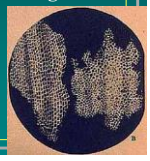
Cell Structure and Function

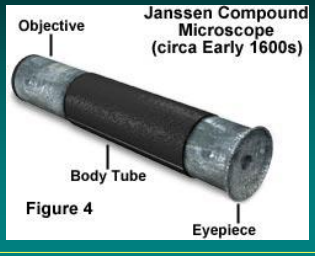
Life is Cellular, Eukaryotic Cell Structure, Cell Boundaries, The Diversity of Cellular Life

Life is Cellular

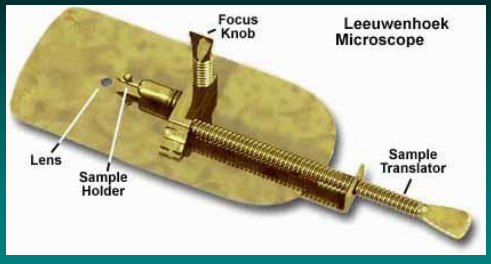
- Early microscopes allowed scientists to view life on a cellular level.
- **Anton van Leeuwenhoek** (1632-1723) first to view bacteria and microscopic organisms in water.
- **Robert Hooke** coined the term "cells" after viewing cork under the microscope.
- The image seen under Hooke's microscope reminded him of the rooms of a monastery, which were called cells.



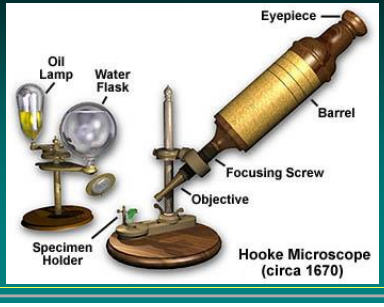
The First Microscope Janssen Brothers/Galileo



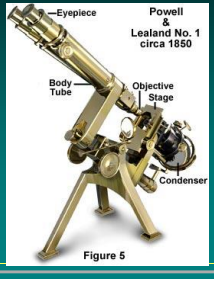
Leeuwenhoek's Microscope



Hooke's Microscope



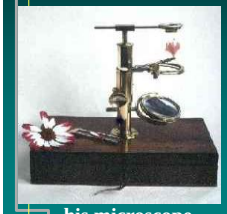
Modern Compound Light Microscope



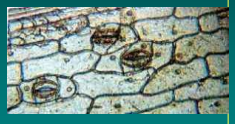
Life is Cellular

ROBERT BROWN-
(1773 - 1858)

FIRST TO RECOGNIZE THAT MANY CELLS HAVE A DARK CIRCULAR OBJECT INSIDE CALLED A NUCLEUS



his microscope



orchid epithelial cells seen by Brown in 1828

The Cell Theory

Schleiden
1804-1881

Schwann
1810-1882

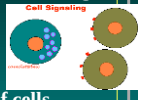
- Created by many scientists.
- **Matthias Schleiden** concluded all plants were made of cells.
- **Theodor Schwann** stated all animals were composed of cells.
- **Rudolf Virchow** stated all cells come from pre-existing cells.

Virchow
1821-1902

Cell Theory

Four Basic Parts

1. All organisms are composed of one or more cells.
2. Cells are the basic unit of structure and function of living things.
3. Cells come from pre-existing cells.
4. Cells pass information on to other cells.



As technology increases, so does our awareness of cells.

1990's scanning probe microscopes have revolutionized the study of surfaces and made it possible to observe single atoms. Unlike SEM and TEM they can observe items in air or solutions

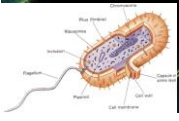
Prokaryotes and Eukaryotes

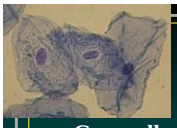
- All cells have a cell membrane and contain DNA.
- There are **prokaryotic cells-** ones that lack a nucleus, and **eukaryotic cells-** ones that have a nucleus.
- **Nucleus-** a large membrane-enclosed structure that contains the cell's genetic material (DNA) that controls the cell's activities.

pro- before
karyon- kernel

Prokaryotes

- Generally smaller and more simple than eukaryotic cells.
- DNA is not protected within a nucleus.
- Some prokaryotes have internal membranes.
- Able to carry out all characteristics of life.
- Bacteria are examples of prokaryotes.





