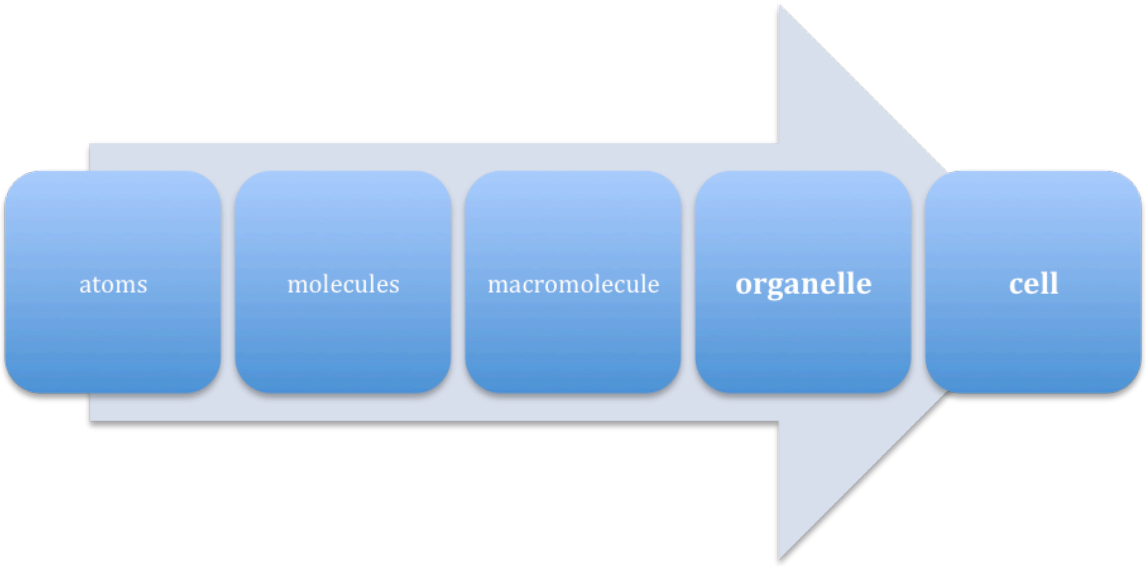
Chapter 4 Cells, Cell Structure & Cell Transport

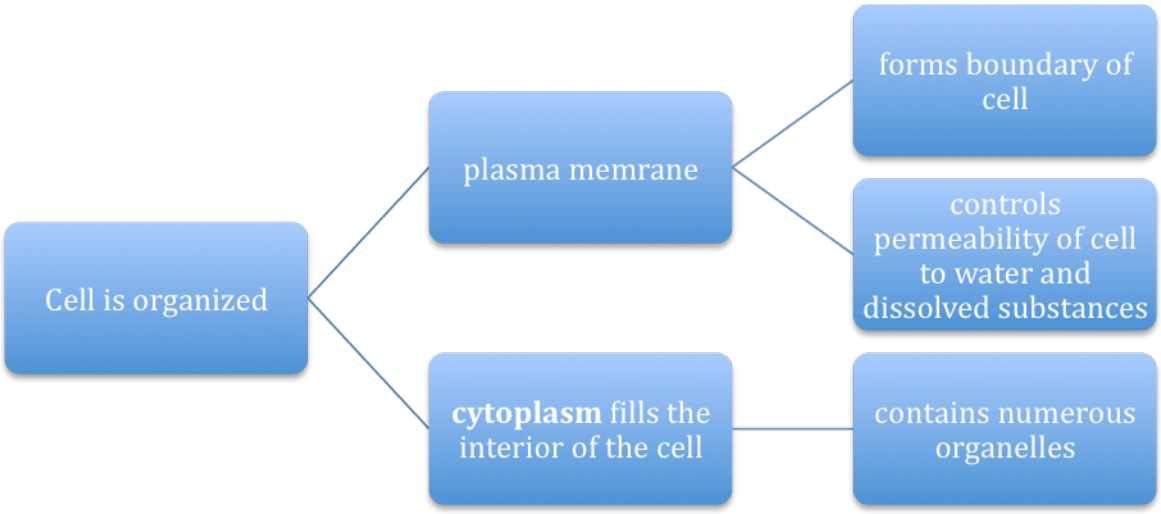


Cell theory

1.All organisms are composed of one or more cells

2.Cell are the smallest living things

3.Cells arise only by division of previously existing cells



Cellular structure is organized

The Plasma Membrane

- A phospholipid has a **polar** head and two **non-polar** tails
- polar region: phosphate chemical group and is **water-soluble**
- non-polar region: fatty acids and is **water-insoluble**

