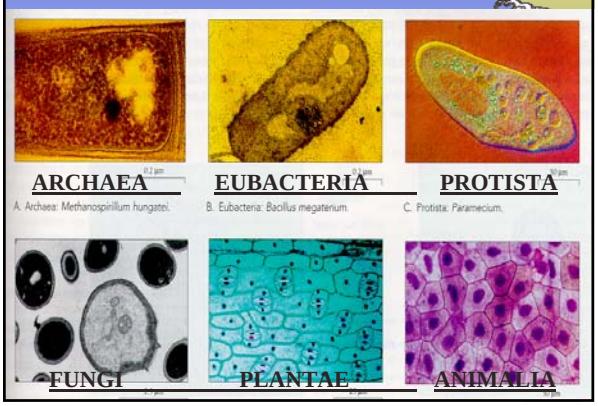
CELLS

3

Unit One

Karen Webb Smith

CELLS OF THE SIX KINGDOMS

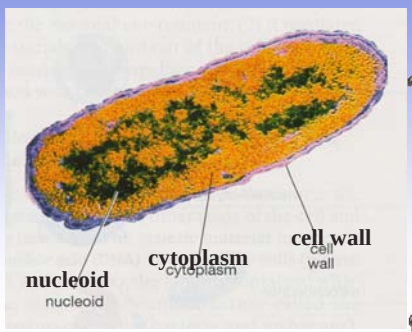


ARCHAEA | EUBACTERIA | PROTISTA

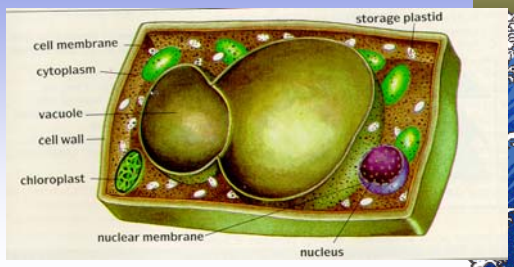
A. Archaea: Methanospirillum hungatei. B. Eubacteria: Bacillus megaterium. C. Protista: Paramecium.

FUNGI | PLANTAE | ANIMALIA

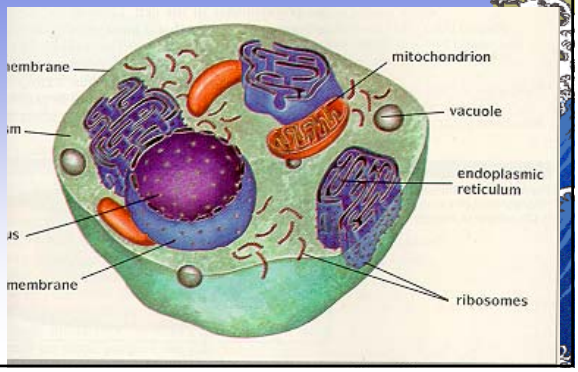
PROKARYOTIC CELL (bacterium Escherichia coli)



TYPICAL PLANT CELL



ANIMAL CELL



I. Introduction

A. The human body consists of 70 trillion cells.

B. Human cells vary considerably in shape and size.

- *Cells are the smallest unit of life.
- *Cells are the basic unit of an organism

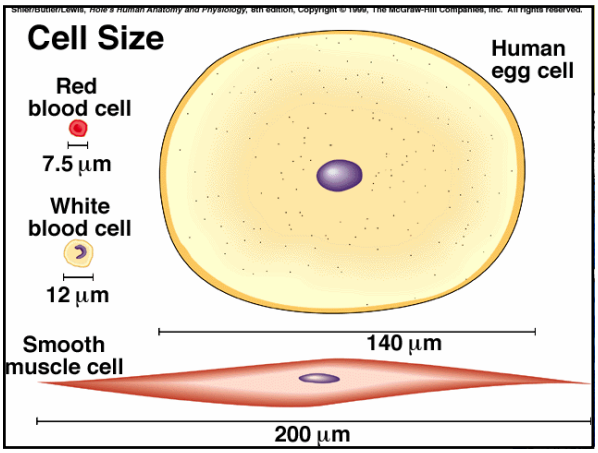
C. The size of cells is measured in micrometers; most cells range from 7.5 to 140 micrometers.

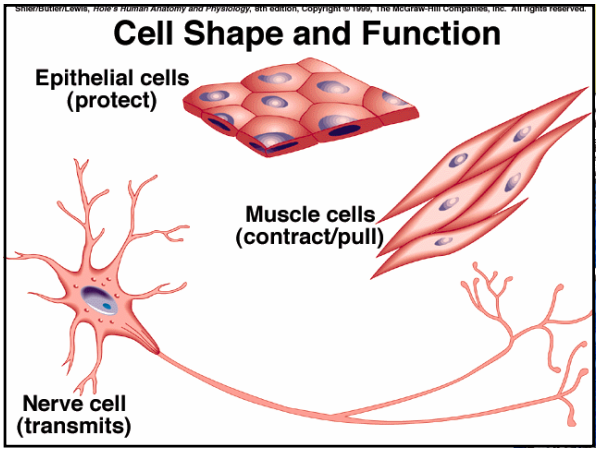
D. Differences in the shapes of cells make different functions in the body possible.