Eukaryotes

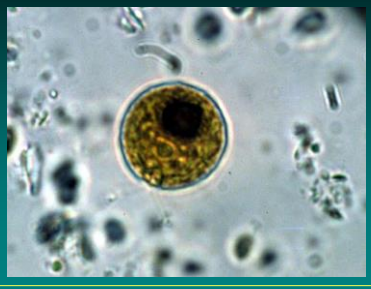
eu-true

- Generally larger and more complex.
- Many structures, internal membranes, and are highly specialized.
- They contain a nucleus.
- Some organisms are unicellular and eukaryotic like protists and yeast.
- Others form large multicellular organisms like plants, animals, fungi, and some protists.

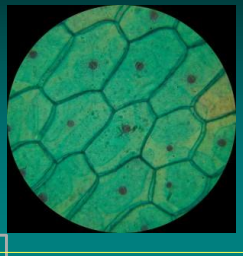
Light Microscopes

- Compound light microscopes passes light through the specimen and uses two lenses to form an image.
- Light microscopes can only magnify 1000x due to the properties of light.

Light Microscope



Light Microscope



Electron Microscopes

- Use beams of electrons that are focused by magnetic fields
- TEM = Transmission Electron Microscope
- SEM = Scanning Electron Microscope

Scanning Electron Microscopes (SEM)

- In a scanning electron microscope, a beam of electrons scans over the surface of a specimen, creating a 3D image.

Transmission Electron Microscopes (TEM)

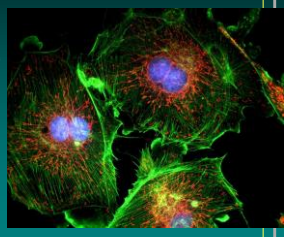
- In a Transmission Electron Microscope, a sample must be cut into a thin slice before being viewed.
- This creates a 2D or flat image of the sample.
- Used to see inside the cell.

Electron Microscopes

TEM

Fluorescent Dyes

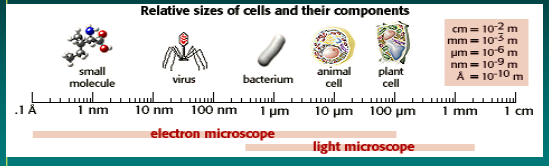
- Fluorescent dyes help scientists see the movement of compounds and structures in living cells.

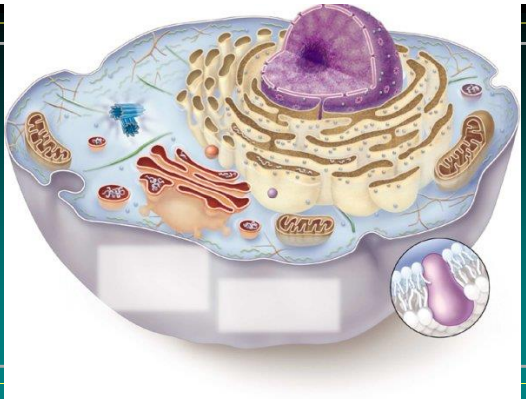


Atomic Force Microscope (AFM)

- **Atomic Force Microscopy** is a very high-resolution type of Scanning probe microscope, with demonstrated resolution on the order of fractions of a nanometer
- The information is gathered by "feeling" or "touching" the surface with a mechanical probe

SIZES OF CELLS



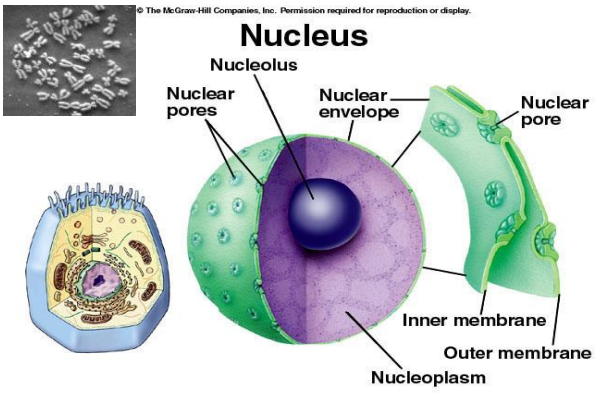


Eukaryotic Cell Structures

- **Organelles-** means little organs, are tiny structures within cells that perform specific functions.
- **Cytoplasm-** portion of the cell outside of the nucleus that suspends organelles and allows materials to be transported through it.