Interior of lipid bilayer is NONPOLAR: no water soluble molecules can cross

- **cholesterol** is also found in the interior
  - affects the fluid nature of the membrane
  - accumulation in walls of bld vessels » plaques
  - plaques lead to cardiovascular disease
- **Plasma membrane proteins:** embedded within the lipid bilayer

transmembrane proteins: form channels that span the membrane
other proteins are integrated into the structure of the membrane

- Ie: **cell surface proteins:** attached to outer surface of the membrane/ act as markers

There are two major types of cells

prokaryotic the simplest cellular organisms	**Eukaryotic** Larger in size &more complex
lacks a nucleus/ No extensive system of internal membranes all bacteria and archaea have this cell type have a plasma membrane surrounding a cytoplasm without interior compartments some bacteria have additional outer layers to the plasma membrane	has a nucleus has internal membrane-bound compartments all organisms other than bacteria or archaea have this cell type

cell wall comprised of carbohydrates to confer rigid structure
capsule may surround the cell wall

Prokaryotic Interior: simple, uniform cytoplasm,

ribosomes (protein synthesis) are scattered t/o the cytoplasm

nucleoid region (where DNA is localized)

flagellum (plural, **flagellae**) is a collection of protein fibers that extends from the cell surface .

- aids in attaching to substrates and in exchanging genetic information between cells
- may be one or many
- aids in locomotion and feeding
- **pilus** (plural, **pili**) is a short flagellum

Eukaryotic Cells larger and more complex

have a plasma membrane encasing a cytoplasm
internal membranes form **organelles**

cytoplasm is semi-fluid & has a network of protein fibers that form a scaffold called a **cytoskeleton**

Nucleus: a membrane-bound compartment for DNA. The Cell's Control Center/ stores hereditary information

endomembrane system: gives rise to internal membranes found in cell each compartment can provide specific conditions favoring a particular process

not all eukaryotic cells are alike.

- The cells of plants, fungi, and many protists have a **cell wall** beyond the plasma membrane
- all plants and many protists contain organelles called **chloroplasts**
- plants contain a **central vacuole**
- only animal cells contain **centrioles**

NUCLEUS:

- The nuclear surface is bounded by a double-membrane called the **nuclear envelope**

- groups of proteins form openings called **nuclear pores** that permit proteins and RNA to pass in and out of the nucleus

Inside the nucleus
Chromosomes: Segments of DNA packaged w/ protein

- the proteins enable the DNA to be wound tightly so it appears condensed

- the condensed or chromosome form of DNA occurs during cell division

- When cell is not dividing DNA is stored as **chromatin** (hard to see)

- protein synthesis occurs when the DNA is in the chromatin form

What else is in the nucleus?
nucleus is the site for the subunits of the ribosome to be synthesized

Nucleolus: dark-staining region of nucleus

- it contains the genes that code for the rRNA (ribosomal RNA) that makes up the ribosomal subunits
- the subunits leave the nucleus via the nuclear pores and the final ribosome is assembled in the cytoplasm

The Endomembrane System: an extensive system of internal membranes
some of the membranes form channels and interconnections
other portions become isolated spaces enclosed by membranes (**vesicles)**

- RER: protein synthesis
  the surface of this region looks pebbly
  the rough spots are due to embedded ribosomes

- SER: carbohydrate & lipid synthesis

the surface of this region looks smooth because it contains no embedded ribosomes

After synthesis in ER, the newly-made molecules are passed to **Golgi bodies** (flattened membranes that form collective stacks called the **Golgi complex)**

- their numbers vary depending on the cell
- collect, package, and distribute molecules manufactured in the cell
- The ER and Golgi complex function together as a transport system in the cell

The Golgi complex also gives rise to

1. lysosomes

contain enzymes that the cell uses to break down macromolecules
worn-out cell parts are broken down & recycled to form new parts
particles that the cell has ingested are also digested

2. Peroxisomes

the chemical reactions in peroxisomes

- 1.detoxify harmful byproducts of metabolism
- convert fats to carbohydrates in plants seeds for growth

Organelles That Contain DNA: **nucleus, mitochondria, chloroplasts**

The Theory of **Endosymbiosis**

some organelles evolved from a symbiosis in which one cell of a prokaryotic species was engulfed by and lived inside of a cell of another species of prokaryote

the engulfed species provided their hosts with advantages because of special metabolic activities

the modern organelles of mitochondria and chloroplasts are believed to be found in the eukaryotic descendants of these endosymbiotic prokaryotes

Evidence supporting endosymbiotic theory

1. Mitochondria: ~same size as modern bacteria the cristae in mitochondria resemble folded membranes in modern bacteria
2. mitochondrial ribosomes are similar to modern, bacterial ribosomes in size and structure
3. mitochondria divide by fission, just like modern bacteria

