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AP Biology

Unit 2

Student Notes

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AP Biology
Basic Cell Structure

Cells

Cells are considered to be the *basic units of life*.

The cell is an example of *Emergent Properties*. The organelles alone can do nothing, but if all of them are put together inside a cell membrane, “life” can emerge.

Cytology is the study of cells; **Cytologist** – a person who works with cells.

Cell Types

Prokaryotic cells

These organisms (eubacteria and archae) evolved before the evolution of the nuclear membrane and nucleus. These cells also lack membrane bound organelles. They are extremely small when compared to eukaryotic cells.

It is believed that the first prokaryotic cells came into existence about 3.5 Billion Years Ago (BYA). The oldest prokaryotic fossils are found on stromatolites (bacterial mounds) in Shark Bay, Australia.

Eukaryotic cells (“Eu” means “true”)

These cells evolved after the evolution of the nucleus. All organisms on Earth, other than eubacteria and archae are composed of eukaryotic cells. Eukaryotic cells have a membrane bound nucleus and membrane bound organelles.

Endosymbiotic Hypothesis

The **Endosymbiotic Hypothesis**, proposed by Lynn Margulis in the 1960s, hypothesized that some prokaryotes begin to live together in symbiotic relationships with the smaller prokaryotes living **inside** larger ones. This gave the symbionts a survival advantage over other prokaryotes and eventually they evolved into Eukaryotic cells.

Smaller organisms gained protection.

Larger organisms gained energy production or faster motility.

Over time DNA segments were “swapped” to create a more permanent existence. This “swapping” is referred to as **genetic annealing**.

The smaller prokaryotes eventually became the organelles within the larger prokaryotes.

Evidence for this hypothesis is found in mitochondria and chloroplasts.

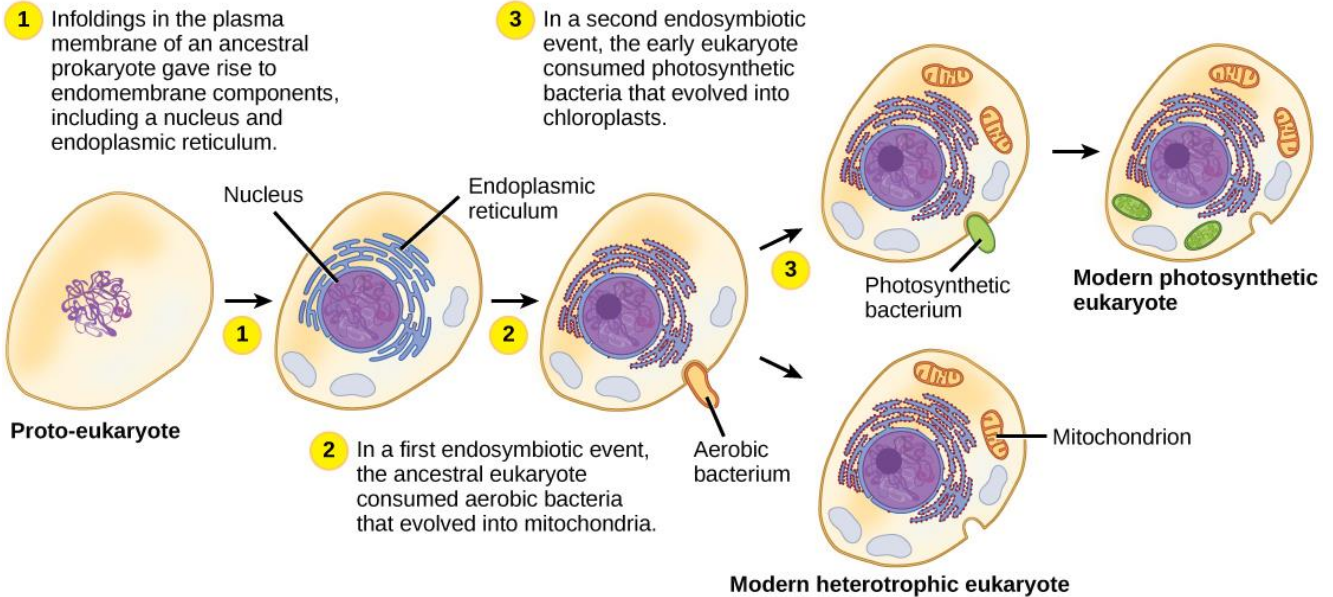
Mitochondria and chloroplasts have their own single circular chromosome like Bacteria.

Mitochondria and chloroplasts have ribosomes that are similar to those found in Bacteria.

Mitochondria and chloroplasts are able to independently reproduce within the larger eukaryotic cells. They use a process similar to binary fission.

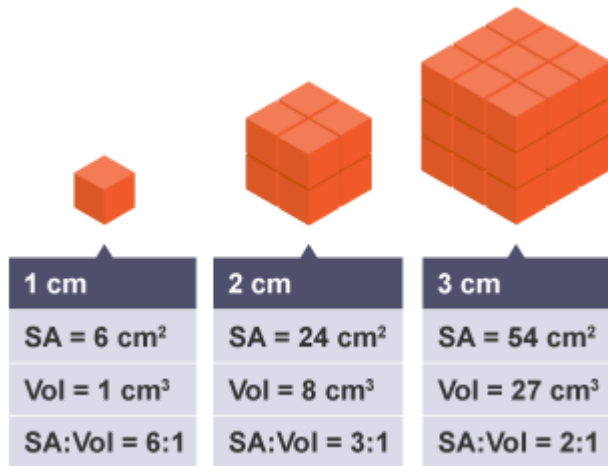
Mitochondria and chloroplasts have a double phospholipid bilayer cell membrane. This might be evidence of the phagocytosis of the original symbionts.

The ENDOSYMBIOTIC THEORY



The Surface Area- to- Volume Ratio is of GREAT Importance for all cells.

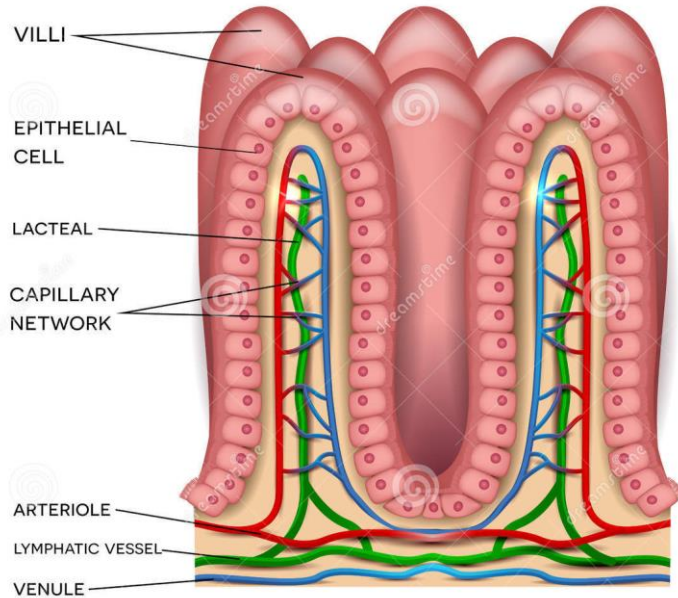
As cells grow, the surface area to volume ratio for the cell decreases. Think of the surface area as the cell membrane and the volume as the internal contents of the cell. As the cell gets larger, it gets harder for cells to transport in and out the required materials. This is one of the main reasons that cells must always be very small. Smaller cells have a higher surface area to volume ratio and are better able to transport materials through the cell membrane.



