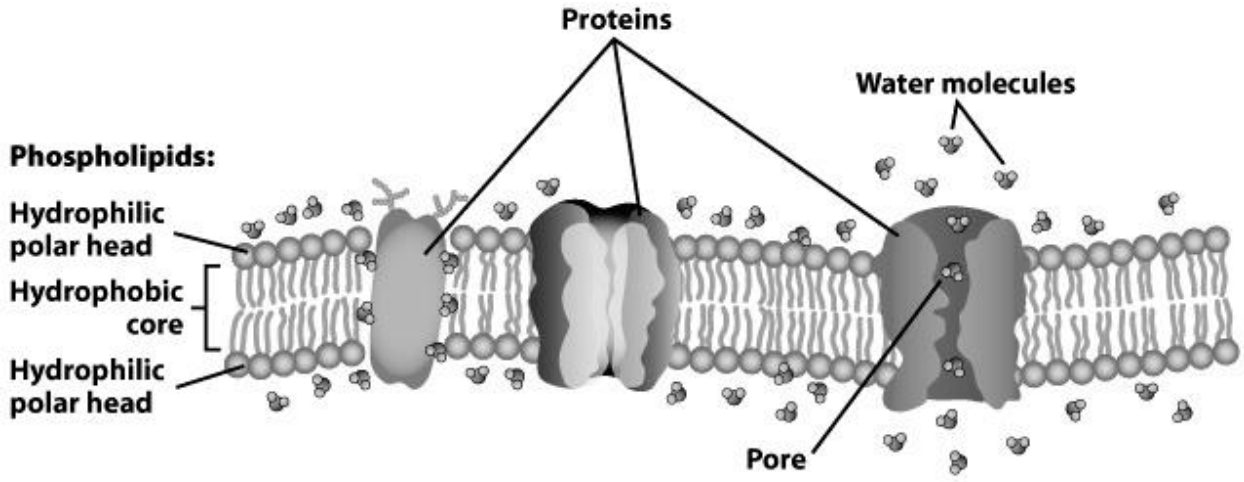
- A model that describes the cell membrane as being a double layer (*bilayer)* composed of a *phospholipid backbone* with proteins embedded throughout. The layer is flexible and is able to move.

Phosphoplipid Bilayer

- Composed of a Head and Tail section.

Head: Hydrophilic or "water loving" (points to the outside of the cell)

Tail: Hydrophobic or "water hating" (points to the inside of the cell).



Activity: Build-A-Membrane Model

Cellular Transport

The cell carries out transport in one of two ways – **Passive** or **Active Transport.**

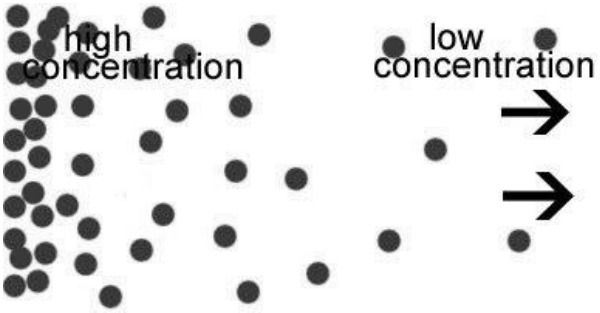
1. ***Passive Transport:*** Transport of materials without the use of energy**.**

There are **three** types of Passive Transport.

a) Simple Diffusion
b) Facilitated Diffusion
c) Osmosis – *a type of special diffusion*

a) Simple Diffusion

The movement of particles from an area of **high** concentration to an area of **low** concentration along a **concentration gradient.** Movement occurs until particles are scattered evenly.