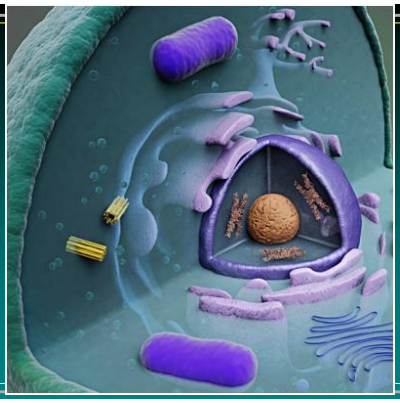
Eukaryotic Cell Structures

- **Nucleus** contains most of cell's DNA and has instructions for making proteins and other important molecules.
- **Nuclear envelope-** composed of two membranes and is dotted with many pores to allow material to move in and out of the nucleus



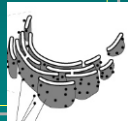
Ribosomes and Endoplasmic Reticulum

- **Ribosomes-** proteins are assembled on them based on instructions from the nucleus.
- They are small particles of RNA and protein found throughout the cytoplasm.
- **Endoplasmic Reticulum-** internal membrane system of the cell where lipid components of the cell membrane are assembled, along with proteins and other materials that are exported from the cell.
- **Rough Endoplasmic Reticulum (RER)-** has ribosomes attached to it, and the proteins that are made by the ribosomes are modified inside the endoplasmic reticulum.



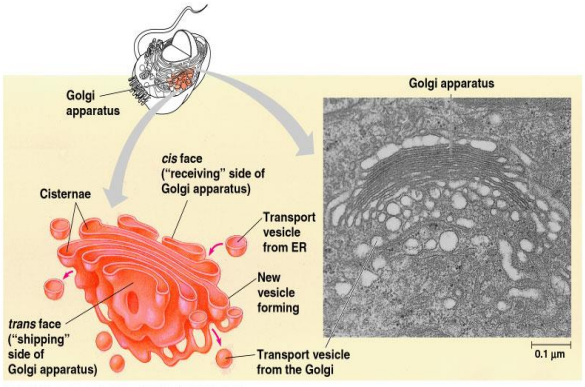
Endoplasmic Reticulum

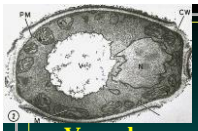
- Proteins made by RER are exported from the cell, while others are used to make the membrane of the cell.
- **"free ribosomes"** are not attached to ER.
- **Smooth Endoplasmic Reticulum (SER)-** lacks ribosomes, contains different enzymes that perform specialized tasks, including the synthesis of membrane lipids and the detoxification of drugs.
- Liver cells contain large amounts of SER.



Golgi Apparatus and Lysosomes

- **Golgi Apparatus-** modifies, sorts, and packages proteins and other materials from the endoplasmic reticulum for storage in the cell or secretion outside the cell.
- Usually receives proteins made from RER.
- **Lysosomes-** small organelles filled with enzymes that digest lipids, carbohydrates, and proteins into their building blocks to be used elsewhere by the cell.
- Lysosomes also break down organelles that no longer do their jobs properly.



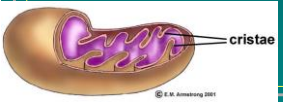


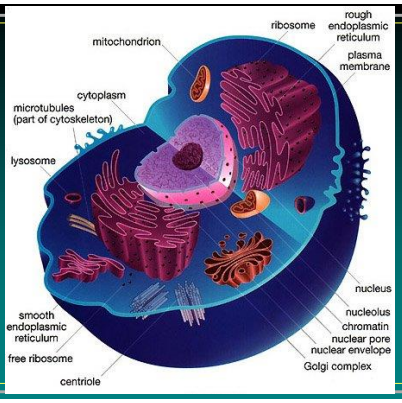
Vacuoles

- **Vacuoles-** saclike structures that store materials such as water, wastes, salts, proteins, and carbohydrates.
- They are larger in plant cells than in animal cells and are modified in protista to work as water pumps.