Adaptions for increasing the surface area without increasing the volume

Surface area to volume ratio can also be used to explain the shape of many cells / cellular surfaces. For example the folds inside the mitochondria or the flat pan-cake like structures inside chloroplasts provide a greater surface area on which specific reactions can occur. The folds in the lining of our stomachs or the tiny cellular, finger-like projections that protrude from the wall of the small intestine (villi and microvilli) all act to increase the surface area without increasing the overall size or volume of the organ.

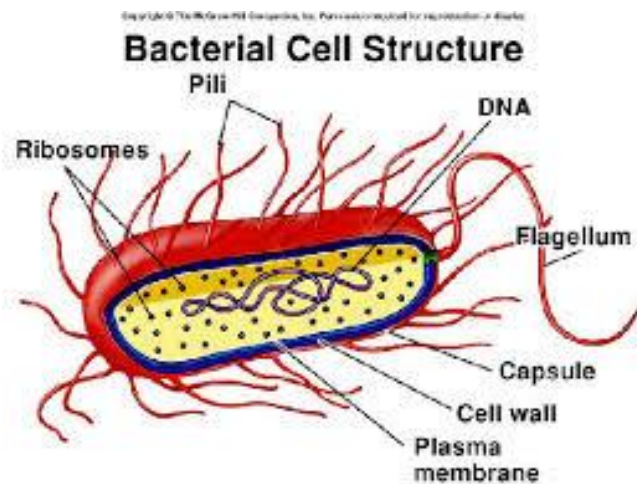
INTESTINAL VILLI



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Basic Prokaryotic Cell (Bacteria and Archae) Structure



All prokaryotes are unicellular. Prokaryotic cells possess a single circular chromosome (not enclosed in a nuclear membrane), ribosomes (for making proteins), and cytoplasm. The cells do not possess membrane-bound organelles like mitochondria or chloroplasts.


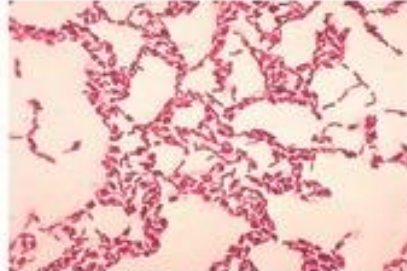
Three basic shapes of prokaryotes exist:

- Cocci (Means "round")
- Bacilli (Means "rod")
- Helical (Means "spiral")

Most prokaryotes will have a **cell wall**. (This is NOT the same as a plant's cell wall.)
 This structure is primarily for protection of the underlying cell membrane.
 It also helps prevent the prokaryotes from bursting in an aquatic environment.
 In eubacteria, the cell wall is mainly composed a protein and sugar substance known as **peptidoglycan**.

Scientists/doctors perform Gram stains to identify bacteria as either Gram positive or Gram negative.
 Different antibiotics work against each group.

Gram positive bacteria stain blue. These bacteria possess a **THICK** peptidoglycan layer.
 Gram negative bacteria stain red. These bacteria possess a **THIN** peptidoglycan layer
BETWEEN phospholipid layers.

Gram Positive	Gram Negative
<ul style="list-style-type: none"> • Inner most plasma membrane • Thick peptidoglycan cell wall • Outer Capsule • More easily treatable with antibiotics • Stains purple/violet after Gram Stain 	<ul style="list-style-type: none"> • Inner most plasma membrane • Thin peptidoglycan cell wall • Another plasma membrane • Outer Capsule • Harder to treat with antibiotics • Stains red/pink after Gram Stain
	

Proper treatment can begin once the results of a Gram Stain are known.

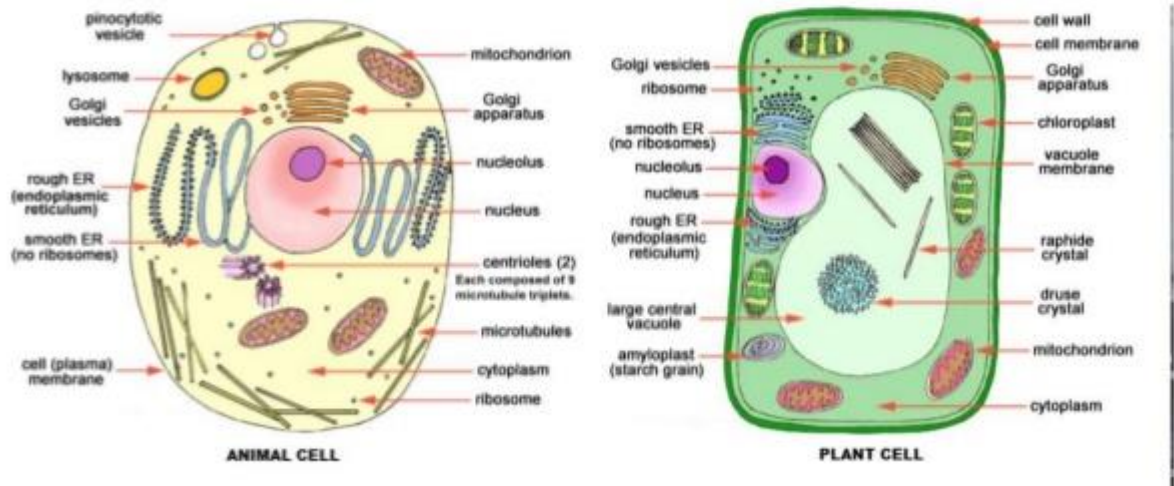
Some bacteria produce a **Capsule** that covers the cell wall. The capsule is a sticky substance for adherence to surfaces. The capsule can protect the bacteria from a host cell's immune response.

Although we think of bacteria as germs that make us sick, most bacteria are beneficial. Bacteria are important in the process of decomposition/mineral recycling. Other bacteria fix nitrogen, do photosynthesis, and help us manufacture certain foods and chemicals.

Basic Structure of Eukaryotic Cells

The First Eukaryotic Cells

- Evolved 2.7 billion years ago
- Larger and more complex than bacteria, Have a nucleus, complex organelles, cytoskeleton



1. Plasma “cell” membrane --This holds the cell together. *The eukaryotic cell membrane is very similar to the prokaryotic cell membrane. The membrane is important for transporting substances into and out of the cell.*
2. Nucleus--This structure controls the activities of a cell by holding the DNA. The DNA serves as the instructions for building proteins. The DNA of eukaryotes is enclosed within a membrane called the nuclear membrane or envelope.
Prokaryotic DNA floats in the cytoplasm and is sometimes referred to as nucleoid (nucleus-like).
3. Cytoplasm or cytosol—This fluid filled space contains the nucleus and the other organelles. This area makes up most the volume of the cell.
4. Membrane-bound organelles—These enclosed structures specialize to carry out specific jobs within the cell. Examples include: the nucleus, mitochondria, chloroplasts, the endoplasmic reticulum, and the Golgi apparatus.