The next 2 slides show different cell shapes. This enables them to perform different functions.

Note the differences in sizes:

- red blood cell - 7.5 um in diameter
- white blood cell – 10-12 um
- human egg cell – 140 um
- smooth muscle cell 20-500 um in length



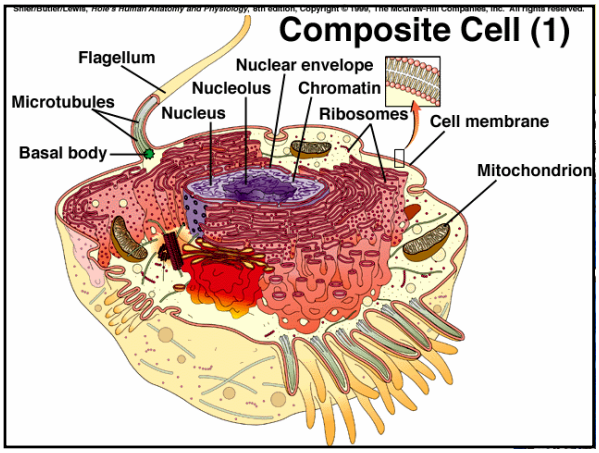


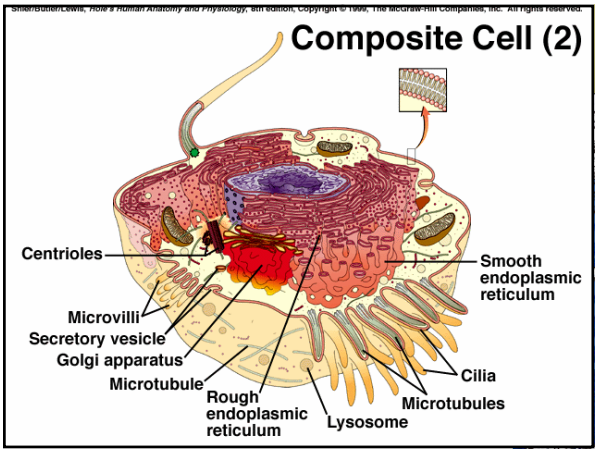
II. A Composite Cell

A. A composite cell includes many known cell structures.

B. A cell consists of three main parts–the nucleus, the cytoplasm, and the cell membrane.

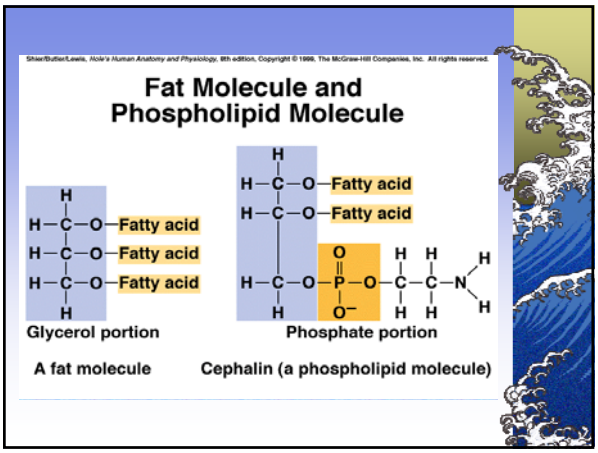
C. Within the cytoplasm are specialized organelles that perform specific functions for the cell.





CELLMEMBRANE

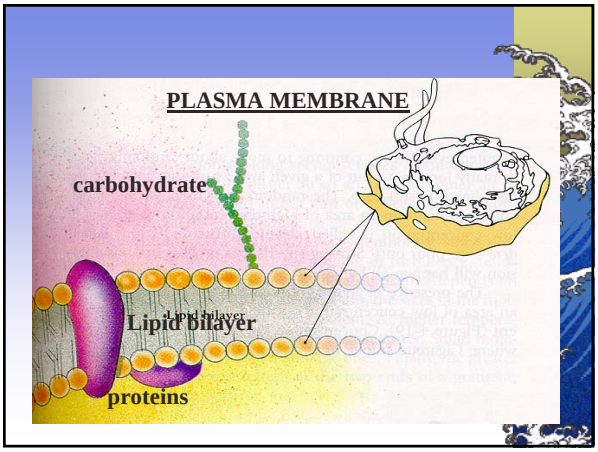
Cell (plasma) membrane - outer cell layer that protects the cell; acts as a selective barrier; composed of a lipid bilayer that has proteins and carbohydrates associated with it