Mitochondria

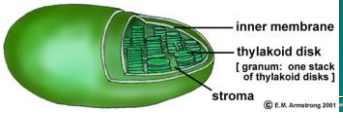
- **Mitochondria-** convert the chemical energy stored in food into compounds that are more convenient for the cell to use.
- Nearly all eukaryotic cells have them.
- They have two membranes that surround them.
- The inner membrane is folded to increase surface area. (folds called **cristae**)
- They contain their own DNA.
- They make ATP



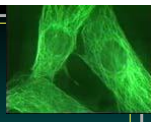


Chloroplasts

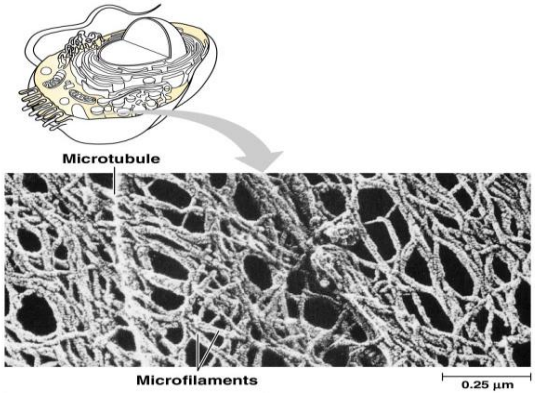
- Plants and some protists contain them.
- **Chloroplasts-** convert light energy into chemical energy in a process called photosynthesis.
- They also have two membranes.
- They also make ATP.
- Contain chlorophyll which traps solar energy.
- Chlorophyll stored in **grana**.
- Chloroplasts also contain DNA.



Cytoskeleton

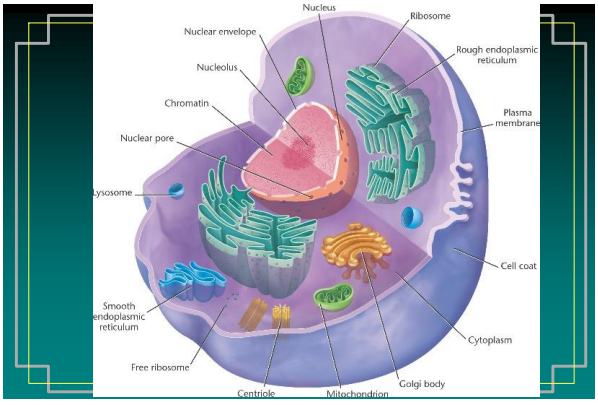


- **Cytoskeleton- a network of protein filaments that helps the cell to maintain its shape, aid in movement of the cell, and movement of materials within the cell.**
- **Cytoskeletons are composed of microtubules and microfilaments.**
- **Microfilaments- thin, solid protein fibers.**
- **Microtubules- larger, hollow, protein fibers.**
- **Both are also involved in cell division.**



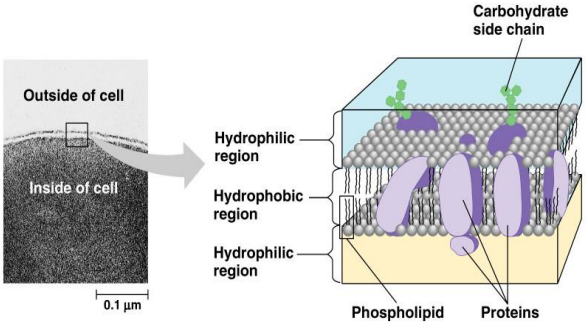
Microtubules

- **Composed of protein called tubulin.**
- **Form mitotic spindle during mitosis.**
- **Used to form centrioles.**
- **Centrioles- located near the nucleus and help to organize cell division by separating the chromosomes.**
- **Microtubules also form cilia and flagella, which are used by cells to move, and to bring materials into the cell.**



Cell Boundaries

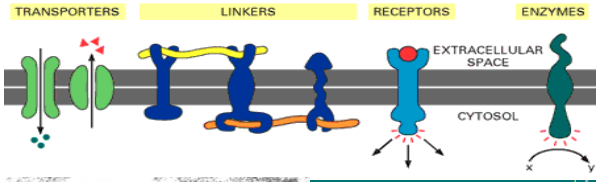
- **Cell membrane- regulates what enters and leaves the cell and also provides protection and support. (B.1.2)**
- **Composed of a lipid bilayer that gives the cell membrane a flexible structure that forms a strong barrier between the cell and its surroundings.**
- **Protein molecules are embedded within the lipid bilayer, and carbohydrates extend from them.**
- **The protein molecules form channels and pumps to move materials.**
- **The carbohydrates act like chemical identification cards, to restrict certain things from entering.**



(a) TEM of a red blood cell

(b) Structure of the plasma membrane

Functions of Proteins in the Plasma Membrane



Proteins also act as linkers and receptors.