AP Biology

Membrane Structure and Transport of Molecules

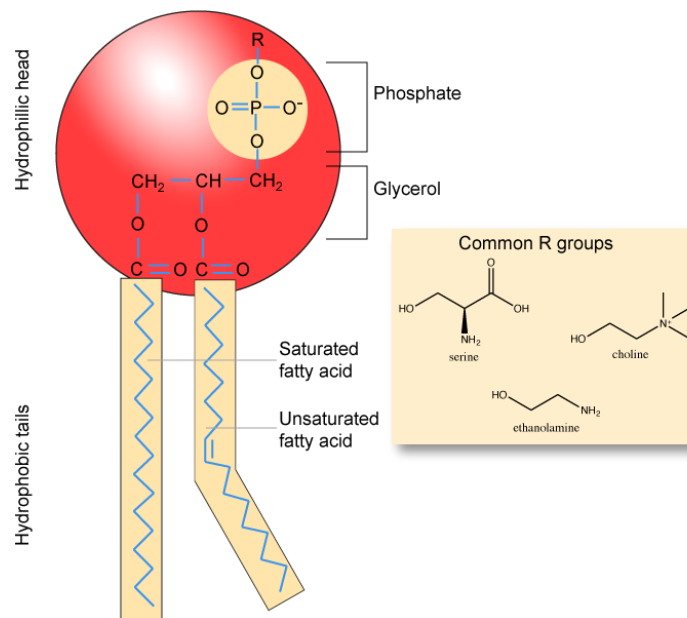
Selectively Permeable

The cell membrane (plasma membrane) is referred to as selectively permeable or semipermeable. This means that the cell allows or actively transports certain materials into or out of the cell while not allowing other materials to enter or exit the cell. Typically, small and nonpolar substances can enter the cell easily, while large and/or polar/charged substances either cannot enter or have to be brought into the cell via some type of protein channel.

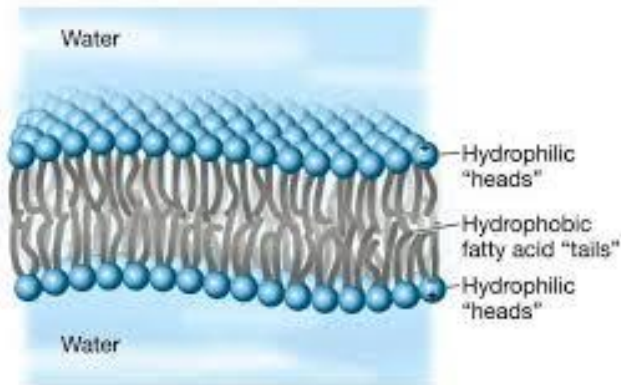
Membrane Structure

A phospholipid bilayer makes up the *majority* of the cell membrane and also the organelle membranes. Phospholipids are **amphipathic** molecules. They have both *hydrophilic and hydrophobic* components/sides. These molecules form a bilayer because the hydrophilic portions of the molecule (the phosphate groups) orient themselves toward the water that is located both inside and outside the cell, while the hydrophobic portions of the molecule (the fatty acid tails) orient themselves away from the water and toward each other in the center of the membrane.

Structure of a Phospholipid



(B) Phospholipid bilayer



LIFE (6e), Figure 3.22 (Part 2)

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Proteins

Many different types of proteins are embedded into the phospholipid bilayer.

Integral Proteins run completely through the bi-layer from the outside to the inside and function in the transport of molecules across the membrane. They also help to maintain the INTEGRITY of the membrane.

Peripheral Proteins are located on one side of the membrane. They do not extend through the bi-layer. Peripheral proteins can act as receptors for cell signals, as catalysts/enzymes, and as structural components of the cytoskeleton.

The proteins of the cell membrane can also perform the following functions:

Molecule transport—Each transport protein aids the transport of a specific molecule, ion, etc... across the membrane.

Act as *enzymes* to catalyze specific reactions.

Cell to cell communication and recognition—These proteins can help cells attach to each other and work together and/or communicate with each other.

Signal Receptors—Act to receive hormones or other signaling molecules which circulate in the blood or interstitial fluids.

Attachment points—Some proteins act as attachment points for the cytoskeleton.

Cholesterol

This lipid molecule functions to keep the membrane from being too fluid, and too permeable to some small molecules. It also helps to secure the proteins that are embedded in the membrane. Cholesterol helps to keep the cell membranes of plant cells from freezing solid in very cold temperatures.

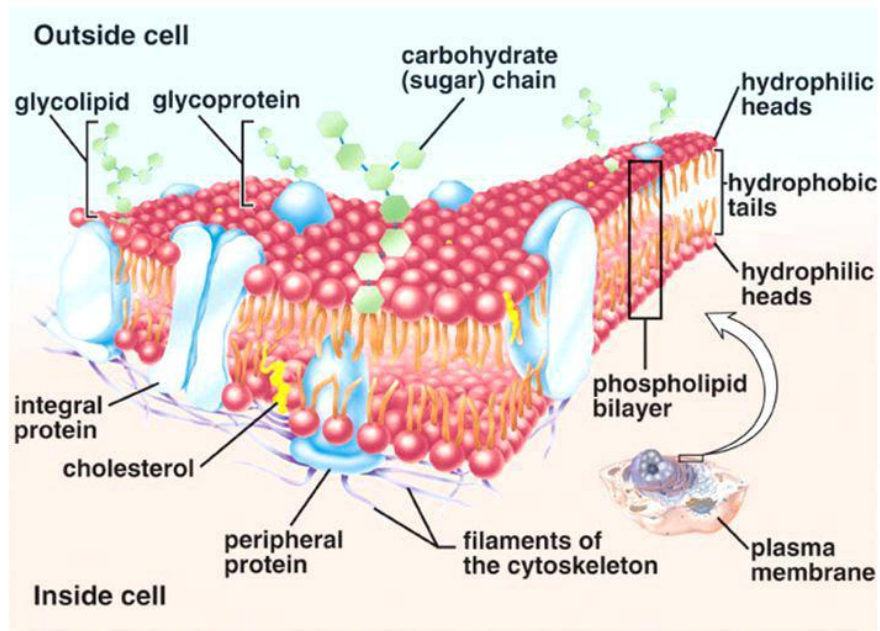
Fluid Mosaic Model of the Cell Membrane

The current scientific model of the cell membrane is referred to as the **Fluid-Mosaic model** because it looks like a *moving* (Fluid) puzzle (mosaic). The phospholipids compose the fluid portion, while the proteins are embedded within like a mosaic. All the pieces can move *laterally*, like students moving from seat to seat. The proteins moving in this sea of phospholipids are like a teacher moving around the student desks. Imagine the ceiling and floor are water molecules. The water molecules prevent vertical movement of the cell membrane

components.

Fluid-mosaic model of membrane structure

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AP Biology Eukaryotic Cell Components

There are four main parts to Eukaryotic Cells:

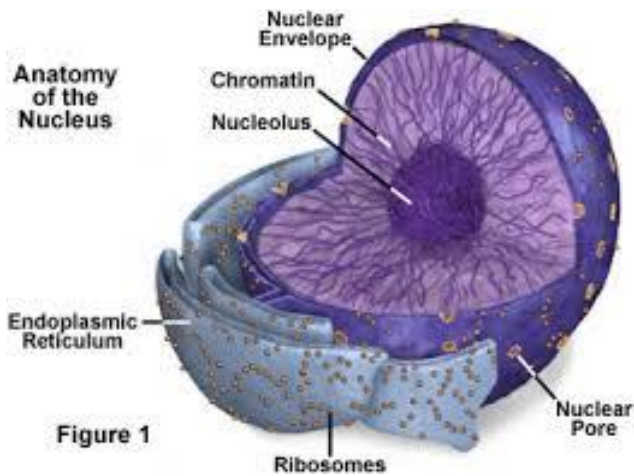
Plasma “cell” membrane—This structure holds the cell together and helps to regulate which substances can enter/exit the cell.