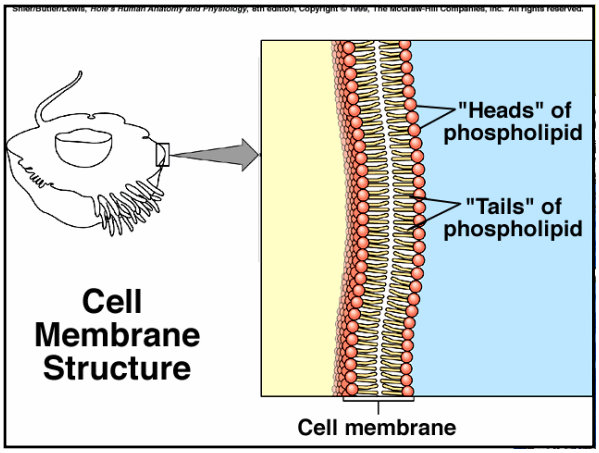


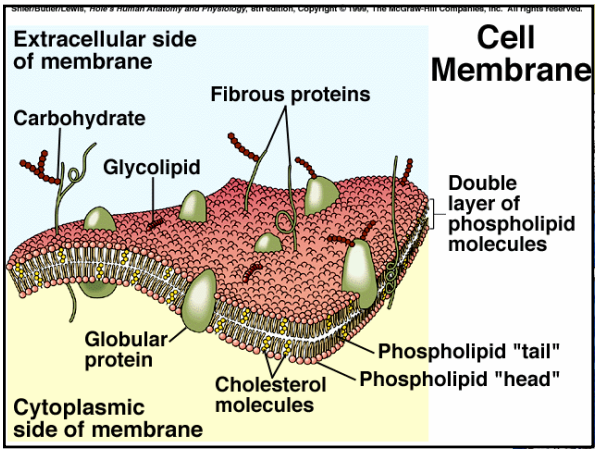
MEMBRANE - a thin sheet of lipids and proteins that surrounds the cell or its organelles, separating them from their surroundings

plasma membrane - the cell's gatekeeper; allows specific substances in and out; passes chemical messages from the external environment to the cell's interior; it defines the limits of a cell, it regulates the cell's internal environment by selectively admitting and excreting specific molecules
Membranes do have different parts that make up different structures.

MEMBRANE STRUCTURE:
1. Lipids - determine the function of the membrane
2. Proteins - regulate the exchange of substances & communicate with the environment
3. Carbohydrates – a small quantity (only)







ALL CELLS ARE SURROUNDED BY H_2O

CYTOPLASM - lies inside the plasma membrane; houses the organelles of the cell

Phospholipid bilayer: a thin, stable fluid film
1. Polar hydrophilic heads
2. A pair of nonpolar hydrophobic tails (Hydrophilic heads line the outer border & the hydrophobic tails provide the inside border.)

*Most substances that contact a cell are H2O soluble (ex.) salts, amino acids, and sugars. They can't get past the bilayer hydrophobic layer.

*Phospholipid layer also contains cholesterol – it makes the bilayer stronger, more flexible so cells do not become stiff or dry out;also helps make membrane impermeable

*Molecules like O_2, CO_2, & steroid hormones can pass through the nonpolar tails

*selectively permeable - cell membrane controls the entrance and exit of substances

*signal transduction – the process in which cells can can receive and respond incoming messages

PROTEINS in the Cell Membrane:
(classified according to their shape)

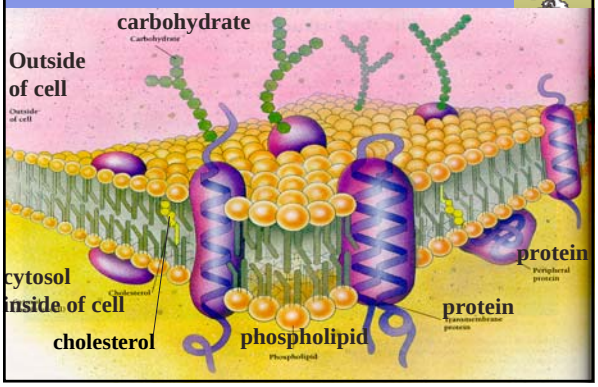
1. fibrous proteins – tightly coiled, embedded in the lipid bilayer, can extend outward, act as receptors that bind with specific kinds of molecules like hormones