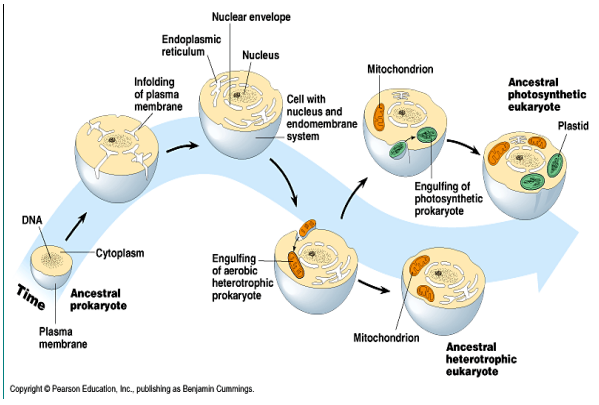
Cell Walls

- Found in plants, algae, fungi, and many prokaryotes (bacteria).
- **Cell Wall-** provides support and protection for the cell.
- Strong supporting layer around the cell membrane.
- Very porous.
- Made from fibers of carbohydrates (**cellulose, chitin**) and protein.

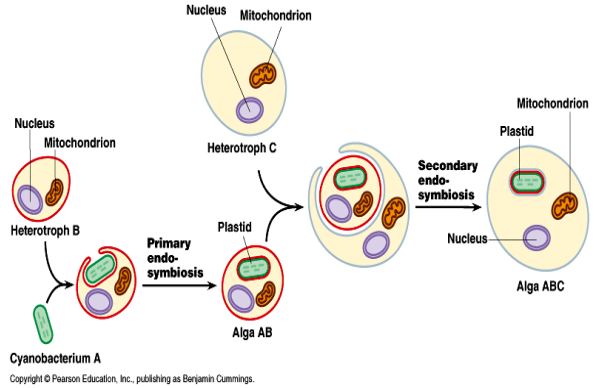
Lynn Margulis

Endosymbiotic Theory

- States that prokaryotic cells may have lived inside other prokaryotic cells, which lead to the evolution of eukaryotic cells.
- Prokaryotic cells that had chlorophyll became chloroplasts.
- Prokaryotic cells that lacked chlorophyll became mitochondria.
- The theory was proposed by **Lynn Margulis**.



Copyright © Pearson Education, Inc., publishing as Benjamin Cummings.



Copyright © Pearson Education, Inc., publishing as Benjamin Cummings.

Diffusion Through Cell Boundaries

- One of the most important functions of the cell membrane is to regulate the movement of dissolved molecules from the liquid on one side of the membrane to the liquid on the other side.
- Cytoplasm is a solution that contains many different substances like gases, ions, food, and waste, that are exchanged across the membrane.

Diffusion Through Cell Boundaries

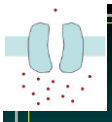
- If a substance is able to cross a membrane, the membrane is said to be **permeable** to it.
- Most biological membranes are **selectively permeable**, meaning that some substance can pass across them and others cannot.

Passive Transport

- **Concentration-** the mass of solute in a given volume of solution, or mass/volume.
- **Diffusion-** particles tend to move from an area where they are more concentrated to an area where they are less concentrated.
- In Passive Transport, particles move by **kinetic energy**. **Requires no energy by the cell.**
- Particles will move across a membrane freely, so long as they are small enough to pass through.

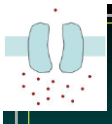
Passive Transport

- Because diffusion depends upon random particle movements, substances diffuse across membranes without requiring the cell to use energy.
- Particles will continue to move even after equilibrium has been reached.



Facilitated Diffusion

- **Facilitated diffusion-** movement of specific molecules across cell membranes through protein channels.
- Cells allow certain substances (like glucose) to move into or out of the cell that are normally too large to diffuse freely.
- Process **does not require energy**, since it still obeys the rules of diffusion.