Nucleus--This *controls the activities* of a cell because it contains the DNA which acts as the instruction for building the cell’s proteins and determining its traits.

Cytoplasm or cytosol—This fluid-filled space contains the organelles and makes up most of the volume of the cell.

Organelles—These structures specialize to carry specific functions within the cell. By specializing, they divide up the labor and make the cell more efficient. **It is important to note that the number and distribution of organelles differs from cell type to cell type.**

Nucleus



This acts as a *control center for all activities* performed by the cell.
It is the source of the cell’s genetic information or DNA.

Nuclear Envelope

It is composed mainly of a double phospholipid bi- layer.

It encloses the DNA.

It also contains pores (tunnels) composed from *proteins* which allow certain specific materials to enter/exit the nucleus. The messenger RNA must exit the nucleus and go to the ribosomes where it acts as the directions for making proteins.

DNA

Chromatin phase—During most of the cell’s life cycle, the DNA is loose and spread-out throughout the nucleus. During the chromatin phase, the DNA looks like a bowl of plain spaghetti noodles.

During the phase, the DNA can be transcribed and used to make proteins.

Chromosome phase—During this phase, the DNA coils around proteins called histones (in eukaryotes and archae). The coiling helps to organize the DNA so that it can be corrected distributed during the processes of nuclear and cell division

Nucleolus

This structure appears as a dark spot within the nucleus.

The nucleolus functions to make the ribosomal RNA (rRNA) and proteins which make up the cell’s ribosomes.

Ribosomes

These are CELL PARTICLES made of ribosomal RN A(rRNA) and proteins. Ribosomes are not usually considered to be organelles because they are not enclosed within a membrane. All cell types, both prokaryotic and eukaryotic, have ribosomes.

Ribosomes are the sites of Protein Synthesis. The cell’s normal proteins and enzymes are ALL made here.

Two types of ribosomes exist based on location:

Free Ribosomes– These float “freely” in the cytoplasm of a cell. (They are found in ALL TYPES of cells.) These ribosomes make proteins that will stay and function *inside* the cell that made them.

Bound Ribosomes – These ribosomes are attached to the rough endoplasmic reticulum (RER). (These are ONLY found in Eukaryotes ONLY because only they have the RER.) Bound ribosomes make proteins that will *leave* the cell to be used elsewhere. Many of these proteins acts as cellular communication signals or as antibodies to fight infections.

Endomembrane system

The endomembrane system (*endo* = “within”) is a group of membranes and organelles in eukaryotic cells that work together to modify, package, and transport lipids and proteins. Once the bound ribosomes make their proteins, the proteins enter the Rough ER and are eventually packaged into phospholipid-based secretory vesicles. These vesicles transport the proteins to the Golgi apparatus where they will be modified. After modification, the proteins are once again packaged into a lipid-based vesicle and shipped to the cell membrane. The proteins are excreted from the cell while the phospholipids that made up the vesicle become part of the cell membrane. The general pathway is (RER → Secretory vesicle → Golgi → secretory vesicle → Membrane for release. In some cases, the packaged proteins/enzymes become part of lysosome instead of being transport out of the cell.

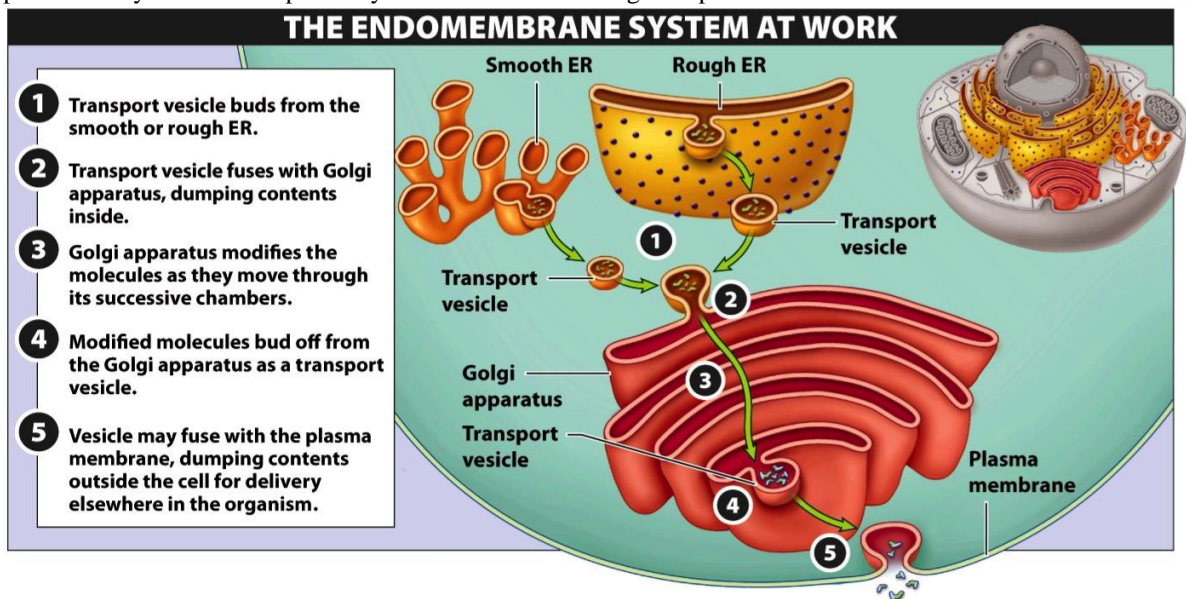


Figure 3-37
What Is Life? A Guide To Biology, Second Edition
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Endoplasmic Reticulum (ER)

It is composed of a network of small tubes called cisternae. (“cisternae” means “tubes”)

The ER is ALWAYS found just outside and around the nucleus.

Two types of ER can exist inside EUKARYOTIC cells:

Smooth Endoplasmic Reticulum (SER)

This structure helps with the *synthesis* of lipids, phospholipids, and steroids.

It also helps with carbohydrate *breakdown*.

The smooth ER can also aid in the detoxification of the blood. (Liver cells are loaded with SER.)

It also helps the storage of Ca^{++} , needed for *muscle contraction*. (Muscle cells have lots of SER.)

Rough Endoplasmic Reticulum (RER)

This structure helps with *protein synthesis*, modification, and transport.

Ribosomes are bound to the outside of the organelle and deposit the newly constructed proteins *into the Rough ER*. Inside the structure, the proteins are folded into the specific 3-D structure needed to function.

Golgi Apparatus

The Golgi Apparatus or Golgi Body *modifies* proteins by attaching sugars to them. (called Glycoproteins). The Golgi make act as a warehouse for storage of proteins, but eventually packages the proteins and ship them out in vesicles.

The Golgi apparatus is usually located near the cell membrane.