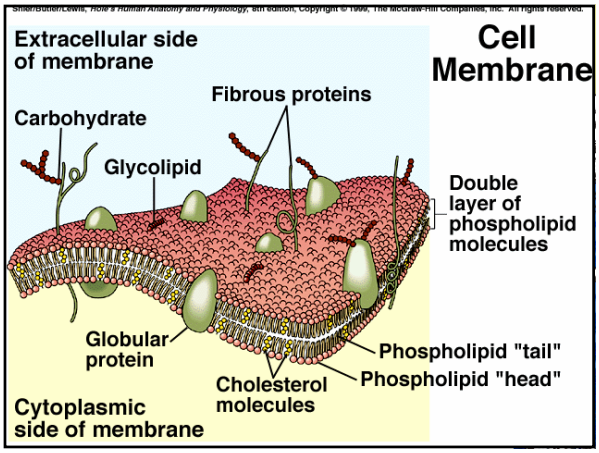
2. integral proteins – globular,embedded in interior, help small molecules to permeate cell membrane, form pores or channels to let water and ions pass

3. peripheral proteins – on cell membrane surface, act as enzymes, are part of signal transduction

4. glycoproteins – help cells recognize & bind to each other to form tissues; enables the immune system to distinguish between "self" & "nonself" cell surfaces

Carbohydrates stud the outer membrane and transmembrane proteins pass through the lipid bilayer

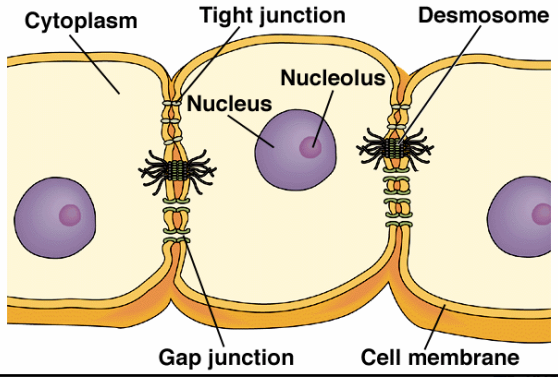




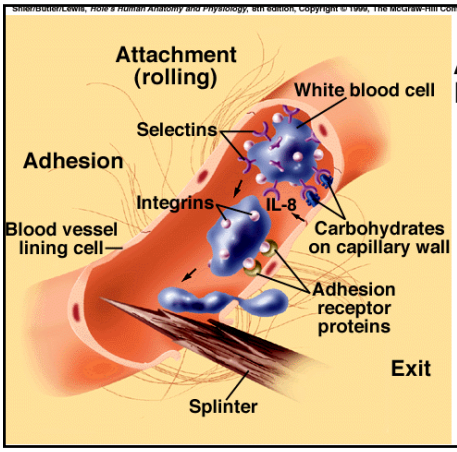
INTERCELLULAR JUNCTIONS: structures that connect cell membranes together
1. tight junction – adjacent cell membranes fuse;form sheetlike layers, tight with no space; line digestive tract & tiny blood vessels
2. desmosome – form rivets; adjacent skin cells
3. gap junction – form channels, heart muscle & muscle of the digestive tract, allow substances to move between them

CELL ADHESION MOLECULES (CAMs) – guide cells on the move; (ex.) when white blood cell must travel to site of infection
1. selectin – coats white blood cell, allows for traction
2. integrin – grabs the white blood cell and directs it to the injury site

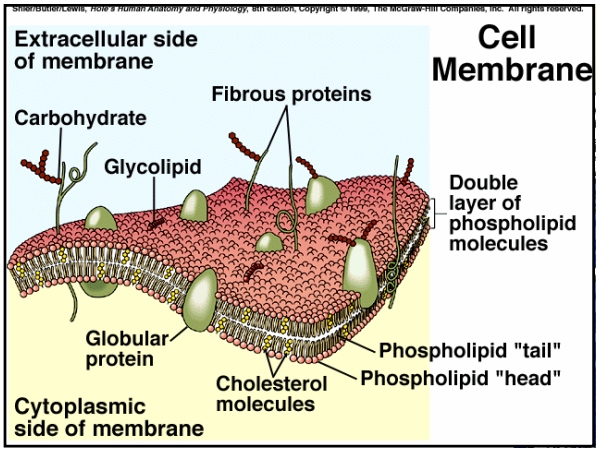
Intercellular Junctions



Cell Adhesion Molecules (CAMs)



Cell Membrane



THE AMAZING CELL

**Schleiden & Schwann - All living organisms are composed of individual, self-reproducing structures called CELLS. (Cell Theory)

70-75 trillion cells in the body

EUKARYOTES: "true nucleus"

1. larger than prokaryotes (cells without a nucleus)
2. cytoskeleton - network of protein fibers that give shape and organization
3. plant cells differ from animal cells; each has organelles specific to it
4. ***cell shapes make various functions possible.

cytoplasm

*cytoplasm - clear, thick, jelly-like (water, salts, organic molecules, enzymes); fills space between cell membrane & nucleus; organelles suspended in it

cytosol – the clear liquid of the cytoplasm

The cytoplasm also contains:

*cytoskeleton - protein rods that provide cellular support for eukaryotic cells; 3 major classes of filaments:

1. microtubules - hollow, tube-like, are bundles in cytoplasm, give support to cell surface
   centrioles - microtubules that aid in cell division
2. intermediate filaments - help determine cell shape
3. microfilaments - help stabilize cell shape

ORGANELLES - the structures in the cytoplasm

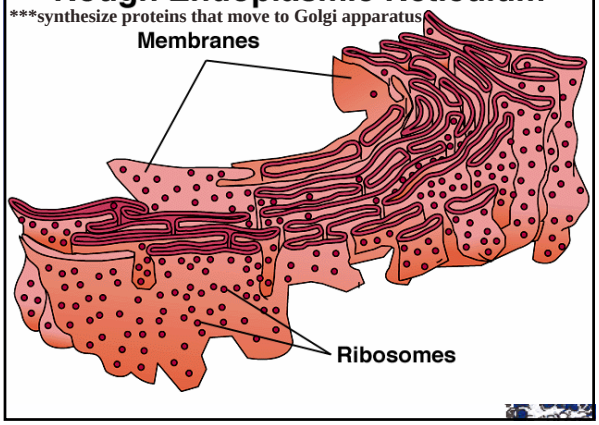
*endoplasmic reticulum – membrane bound flattened sacs, canals, & vesicles, interconnected & communicate with cell membrane & nuclear envelope, can synthesize lipid & protein molecules for new cell membranes

*rough - ribosomes on outside; can synthesize proteins that can move through the canals of the ER to the Golgi apparatus for further processing

*smooth - embedded enzymes are site of lipid synthesis for membrane formation; enzymes can detoxify harmful drugs in liver cells

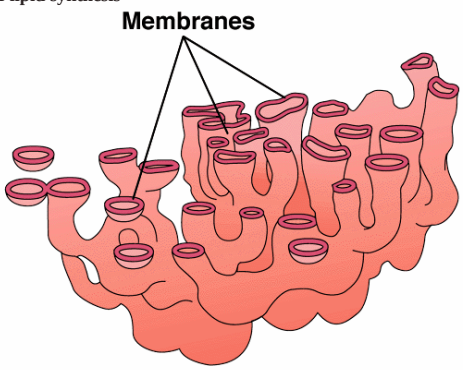
Rough Endoplasmic Reticulum

***synthesize proteins that move to Golgi apparatus



Smooth Endoplasmic Reticulum

**site of lipid synthesis



ORGANELLES

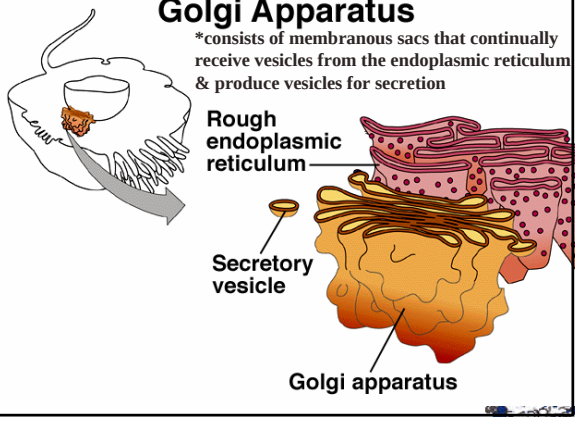
*ribosomes – some are scattered freely, some on endoplasmic reticulum & some in the nucleus, made of protein & RNA, provide structural support & enzymes required to link amino acids to produce proteins

*Golgi apparatus – composed of cisternae – flat membranous sacs, assembles, stores & delivers proteins synthesized by the ribosomes associated with the rough ER

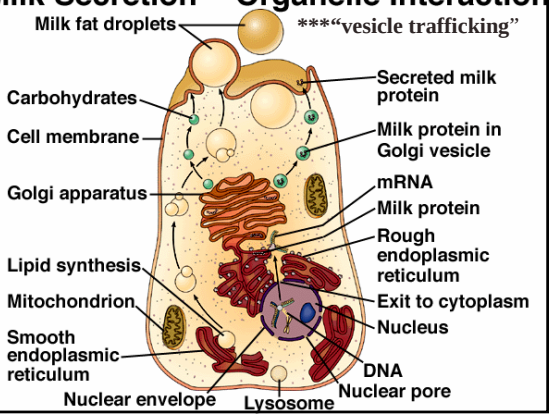
*vesicles - membrane bound sacs that carry protein cargo (when it is needed) to Golgi apparatus (vesicle trafficking)

Golgi Apparatus

*consists of membranous sacs that continually receive vesicles from the endoplasmic reticulum & produce vesicles for secretion



Milk Secretion — Organelle Interaction



ORGANELLES

*mitochondria

-elongated, fluid-filled sacs. Contain DNA for encoding proteins & RNA, inner membrane folds to form cristae (partitions) that have embedded enzymes which control reactions that release energy from glucose, energy is transformed into ATP – adenosine triphosphate. 1700 mitochondria (at least) in a typical cell