The Cytoskeleton: Interior Framework of the Cell

- internal framework of protein fibers thatanchor organelles to fixed locations
- support the shape of the cell
- helps organize ribosomes and enzymes needed for synthesis activities
- The cytoskeleton is dynamic and its components are continually being rearranged

Three different types of protein fibers comprise the cytoskeleton

1. **intermediate filaments**: Thick ropes of intertwined protein

2. **microtubules**: hollow tubes made up of the protein **tubules** Microtubules provide a means to transport material inside the cell efficiently over long distances

3. **microfilaments:** long, slender microfilaments made up of the protein **actin**

Centrioles are complex structures

- assemble microtubules in animal cells and the cells of most protists
- anchor organelles such as flagella/**cilia**
- assemble microtubules near nuclear envelope
- they might also have an endosymbiotic origin

The cytoskeleton also anchors storage compartments

- **Vacuoles:**membrane-bound storage centers

- **central vacuole:** lrg space inside a plant cell filled w/ water/dissolved substances

- **contractile vacuole** is found near the cell surface of some protists and accumulates excess water from inside the cell that it then pumps out

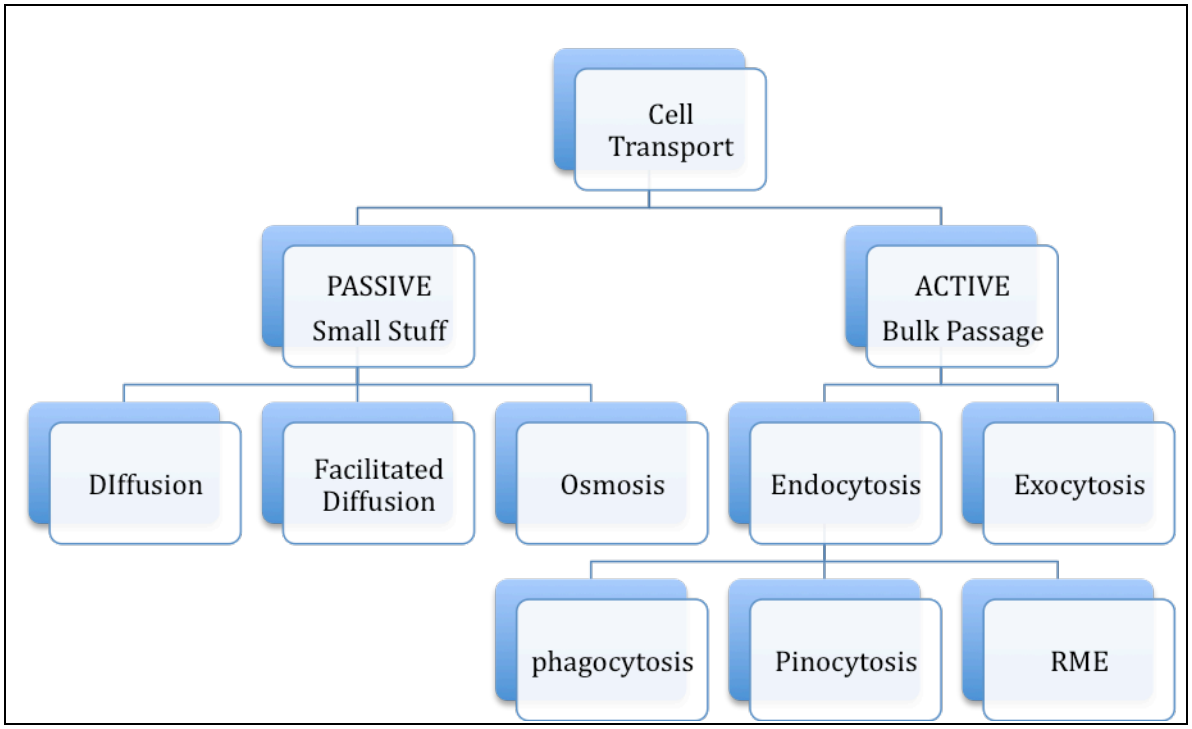
Outside the Plasma Membrane

Cell walls

- found in plants, fungi, and many protists
- comprised of different components than prokaryotic cell walls
- provides protection, maintains cell shape, prevents excessive water loss/uptake

Extracellular matrix (ECM)

- comprised by a mixture of proteins secreted by cell
- **collagen** and **elastin** proteins form a protective layer over the cell surface
- **fibronectin** protein connects the ECM to the plasma membrane
  ECM influences cellular behavior and coordinates groups of cells functioning as tissues



Diffusion and Osmosis:
Movement of water and nutrients into a cell or elimination of wastes out of cell is essential for survival

This movement occurs across a biological membrane in one of three ways

diffusion

membrane folding

protein transport

PASSIVE TRANSPORT across the plasma membrane.