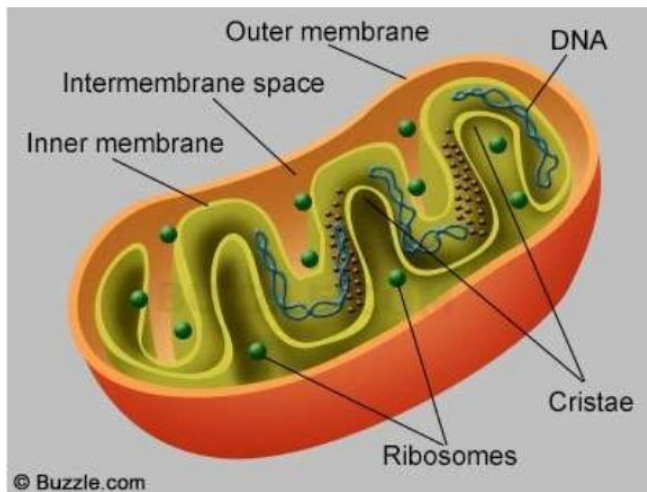
Lysosomes - These organelles contain powerful hydrolytic enzymes and acids.

The lysosomes help to carry out the process of intracellular digestion. This process helps to breakdown materials within a cell.

Once broken down, the components of some of these materials may be recycled for other purposes.

Vacuoles and Vesicles – These organelles act as phospholipid-based storage containers for the storage of materials needed by the cell. Various types such as Food, Contractile, Central exist in different types of cells.

Mitochondria - Nicknamed the “Power House”.

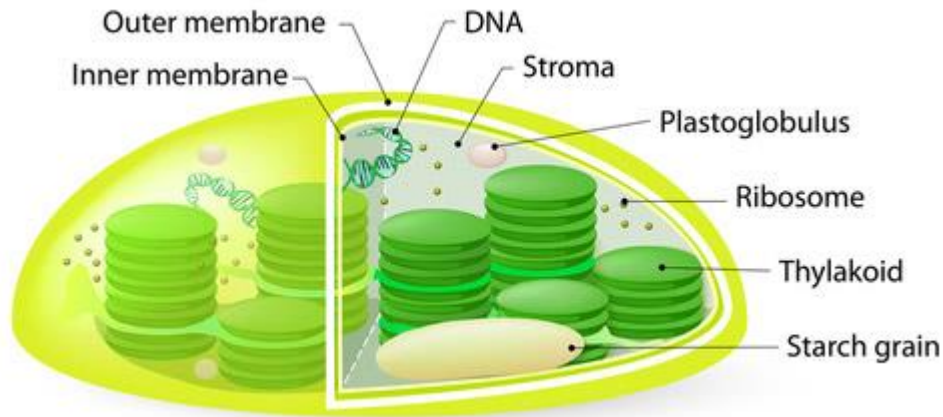


The mitochondria perform the process of aerobic cellular respiration. During this process the energy from food is transferred to the bonds of ADP and P to create ATP. ATP then serves as the source of energy for most of the cell's processes.

This organelle has its own DNA, its own bacteria-like ribosomes, its own enzymes and it can even reproduce independently via binary fission. The inner membrane of the mitochondria are folded into structures known as **cristae**. The folds increase the surface area and serve as the sites for the electron transport chain.

Evolutionary Significance—Mitochondria are believed to have descended from aerobic bacteria that entered into a symbiotic relationship with a larger prokaryote cells that could provide protection in return for the ATP produced by the mitochondria. Together they would have an evolutionary advantage over other bacteria. The advantage allowed them to survive and reproduce and eventually led to the evolution of Eukaryotic cells.

Chloroplasts



These organelles are the sites of *Photosynthesis* in plants and algae.

Chloroplasts are a type of **Plastid or pigment container**.

Like mitochondria, chloroplasts have their own DNA, ribosomes, and enzymes! They can also reproduce independently via binary fission too!

The interior of a chloroplast is composed of stacks of sack-like structures known as thylakoids. This stack-like arrangement increases the surface area needed to carry out the light-dependent stages of photosynthesis.

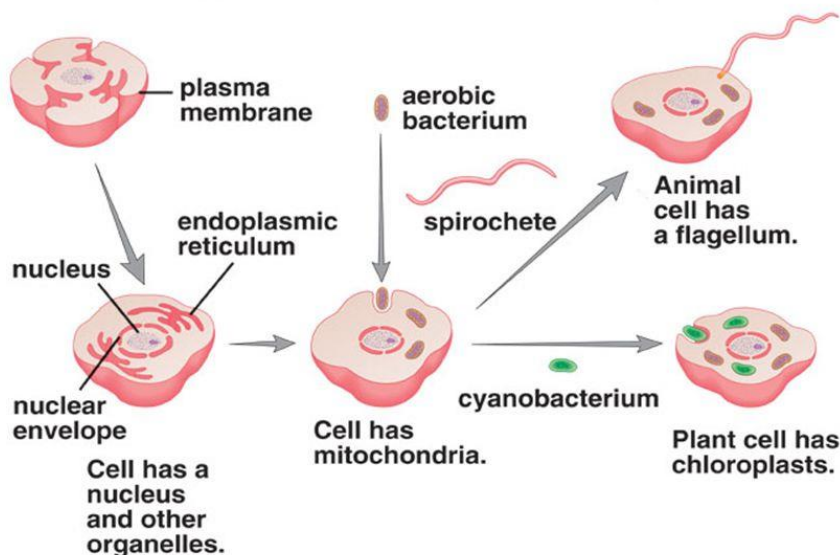
The stroma is mostly watery space in between the thylakoids and outer membrane. The stroma serves as the site of the Calvin Cycle (the metabolic pathway in which sugar is made).

Evolutionary Significance—Chloroplasts are thought to have evolved from blue-green bacteria (cyanobacteria) that entered into a symbiotic relationship with other bacteria for protection in return for sugar production.

Endosymbiont Hypothesis tries to *scientifically* explain the symbiotic relationships that led to the evolution of eukaryotic cells from prokaryotic cells.

Evolution of the eukaryotic cell- Endosymbiotic Hypothesis

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This hypothesis was proposed by Lynn Margulis in the 1960's.

It basically hypothesized that Prokaryotes came to live together in symbiotic relationships with smaller prokaryotes living *inside* larger prokaryotes in order to gain a survival advantage over other prokaryotes. In return, the larger prokaryotic hosts gained extra sources of energy or better motility. These symbiotic partnerships eventually evolved into Eukaryotic cells over many generations that spanned hundreds of thousands of years.

Cytoskeleton

These structures help to support and protect the cell.

The cytoskeleton also helps to keep inner organelles organized. The spindle fibers that help to move the chromosomes during mitosis and meiosis are composed of elements of the cytoskeleton.

The cytoskeleton also helps to make up structures such as flagella and cilia which aid in cell motility or cell organelle movement. (Much like your skeleton helps you move.)

The cytoskeleton is composed of various sized protein fibers known as either microtubules, microfilaments, or intermediate filaments. (Your skeleton has different sized structures too. Largest – bones, middle – Ligament and tendons, smallest- muscle fibers.)

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

Protective or weight bearing structures for cells:

Cell Wall of Plant Cells--It is composed primarily of the carbohydrate cellulose. It functions to provide support and protection to the plant. It may also protect the cells from bursting if they are exposed to hypotonic conditions.

Cell Walls of Fungus--Composed of the carbohydrate called *Chitin*. The functions of the fungal cell wall are similar to those of the plant cell wall.

Extra Cellular Matrix (ECM)

The extracellular matrix consists of molecules that are secreted by a cell into the space out the cell's membrane. The extracellular matrix can form cell walls, bone, cartilage, etc... The ECM can function to provide support, to segregate different tissues from one another, and to regulate intercellular **communication**.

A CELL IS THE MORE THAN THE SUM OF ITS PARTS! Only when all the parts come together and work together can "LIFE" happen.