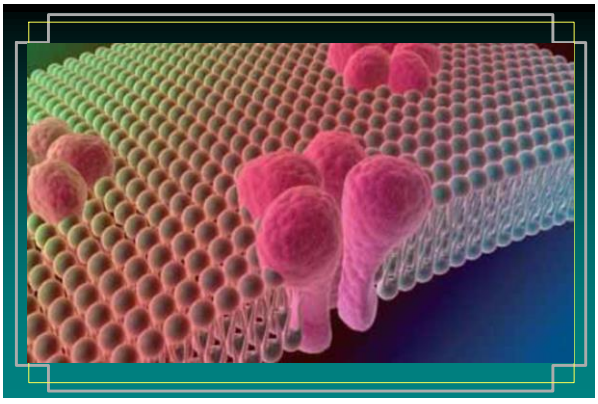


Facilitated Diffusion

- An example of facilitated diffusion is **osmosis**
- **Osmosis-** the movement of water through a selectively permeable membrane from an area of higher concentration to an area of lower concentration.

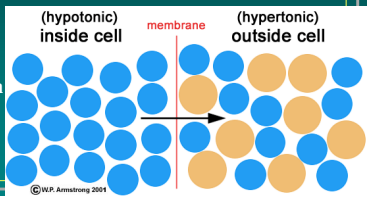
Facilitated Diffusion

- Recall that the inside of a cell's lipid bilayer (cell membrane) is hydrophobic, or "Water Fearing".
- Water has a hard time passing through the membrane.
- Many cells contain **aquaporins**, protein channels that allow the movement of water through cell membranes by facilitated diffusion.



How Osmosis Works

- **Isotonic-** the concentration of solute and water are equal on both sides of a membrane.
- **Hypertonic-** when comparing two solutions, the solution with the greater concentration of solutes.
- **Hypotonic-** when comparing two solutions, the solution with the lesser concentration of solutes.



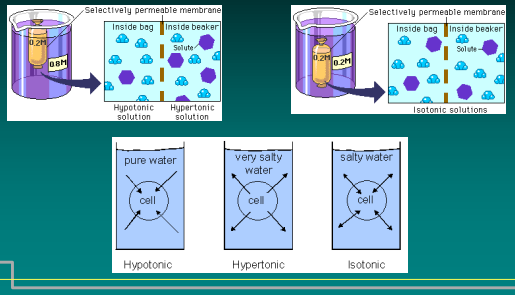
RBC's in Different Solutions

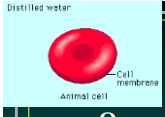
isotonic — H_2O concentration equal inside and out

hypotonic — H_2O concentration greater outside

hypertonic — H_2O concentration lower outside

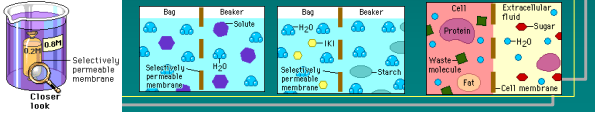
Types of Solution





Osmotic Pressure

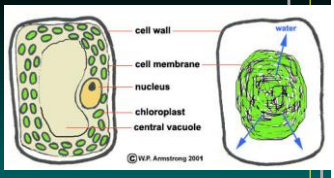
- **Osmosis exerts a pressure known as osmotic pressure on the hypertonic side of a selectively permeable membrane.**
- **Cells are not bathed in 100% pure water, which is good because the osmotic pressure would be too great for the cell.**

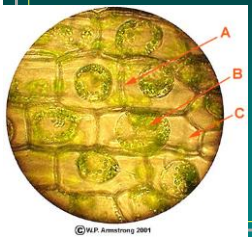


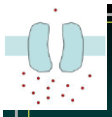
Osmotic Pressure

- A pressure caused by a difference in the amounts of solutes between solutions that are separated by a semi-permeable membrane.

Osmotic Pressure

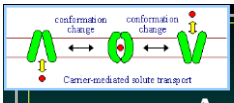






Facilitated Diffusion

- **Facilitated diffusion-** movement of specific molecules across cell membranes through protein channels.
- Cells allow certain substances (like glucose) to move into or out of the cell that are normally too large to diffuse freely.
- Process does not require energy, since it still obeys the rules of diffusion.



Active Transport

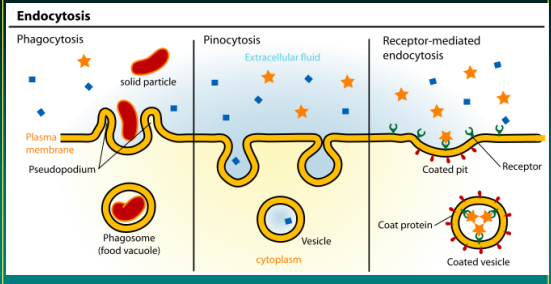
- **Active transport-** energy-requiring process that moves material across a cell membrane against the concentration difference.
- Cells at times must move things against a concentration gradient. (low conc. to high conc.)
- This process requires energy (ATP).
- Smaller molecules (ions) are transported by **protein pumps. (transport proteins)**
- Larger molecules are moved by endocytosis and exocytosis.