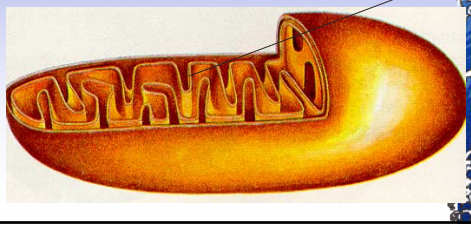
*lysosomes

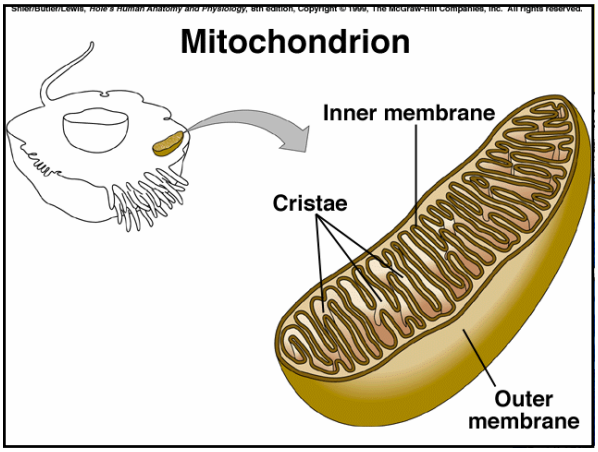
-produced by Golgi complex, filled with digestive enzymes that can break down proteins, carbohydrates, & nucleic acids, also eat up waste materials of cell & old worn out cell parts. (lysosomes serve as the cell's digestive system)

MITOCHONDRIA: SITE OF AEROBIC METABOLISM

They extract energy from food molecules and store it in the bonds of ATP.

The inner membrane forms deep folds called cristae.





ORGANELLES

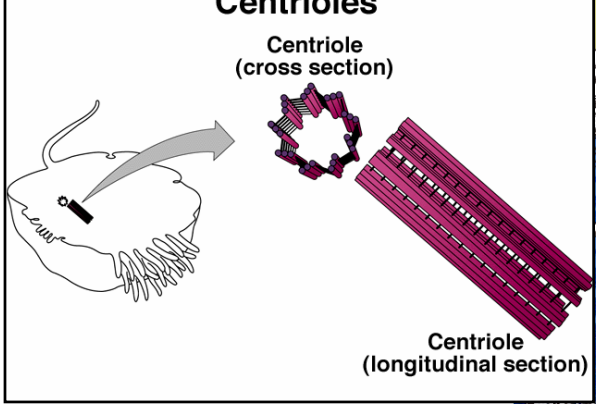
*peroxisomes – membranous sacs, found in liver & kidney cells, contain enzymes called peroxidases – catalyze reactions to release H_2O_2, contain the enzyme catalase which decomposes hydrogen peroxide, the outer membrane contains about 40 enzymes that can catalyze:
1- bile acids for fat digestion
2- breakdown lipids
3- degrade rare biochemicals
4- detoxify alcohol

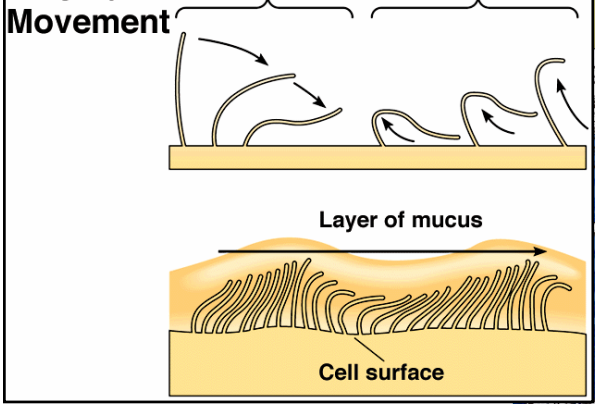
***When peroxisomal enzymes are not present, health is affected.

ORGANELLES

*centrosome – located in cytoplasm near Golgi apparatus & nucleus, consists of 2 hollow centrioles which are made of proteins – microtubules, function in cellular reproduction, distribute chromosomes which carry DNA to new cells, also found in cilia & flagella

*cilia & flagella – consist of microtubules, projections
*cilia - found on skin's outer epithelial cells, help propel mucus over lining of respiratory tract, cigarettes destroy cilia
*flagellum – forms tail of sperm cell and causes the sperm's swimming movements