**AP Biology
Cellular Transport Mechanisms**

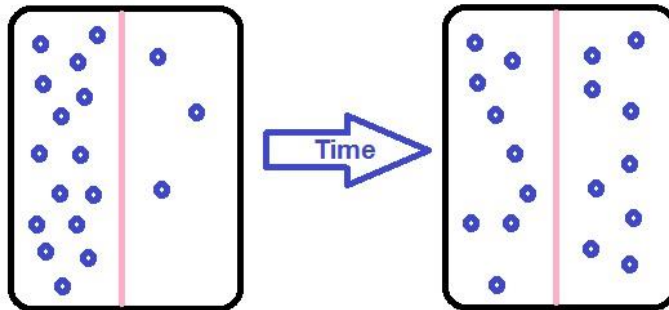
Material Transport

CO₂ and O₂ (both gases) can diffuse across the *wet phospholipid bi-layer* because they are *neutrally* charged and small particles.

Ions, polar molecules, and large molecules move through the membrane with the help of either channel or carrier proteins.

Types of **Passive Transport** (This type of transport doesn't require the cell to use any of its own energy. The process is powered by energy (usually heat) from the environment.)

Diffusion



This process operates upon an *established concentration [] gradient* or difference in concentration. Materials flow from high concentration to low concentration until equilibrium is achieved. Once equilibrium is reached, the particles still move, but net diffusion ceases.

This is how the majority of materials are transported in cells. (Because it requires no E expenditure by the cell...which saves E for maintaining homeostasis, repair, and reproduction.)

Osmosis (The diffusion of Water.)

Osmosis is a type of diffusion. This means that water moves from areas of high water concentration to areas of low water concentration. Osmosis is also often defined in terms of the solutes that are dissolved in the water. In terms of solutes, water moves from areas of low solute concentration (high water concentration) to areas of high solute concentration (low water concentration).

Osmosis is also often defined in terms of the words hypotonic and hypertonic. Water ALWAYS flows from Hypotonic (low solute concentration/high water concentration) to Hypertonic (high solute concentration/low water concentration).

Osmosis often happens when a membrane is impermeable to a solute that is present in different concentrations on each side of the membrane. Water moves to even out the solute concentrations.

Plants, fungi, and bacteria have cell walls that *may* affect water movement, see below. Most water movement into or out of the cell occurs through proteins called aquaporins. These proteins act as tunnels for only water movement.

Osmosis is crucial for *all* cells to control.

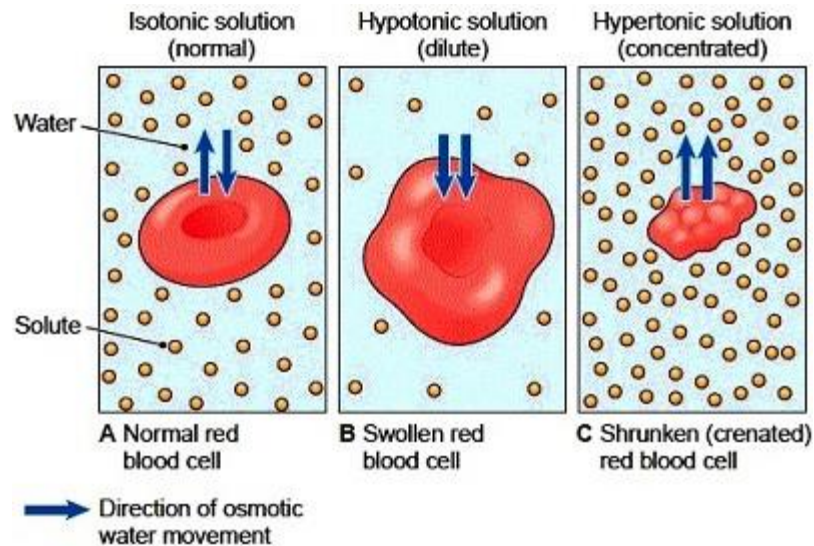
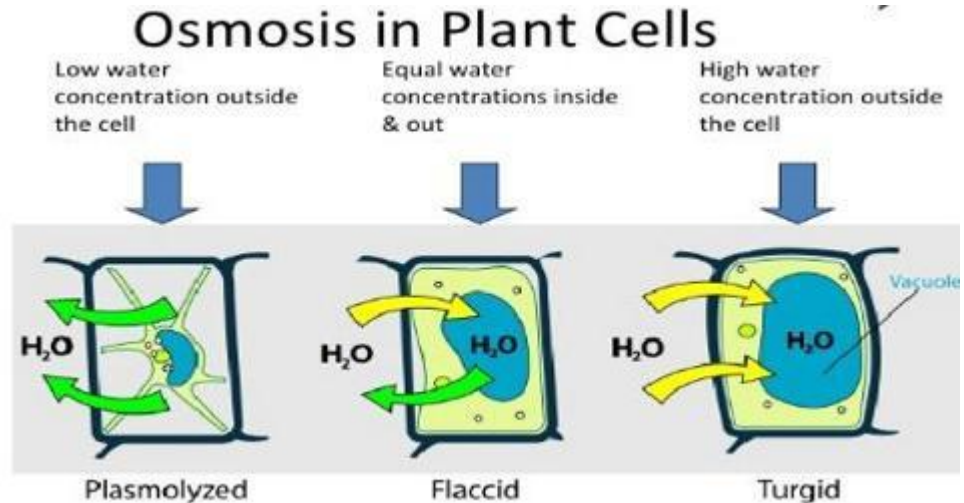
Osmoregulation—the process of regulating the solute and water concentrations of the cell or body. This is one of the main functions of the urinary system.

Turgid – This refers to a condition when there is *lots of water* in a cell that possesses a cell wall, so the cells are rigid and stiff.

Flaccid – This refers to a condition when there is *not very much water* in a cell that possesses a cell wall, so the cells are limp and wilted.

Plasmolysis – This is when the cell membrane *shrivels away* from the cell wall. This happens when a cell is placed into a hypertonic environment. Water leaves the cell and it shrivels up. This is why salty environments kill plants.

Assume that the membrane is impermeable to the solute in each of the two diagrams included below.



Water Potential

(Represented by the Greek letter psi – Ψ ...after Poseidon's Trident.)

Water Potential is a measure of the relative tendency of **water** to move from one area to another. Water potential takes into account both the effects of solute concentration and pressure. Such calculations are important when trying to determine the effects of osmosis on cells that possess a cell wall.

Water always flows from High Ψ to Low Ψ . The total water potential of pure water in an open container is 0.

Pressure Potential (Represented by Ψ_p .)

Pushing is positive pressure being exerted on the cell. (+ Ψ_p)

Pulling away from is negative pressure (- Ψ_P) being exerted on a cell. (Important when you consider a plant is having water pulled out of it by transpiration at the stomata and pushed into the xylem vascular cylinder in the root.)

Solute Potential (Represented by the symbol Ψ_S .)

$$\Psi_S = -iCRT$$

i is the *ionization constant*. The ionization constant is essentially the number of ions that are formed when a substance dissolves. The ionization for sugars is always 1. Sugars don't ionize when they dissolve. The ionization constant for NaCl is 2 because it ionizes into 1Na⁺ and 1Cl⁻ ion when it dissolves. The ionization constant for CaCl₂ is 3 because the salt dissolves into 1 Ca⁺² and 2Cl⁻ ions.

Don't forget to include the leading negative sign from the formula.