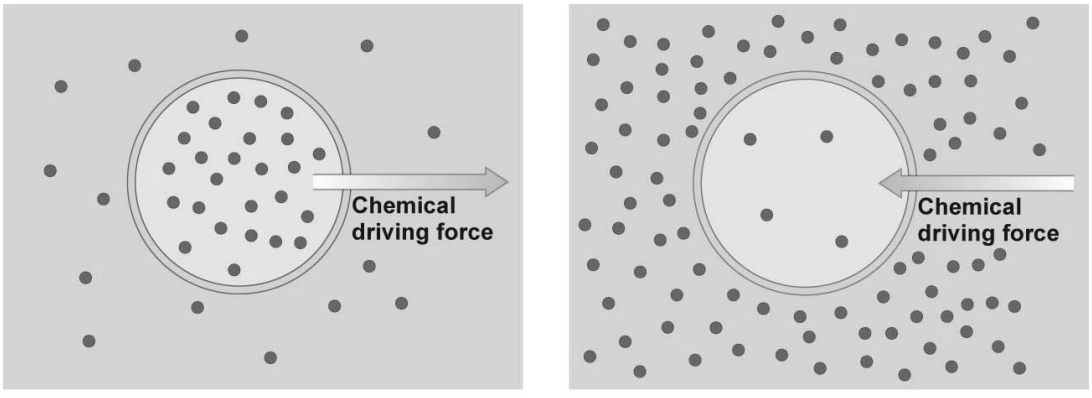


High Concentration:
An area having a large amount of particles.

Low Concentration:
An area having a small amount of particles.

Concentration Gradient: The difference between an area with many particles and one with few particles.

Q. What drives Diffusion?
A. Molecules and particles are in constant random motion which creates a concentration gradient and as such causes particles to move.



Note:

Particles such as **Oxygen(O_2), Carbon Dioxide(CO_2) and Alcohols**
cross the cell membrane by simple diffusion.
These particles are small enough to pass right through the membrane.

Factors Affecting the Rate of Diffusion

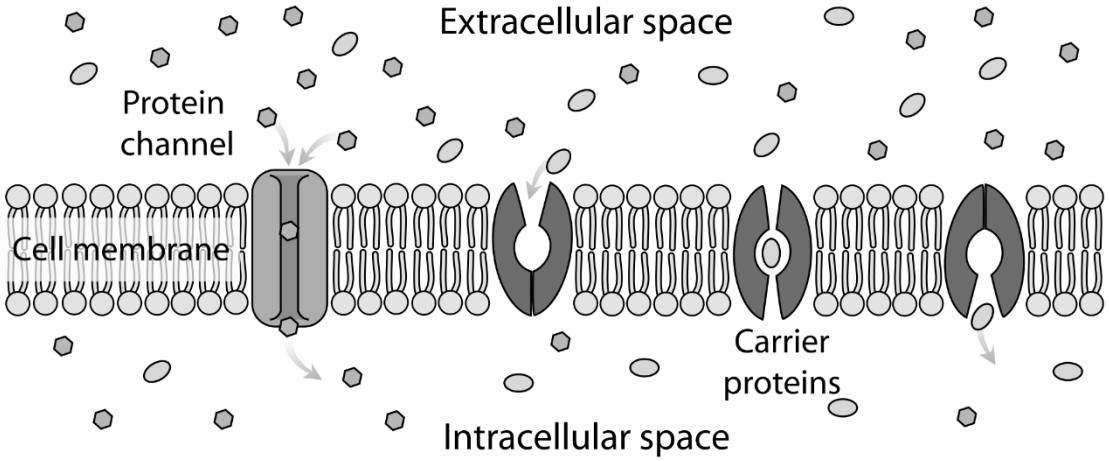
1. *Temperature* --- the higher the temperature the greater the rate of diffusion.
2. *Size of Molecule* --- the smaller the molecule the faster diffusion occurs.
3. *Size of Concentration Gradient* – the greater the difference between areas with high concentration and areas with low concentration, the faster diffusion occurs.

b) Facilitated Diffusion

Similar to diffusion except, the particles trying to cross the cell membrane are too large, so they are assisted/facilitated by **special proteins** in the cell membrane.

<u>Two types of Proteins in the cell membrane</u>

1. **Carrier Protein Facilitated Diffusion** – Diffusion of ***NONCHARGED*** molecules across the cell membrane. ***Ex: Glucose***
2. **Channel Protein Facilitated Diffusion -** Diffusion of ***CHARGED*** particles such as **ions** across the cell membrane. ***Ex: sodium, Na+, K+***