Endo = inside
Cyto = cell
Sis = condition

Endocytosis and Exocytosis

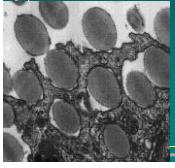
- **Endocytosis-** process of taking material into the cell by means of infoldings, or pockets, of the cell membrane.
- Vacuoles are formed from this process.
- Enzymes will break down contents of vacuoles and the contents will diffuse to the rest of the cell.
- There are two types of endocytosis: pinocytosis and phagocytosis.
- **Phagocytosis-** cell eating, or taking in food
- **Pinocytosis-** cell drinking, or taking in liquid.

Pino = drink
Phago = eat



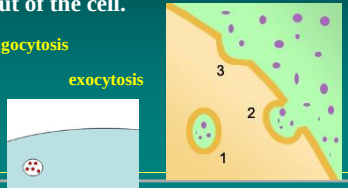
Endocytosis and Exocytosis

- **Exocytosis-** cells releasing large amounts of material from the cell.
- The membrane of the vacuole surrounding the material fuses with the cell membrane, forcing the contents out of the cell.



phagocytosis

exocytosis



The Diversity of Cellular Life

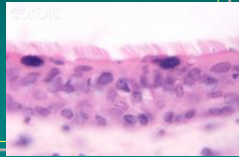
- B1.3, B1.16
- **Unicellular-** organisms composed of one cell
- Bacteria, some protists, and yeast have to do all of the characteristics of living things by themselves.
- **Multicellular-** organisms composed of many cells.
- Plants, animals, fungi, algae usually have a division of labor, where cells specialize.

Maintaining Homeostasis

- **Homeostasis** – relatively constant internal physical and chemical conditions that organisms maintain
- To maintain homeostasis, unicellular organisms grow, respond to the environment, transform energy, and reproduce
- The cells of multicellular organisms become specialized to maintain homeostasis

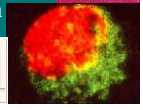
The Diversity of Cellular Life

- **Cell specialization-** where cells throughout an organism can develop in different ways to perform different tasks.
- Cooperation and communication are important to specialized cells of multicellular organisms.



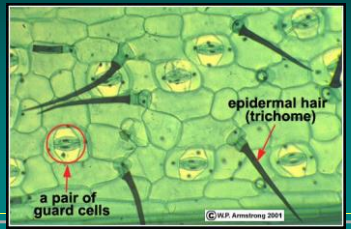
Specialized Animal Cells

- Red blood cells transport oxygen.
- White blood cells fight infections.
- Neurons transport impulses.
- Muscle cells move bones.
- Pancreatic cells digest food, release insulin.
- Each of these cells must be modified in particular ways to do their jobs.



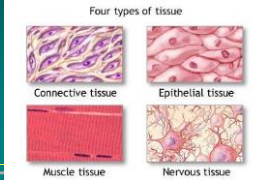
Specialized Plant Cells

- Guard cells regulate gases and water movement on leaves of plants.



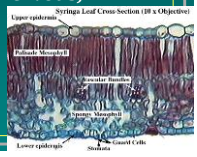
Levels of Organization

- **Individual cells, tissues, organs, and organ systems** make up the hierarchy of multicellular organisms.
- **Tissues-** made of similar cells that perform a particular function.
- Four types of tissue are muscle, epithelial, nervous, and connective.



Levels of Organization cont.

- **Organs-** many groups of tissues working together.
- Each muscle, an ear, an eye, heart, liver, pancreas, and the leaf of a plant are all organs.
- **Organ system-** a group of organs that work together to perform a particular function.
- Digestive, respiratory, excretory, nervous, circulatory are examples.



Cellular Communication

- Cells in large organisms communicate by means of chemical signals that are passed from one cell to another.
- To respond to one of these signals, a cell must have a **receptor** to which the signaling molecule can bind.

Cellular Communication

- A **receptor** is a specific protein to whose shape fits that of a specific molecular messenger, such as a hormone.