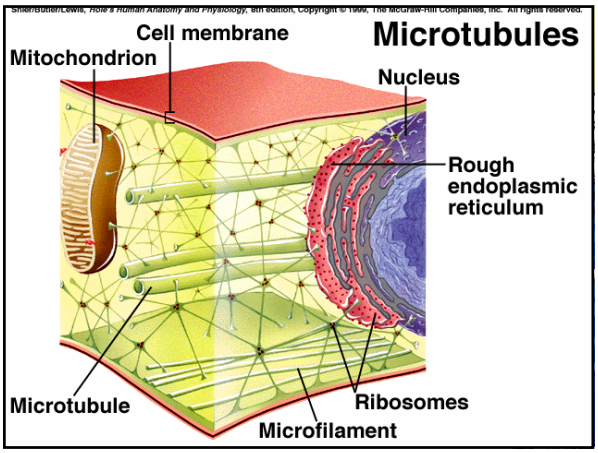
ORGANELLES

*vesicles – membranous sacs form when cell membrane folds inward and pinches off, Golgi apparatus and ER also form vesicles

*microfilaments – made of protein actin, can cause cellular movements (ex.) myofibrils in muscle cells cause cells to contract, can aid cell motility

*microtubules – composed of globular protein tubulin, form cytoskeleton and give shape to cell, can move organelles within the cell

*cytoplasmic inclusions – lifeless chemicals – stored glycogen, lipids, and pigment (melanin) found in skin



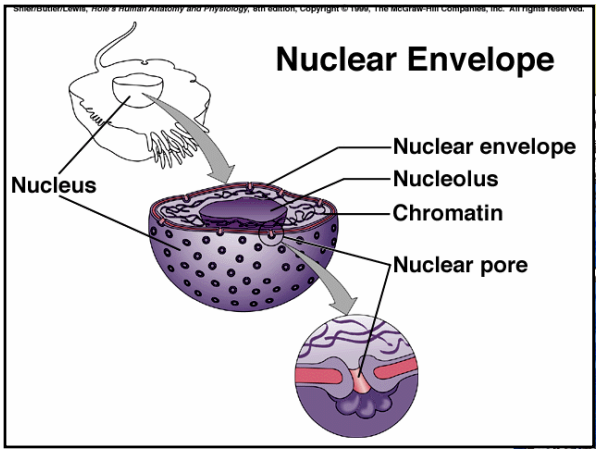
Cell Nucleus

THE CELL MANAGER

Stores DNA - information needed to construct the cell & direct chemical reactions necessary to life & reproduction

Organelles of the nucleus:

1. nuclear envelope - consists of 2 lipid bilayers (2 membranes) with nuclear pores so water, ions, ATP, & RNA can pass
2. nucleoplasm – fluid inside nucleus
3. nucleolus - dark stained (genes are clustered there) composed of RNA & proteins, site where ribosomes are produced (ribosomes synthesize proteins)
4. chromatin - composed of DNA wrapped around clusters of proteins & form long strands called chromosomes when cell division begins



III. Movement Into and Out of the Cell)

A. *The cell membrane controls what passes through it.*

B. *Mechanisms of movement across the membrane may be passive, requiring no energy from the cell (diffusion, facilitated diffusion, osmosis, and filtration) or active mechanisms, requiring energy (active transport, endocytosis, and exocytosis).*

III. Movement Into and Out of the Cell

PHYSICAL (PASSIVE) PROCESSES:

C. Diffusion
D. Facilitated Diffusion
E. Osmosis
F. Filtration

PHYSIOLOGICAL (ACTIVE) MECHANISMS:

G. Active Transport
H. Endocytosis
I. Exocytosis
J.Transcytosis

PHYSICAL/PASSIVE PROCESSES:

1. DIFFUSION - movement of molecules in a fluid down a concentration gradient (dye in a glass of water)

net diffusion – when diffusing particles move from regions of high concentrations to regions of low concentration
concentration gradient – the differences in concentrations of a substance causes this

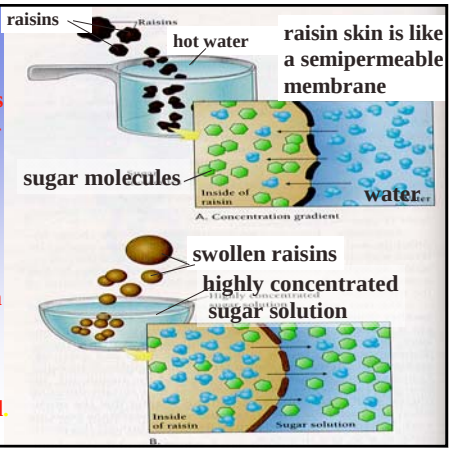
concentration - # of molecules in a given unit volume

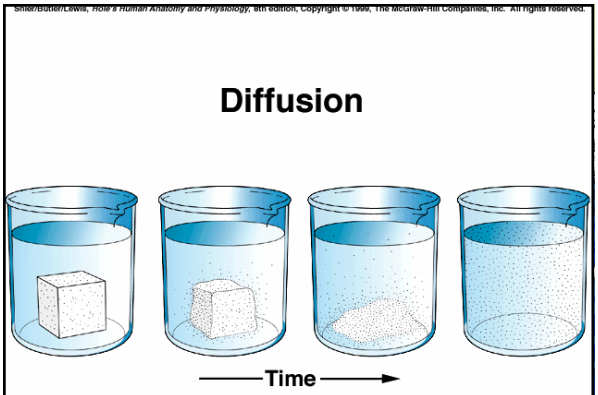
gradient - physical difference between 2 regions of space; concentration gradient - difference in concentration between one region & another
Ex. – sugar (solute) in a glass of water (solvent), net diffusion moves the sugar molecules down the concentration gradient until equilibrium is reached.