c) Osmosis

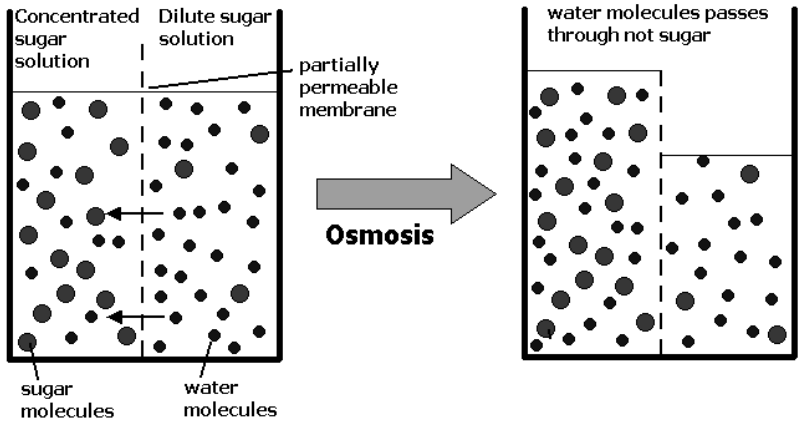
- This is the diffusion of ***water*** across a semipermeable membrane.
- Water flows from an area of HIGH concentration to an area of LOW concentration.

Types of Membranes

i) *Permeable* -- *a* membrane that allows all particles to cross.

ii) *Semipermeable* – a membrane that allows some particles to cross, but not others.

iii) *Impermeable* -- a membrane that ***does not*** allow any particles to cross.

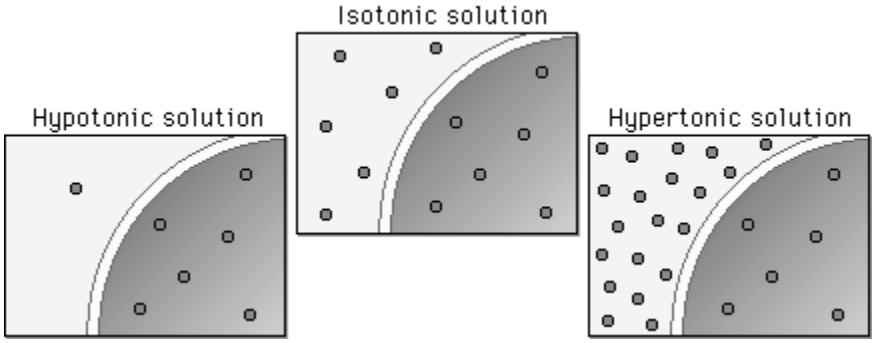


Osmosis and Effects on Cells

a) *Hypertonic solution:* A solution having a **greater** concentration of *solutes* than solvent.

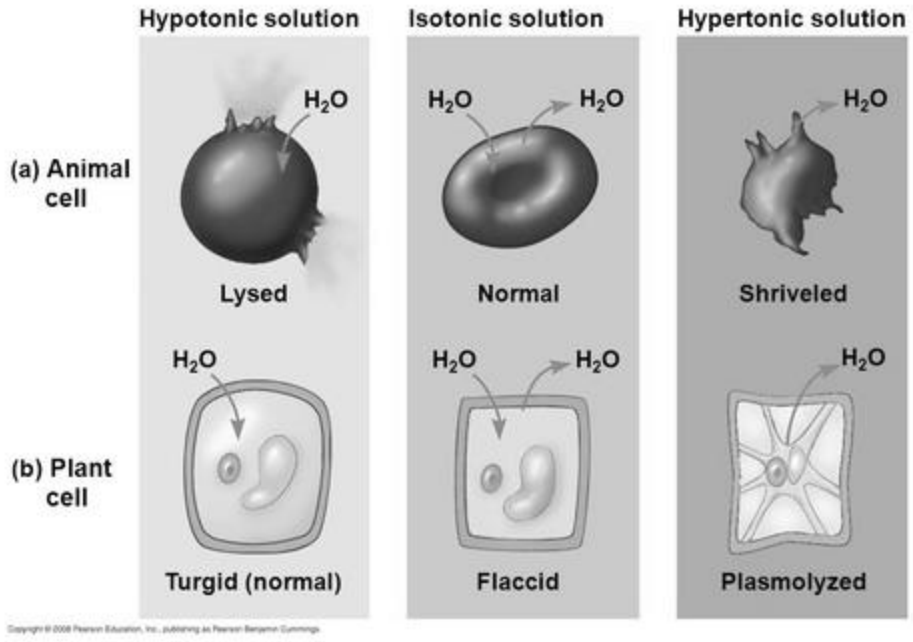
b) *Isotonic solution:* A solution having an **equal** concentration of solutes and solvent.

c) *Hypotonic solution:* A solution having a ***lower*** concentration of solutes than solvent.