C is the *molar concentration or molarity measured in moles of solute/Liter of solution*.

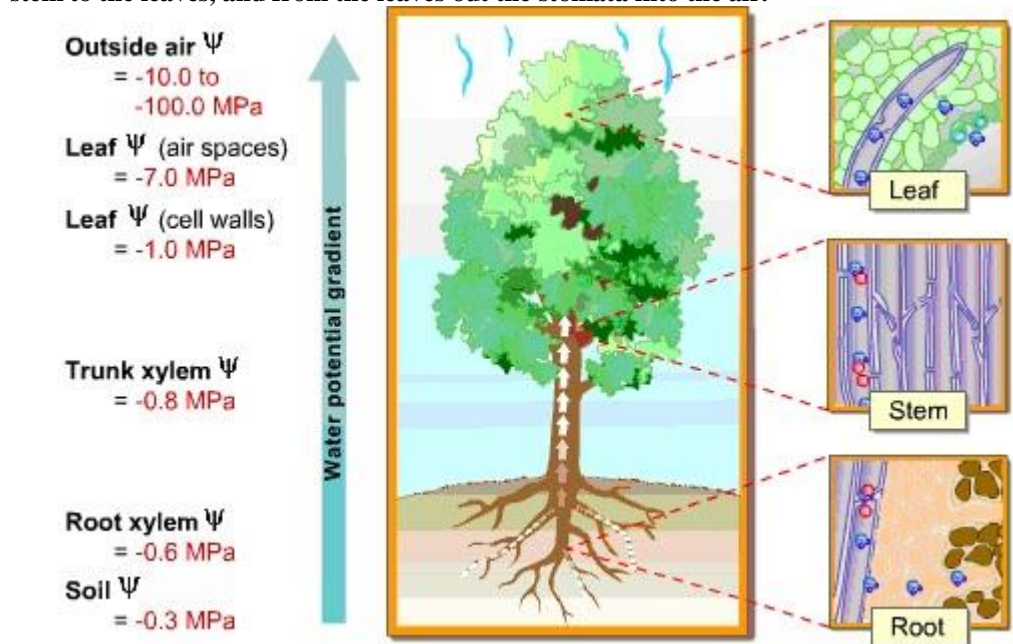
R is the pressure constant. ($R = 0.0831 \text{ liter-bars/mole-K}$)

T is the temperature in Kelvin. ($273 + ^\circ\text{C} = \text{K}$) You must use the Kelvin temperature in these calculations.

Total Water Potential (Represented by Ψ_T)

$$\Psi_T = \Psi_S + \Psi_P$$

Water Potential is important during the process of transpiration. The water potential is highest in the soil and lowest in the air. Water thus moves from the soil into the roots, from the roots to the stem, and the stem to the leaves, and from the leaves out the stomata into the air.



Facilitated Diffusion

Facilitated diffusion (a type of passive transport) transports materials from high concentration to low concentration. This type of transport requires the *help* of channel or transport proteins because the materials that are being transported are either polar/ionic/large.

Aquaporins- Channel proteins which help move water (because it is a polar molecule) across a membrane via facilitated diffusion.

Gated-ion channels which move sodium and potassium ions in and out of neurons are also examples of channel proteins which aid in the process of facilitated diffusion.

Active Transport

(This process the use of **ENERGY by the cell. This energy is often provided by ATP Hydrolysis.**)

This process moves materials against the concentration gradient. (Like pushing a car up a hill...it will require energy.) Materials are being moved from areas of low concentration to areas of high concentration.

The Na⁺/K⁺ Pump of the nervous system, is an example.

Energy from ATP by **Phosphorylation** (Attaching a phosphate ion to a structure to make it work.) **activates** the protein to grab and move molecules.

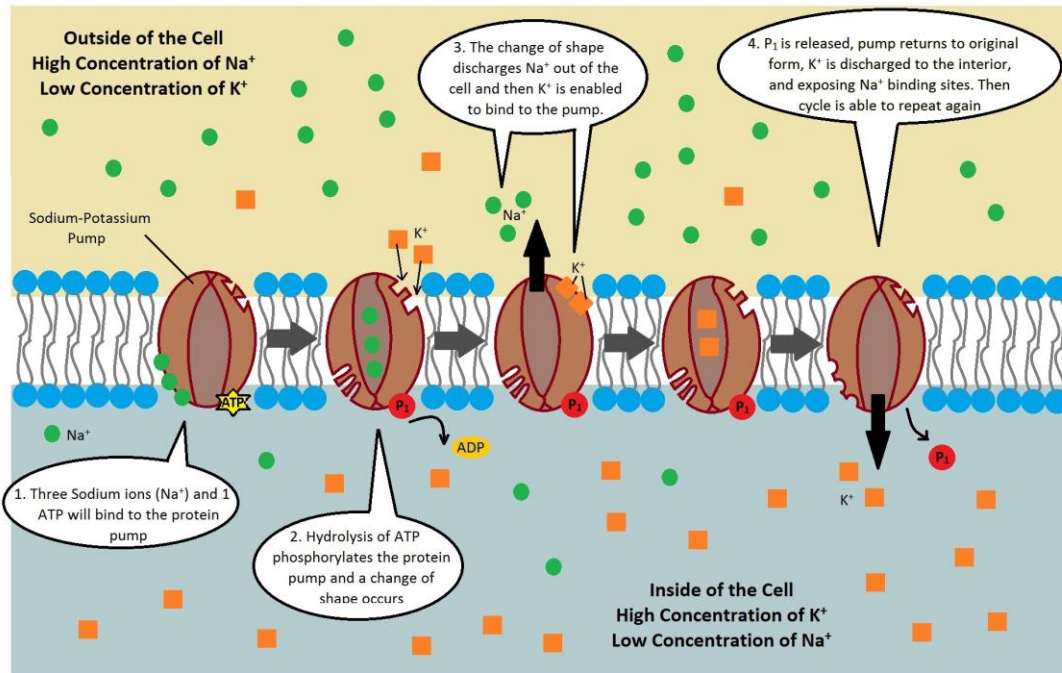


FIGURE: The Sodium-Potassium Pump

Electrogenic Pump (A.K.A. Proton [H^+] Pump)

This is the *most important active transport protein for all life forms*. Proton pumps are important in processes involved in the electron transport chain of photosynthesis and cellular respiration. Hydrogen ions, H^+ , move out of the cell to create a gradient. (Outside is + and inside is -.) Diffusion can now occur based on charges into and out of cell. The gradient serves as a source of energy for producing ATP.

Co-transport

Co-transport is a process in which two substances are simultaneously transported across a membrane by one protein, or protein complex which does not have ATPase activity. Co-transport is a type of active transport. Usually one of the substances moves with the concentration gradient (from high to low concentration). The movement of this substance provides the energy to transport the other substances against the concentration gradient (from low to high concentration).

When both substances are transported in the same direction the transport protein is known as a **symport**.