Diffusion:

The net movement of molecules from an area of higher concentration to an area of lower concentration is termed **diffusion**

- Molecules diffuse **down** a concentration gradient from higher to lower concentrations
- diffusion ends when **equilibrium** is reached
- Only certain substances undergo diffusion across the plasma membrane
- Ie: oxygen, carbon dioxide, and nonpolar lipids
  ions and polar molecules cannot cross the interior of the membrane
- Water, although polar, is able to diffuse freely across the plasma membrane
- **aquaporins** are selective channels that permit water to cross

Osmosis: the diffusion of water

Water moves down its concentration gradient moving into/out of a cell the movement of water is dependent on the concentration of other substances in a solution

- the greater the amount of solutes that are dissolved in a solution, then the lesser the amount of water molecules that are free to move
- The concentration of all molecules dissolved in a solution is called the osmotic concentration of the solution
- Osmotic concentrations of different solutions can be compared relative to each other

Passive Transport continued

Facilitated diffusion

proteins act as carriers that can bind only to specific molecules to transport

- transport is limited by the availability of carriers
- if there are not enough carriers, then the transport is **saturated**

Consider two solutions with unequal osmotic concentrations

- the solution with the higher concentration is called **hypertonic**
- The solution with the lower concentration is called **hypotonic**

Consider two solutions with equal osmotic concentrations

- The solutions are each called **isotonic**

Movement of water by osmosis into a cell causes pressure called **osmotic pressure**

- Too much: may cause a cell to swell and burst (explains why so many cell types are reinforced by cell walls)

ACTIVE TRANSPORT across the plasma membrane.

Bulky substances are contained within vesicles as they are moved into and out of a cell (Uses up to 40% of a cells ATP)

Endocytosis: transport into the cell

- **Phagocytosis:**
- **Pinocytosis:**
- **RME:**

Exocytosis: transport out of cell

ACTIVE ways to enter a cell

1. Phagocytosis: Cell Eating

2. Pinocytosis: Cell drinking

3. Receptor Mediated Endocytosis:
   - transport of specific molecules INTO the cell
   - molecules bind to specific receptors in plasma membrane. A portion of the receptor extends into the membrane in an indented pit coated with protein **clathrin**
   - when a molecule binds to its specific receptor, the cell reacts immediately by initiating endocytosis of a now clathrin-coated vesicle

Selective permeability

allows cells to control specifically what enters and leaves
involves using proteins in the membrane for transporting substances across

Selective diffusion

proteins act as open channels for whatever is small enough to fit inside the channel
common in ion transport

Active transport

utilizes protein channels that open **only** when energy is supplied

pump substances against or up their concentration gradients

allows cells to maintain high or low concentration of certain molecules

diffusion always ends in equilibrium

There are two kinds of channels that perform active transport in cells

1. sodium-potassium pump

    - uses energy, in the form of ATP, to pump three Na^+ out of the cell and to pump two K^+ into the cell

    - nearly 1/3 of the energy expended by the body's cells is given over to driving these pumps

2. proton pump

Transport Mechanisms Summary

Passive Transport	Active Transport
No energy Expenditure Move DOWN a concentration Gradient **Examples:** 1. **Diffusion** • Commonly occurs in liquids/gases • - the rate of diffusion influenced by type of materials, temperature, and concentration • speed of diffusion is dependent only on the concentration gradient. 2. **Osmosis**: **s**pecial case of diffusion that involves the movt of water molecules across a membrane 3. **Facilitated Diffusion:** utilizes membrane protein channels to allow charged molecules (which otherwise could not diffuse across the cell membrane) to freely diffuse in/out of the cell. These channels come into greatest use with small ions like K+, Na+, and Cl-. • The speed of facilitated transport is limited by # of protein channels available	Requires Energy Move UP a concentration Gradient **Example:** 1. **Proton Pump** 2. **Exocytosis:** Molecules packaged in a vesicle that separates them out from the rest of the cell. The vesicle fuses with its specific membrane structure and its contents are released without the vesicle, which is incorporated back into the cell's membrane. 2. **Endocytosis:** 3 types ❑ Pinocytosis: ingesting small molecules and/or fluids surrounding the cell in a process known as fluid-phase endocytosis. ❑ Phagocytosis involves the ingestion of large molecules, such as microorganisms or cell debris using large vesicles, or vacuoles. White blood cells use phagocytosis to remove foreign particles from the blood stream. • Receptor Mediated Endocytosis: molecules bind to receptors in membrane. Pit is created.