NOTE: Water ALWAYS flows from a HYPOTONIC solution to a HYPERTONIC solution.

The Effect of Osmosis on Animal and Plant Cells



Questions to consider?

- Why would plants be negatively affected by too much fertilizer?
- Why are vegetables in grocery stores sprayed with water?
- Why does IV fluid have to be isotonic?

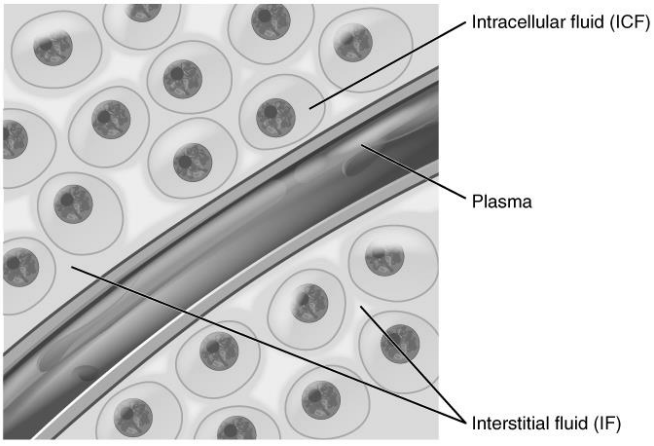
Core Lab Activity: A Cell Membrane Model

Extracellular Fluid:

- Fluid located immediately outside a cell that surrounds and bathes the cell.
- Sometimes called interstitial fluid

Intercellular fluid

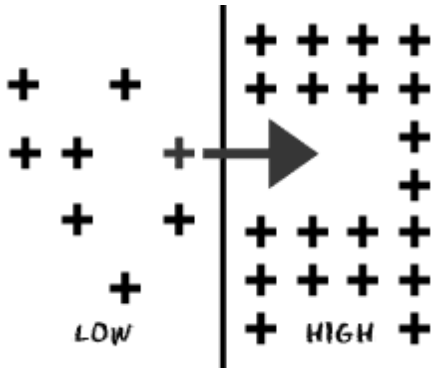
- Fluid located inside the cell membrane



2. ***Active Transport:*** Transport of materials with the use of Energy (ATP)

Oh! BTW

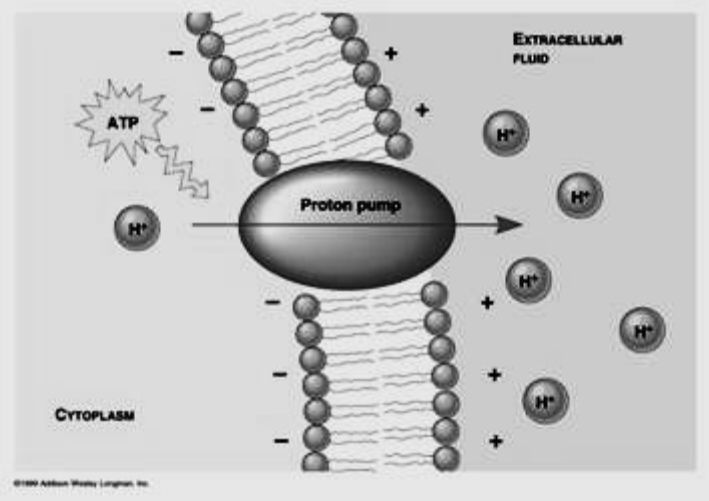
ATP -- Adenosine Tri-Phosphate.
It is the energy molecule of the cell.



The movement of materials *AGAINST* the concentration gradient.
Active transport requires the cell to use ***energy*** (ATP).

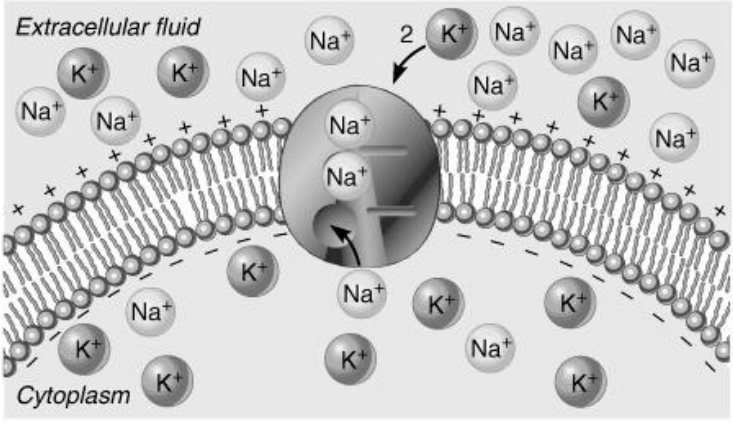
For example:

- Plants pumping nutrients in from the soil
- Intestinal cells pumping nutrients from the gut to the blood stream
- Kidneys pumping glucose and amino acids from the urine back into the blood
- Sodium potassium pump in nerve cells



Sodium – Potassium Pump

What's missing from this picture?



Bulk Transport:

- Transport of large materials through the cell membrane.
- These particles are too large to cross the cell membrane by normal means.
- The cell has to use energy to accomplish this.

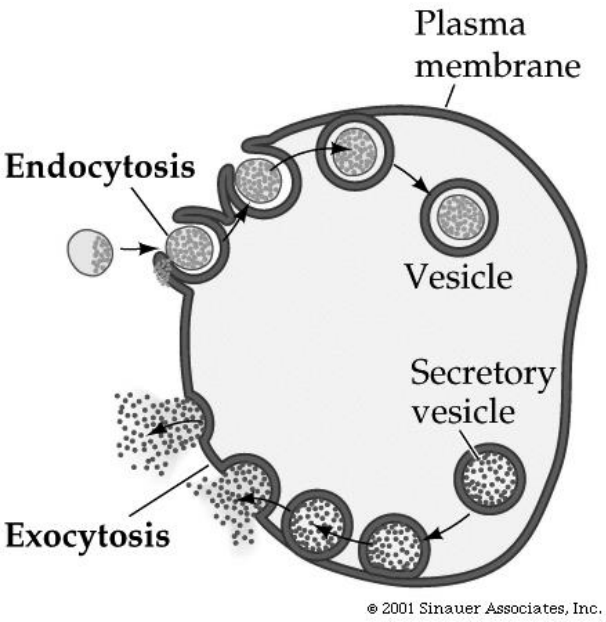
Basically:

- The membrane folds in on itself to create **vesicles (vacuoles)** that contain the materials.

Two types of Bulk Transport

1. Exocytosis:
- This is the movement of large particles ***OUT*** of the cell.

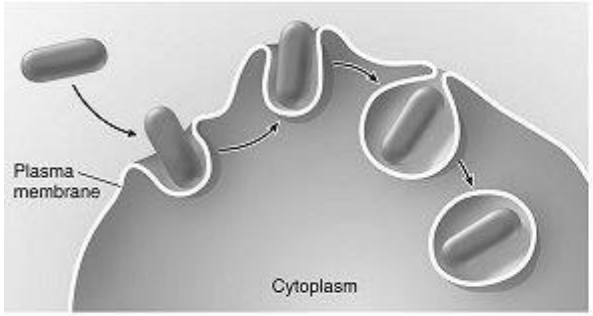
2. Endocytosis:
- This is the movement of large particles ***INTO*** the cell.



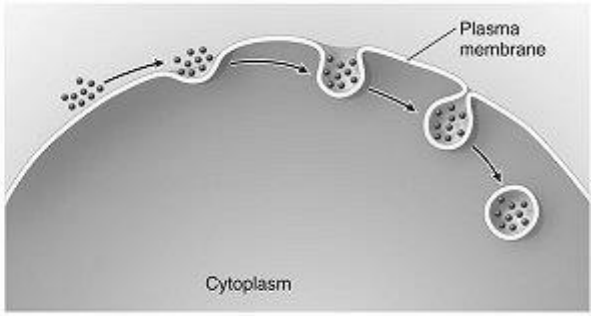
There are ***two*** types of Endocytosis.

A. Phagocytosis: Referred to as "**Cell eating**". The cell ingests a piece of solid material such as a Red Blood Cell or a bacterium.

B. Pinocytosis: Referred to as "**Cell Drinking**". The cell ingests a small amount of "extra cellular fluid" from the outside of the cell.



(a) Phagocytosis



(b) Pinocytosis

Questions p. 61 # 1, 3-11, 13, 14, 16, 17

Why Are Cells So Small?