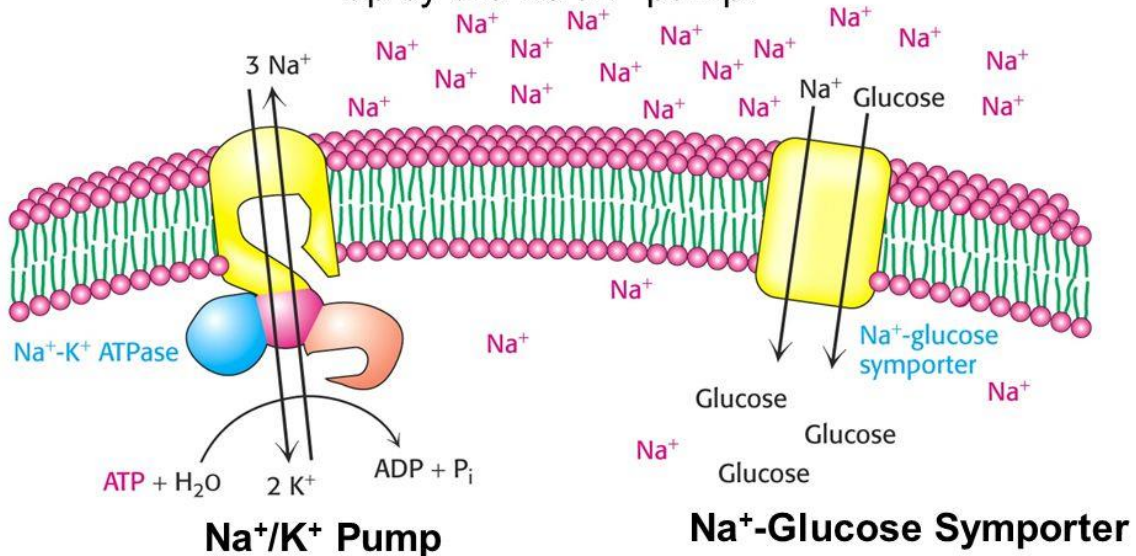
When the substances are transported in opposite directions the transport protein is known as an **antiport**.

An example of co-transport is the absorption of glucose by epithelial cells in the gut. In the gut, glucose is co-transported with sodium ions. The concentration of Sodium ions is higher outside the gut cells than it is inside them. The sodium/potassium pump establishes and helps to maintain the sodium concentration gradient. This is called primary active transport. Sodium then moves into the cells (through a transport protein (symport)) down its concentration gradient. The concentration of glucose is higher inside the cells that it is outside the cells. The energy from the movement of the sodium ions powers the secondary active transport of glucose into the cells by the same transport protein or symport.

EXAMPLE: Symporter

Secondary Active Transport-Na⁺-Glucose Symporter:

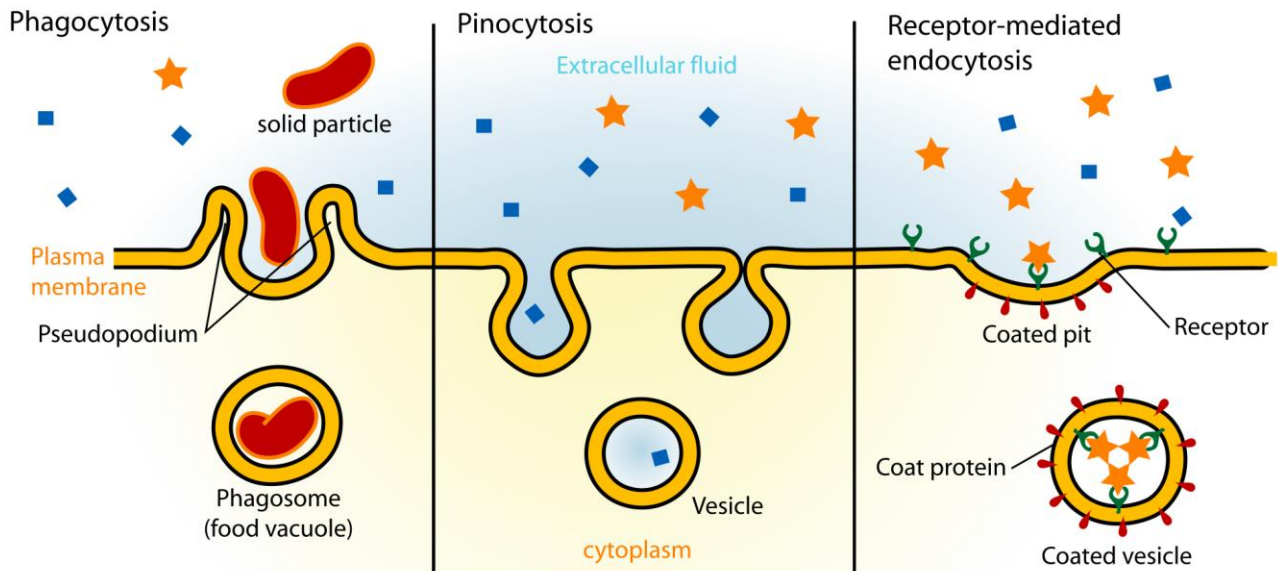
Transports glucose against its concentration gradient utilizing the downhill flow of Na⁺ along its concentration gradient previously set up by the Na⁺/K⁺ pump.



Large Molecule Transport or Bulk Transport

The movement of molecules that are TOO big for proteins to transport. All forms of bulk transport require the cell to expend energy and thus can be classified as forms of active transport.

Endocytosis



Exocytosis – This is the process of moving large materials out of a cell. Exocytosis is often referred to as secretion. An example of this process would be Pancreatic cells releasing the hormone Insulin into the blood

stream to help regulate blood glucose levels. Typically, this involves vesicles from Golgi Apparatus fusing with the cell membrane and secreting the proteins they contained into the interstitial fluids.

Endocytosis – This is the process of moving large materials *into a cell*. (“Endo” means “in”)

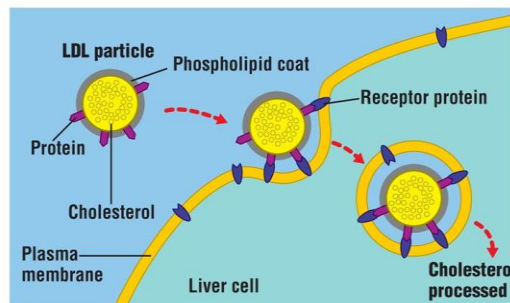
Phagocytosis – This process transports large, solid particles into the cell. It usually involves the surrounding of the particles with the cell membrane, the engulfing of the particles, and the surrounding of the particles with a vesicle. A white blood cell taking in a bacterial cell is a good example of phagocytosis. Phagocytosis is often followed by the process of intracellular digestion.

Pinocytosis – Pinocytosis is a mode of endocytosis in which small particles suspended in extracellular fluid are brought into the cell through an invagination of the cell membrane, resulting in a suspension of the particles within a small vesicle inside the cell. These pinocytotic vesicles subsequently fuse with lysosomes to hydrolyze (break down) the particles.

Receptor-Mediated Endocytosis

Receptor mediated endocytosis is an endocytotic mechanism in which specific molecules are transported into the cell. The specificity results from a receptor-ligand interaction. In this case, the ligand is the substance that is being transported into the cell. The ligand binds to a receptor (on the cell membrane) that is specific to that particular ligand. This triggers an endocytotic process and the ligand is ingested. The transport of cholesterol into cells is a good example. LDL cholesterol normally binds to receptors on the cell membrane and is then transported into cells. Individuals with the genetic condition familial hypercholesterolemia don't have receptors for LDL cholesterol. The LDL can't be transported into the cells, stays in the bloodstream, and causing clogging of the arteries.

Receptor-mediated endocytosis: cholesterol uptake



<http://bcs.whfreeman.com/thelifewire/content/chp05/0502003.html>