Cells are microscopic. The reason cells are microscopic has to do with **two** critical factors.

a) Surface area of the cell membrane
b) Volume of cytoplasm within a cell.

The cell membrane is responsible for controlling what enters and leaves the cell.

The volume of a cell is a measure of the cytoplasm of the cell. The cytoplasm contains all the organelles in a cell and is the site of many reactions.

As a cell's volume grows, the cell membrane has to increase in size in order to:

- bring in enough nutrients
  AND
- get rid of wastes

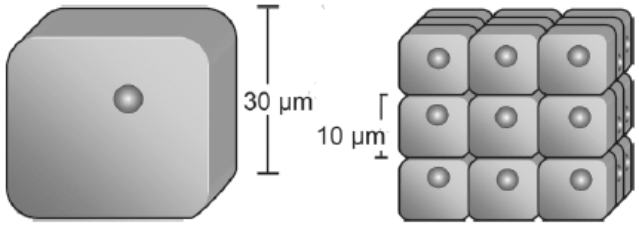
If the cell membrane is not able to increase enough to account for the increasing volume, the cell will not be able to survive. That is the cell membrane gets too small to meet the cell's needs.

A useful ratio called the **Surface Area to Volume Ratio** is a good measure of the efficiency of the interaction between the cell membrane and the volume of the cytoplasm.

A ratio of 1:1 indicates a balance between the volume of the cytoplasm and the cell membrane's surface area.

The **larger** the ratio the more ***efficient*** the cell is at exchanging materials between the cell membrane and the cytoplasmic volume.

In other words, the cell membrane is large enough in surface area to bring in enough materials to supply the volume of the cell while at the same time getting rid of enough wastes.



Surface area of one large cube = 5400 µm^2

Total surface area of 27 small cubes = 16,200 µm^2

Photosynthesis and Respiration

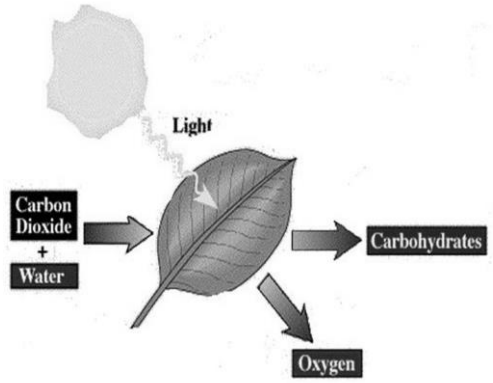
All cells need energy to…

- ④ create molecules
- ④ build membranes and organelles
- ④ move molecules into an out of cell
- ④ movement

Cells make energy in one of two ways:

1) Photosynthesis
2) Respiration

Photosynthesis



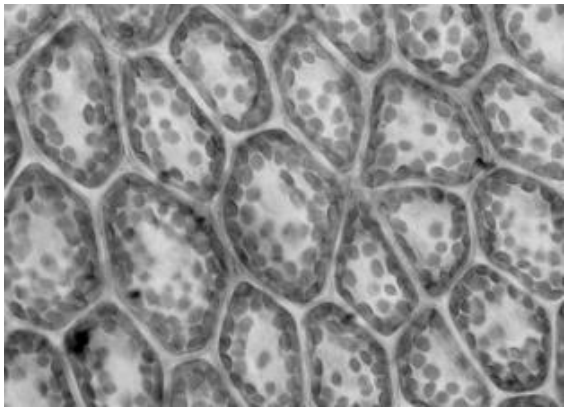
Plants create energy by combining water with carbon dioxide in the presence of light to create glucose (***source of energy***) and oxygen.

Chemically speaking…

Carbon dioxide + water (in the presence of sunlight energy) produces glucose (energy) + oxygen

$$\text{energy} + 6CO_2(g) + 6H_2O(g) \rightarrow C_6H_{12}O_6(s) + 6O_2(g)$$

Photosynthesis occurs in the ***Chloroplasts*** of plant cells.



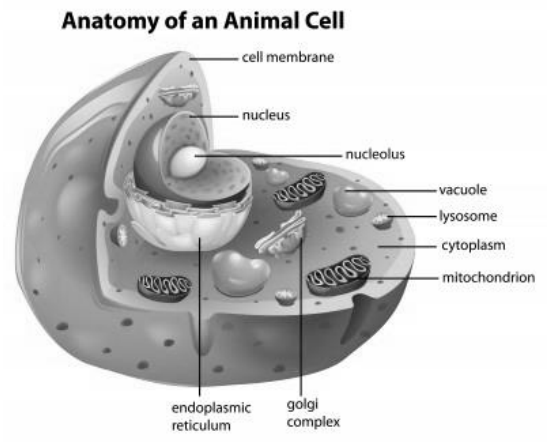
Cellular Respiration

Cells create energy by combining glucose with oxygen to produce water and carbon dioxide.

Chemically speaking…

$$C_6H_{12}O_6(s) + 6O_2(g) \rightarrow 6H_2O(g) + 6CO_2(g) + \text{energy}$$

Respiration occurs within the **<u>mitochondrion</u>** of a cell.



Two types of Respiration

1. Aerobic Respiration: This is respiration that occurs ***WITH*** oxygen. This type of respiration releases water, oxygen and MORE **energy**

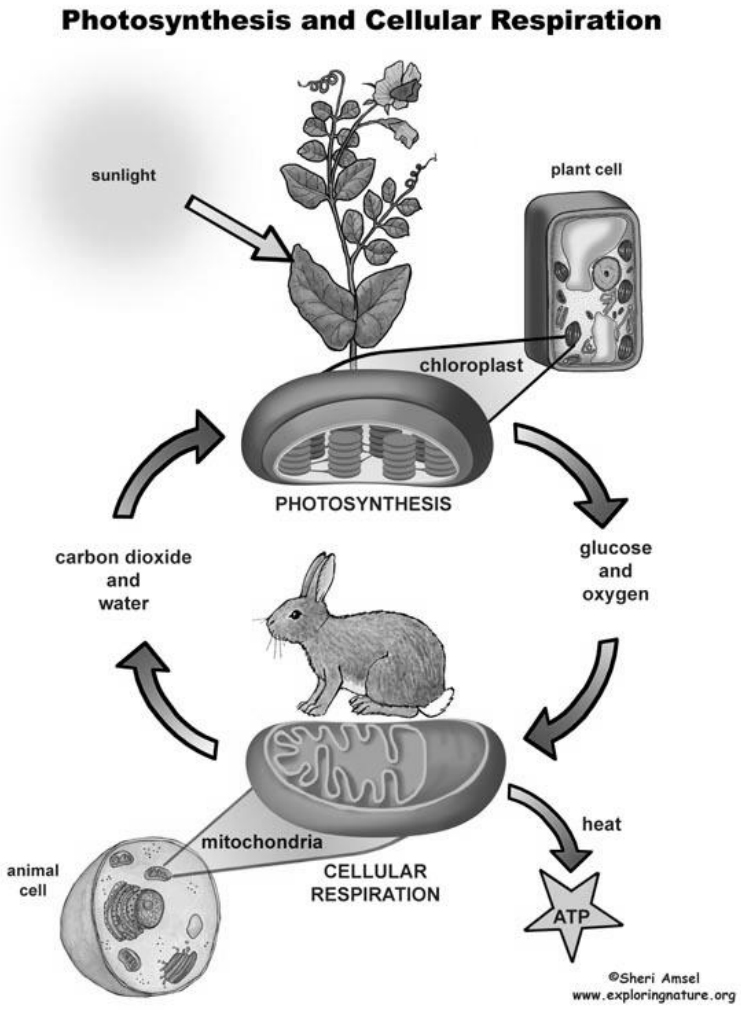
2. Anaerobic Respiration: This is respiration that occurs ***WITHOUT*** oxygen. There are two types of anaerobic respiration.

   - **<u>Fermentation</u>** – The breakdown of vegetables and fruits by bacteria. Releases **alcohol, carbon dioxide** and **LESS energy.**
   - **<u>Lactic Acid Fermentation</u>** – Occurs in muscle cells. Results in a build of lactic acid that makes muscles sore (a stitch). Releases **lactic acid, carbon dioxide** and **LESS energy.**

Respiration and Photosynthesis are OPPOSITE, but COMPLEMENTARY processes.

This means that what is created in one is used as a reactant in another.

One process depends upon the other to run.



Consider the importance of photosynthesis and cellular respiration on a global scale:

- Remember what we learned in Science 1206
- How have humans impacted the carbon cycle?
- What could this mean for primary industries of agriculture, forestry and fisheries?
- What are we doing to reduce our impact?