Concentration Gradient:

A raisin skin is like a semipermeable membrane

In a concentrated sugar solution the water in the swollen raisin flows outward.

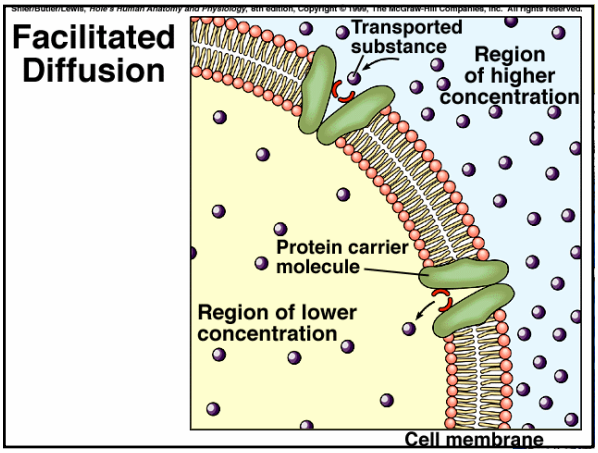




Substances like O2, CO2, steroids, and anesthetics cross the cell membrane by net diffusion. H2O molecules are small enough that they also move into the cell by simple diffusion.

2. Facilitated Diffusion – occurs with the help of proteins (protein channels & protein carrier molecules); is slower than simple diffusion, is important for large water-soluble molecules (glucose and amino acids)

Factors that determine diffusion rate: number of carrier molecules limits facilitated diffusion, distance, concentration gradient, & temperature



Remember:

*Various proteins are embedded within/attached to the surface of a membrane's phospholipid bilayer. They:

1. regulate movement of substances through the membrane
2. communicate with the environment
3. transport, receptor, and recognition proteins

differentially permeable - plasma membranes allow some molecules to pass (permeate) through and prevent other molecules from passing (impermeable)

*cell membranes are semi-permeable

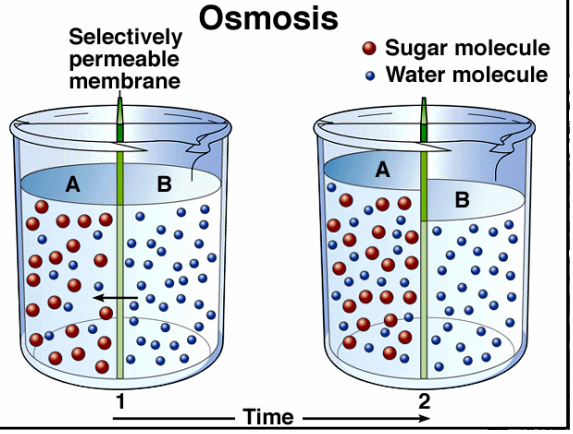
3. OSMOSIS - movement of H2O across a selectively permeable membrane. (a special case of diffusion)

The higher the concentration of dissolved substances, the lower concentration of H2O.

(Because cells contain high concentrations of dissolved material surrounded by a cell membrane osmosis can cause water to move into or out of the cell.)

osmotic pressure – ability of osmosis to generate enough pressure to lift a volume of water

The greater the concentration of nonpermeable solute particles in a solution, the lower the water concentration of that solution and the greater the osmotic pressure.



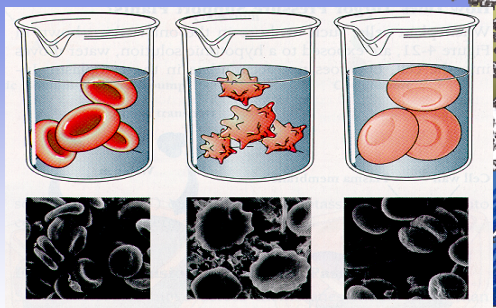
Effects of osmotic pressure:

isotonic - when equilibrium in a solution concentration is reached and movement of water stops (cells are normal size and shape)

hypertonic solution - when a solution on one side of a membrane has a higher concentration of solute than the solution on another side (causes cells to shrink)

hypotonic - solution with a lower concentration of dissolved material (osmotic pressure), (causes cells to swell)

Red blood cells in iso, hyper, and hypo salt solution

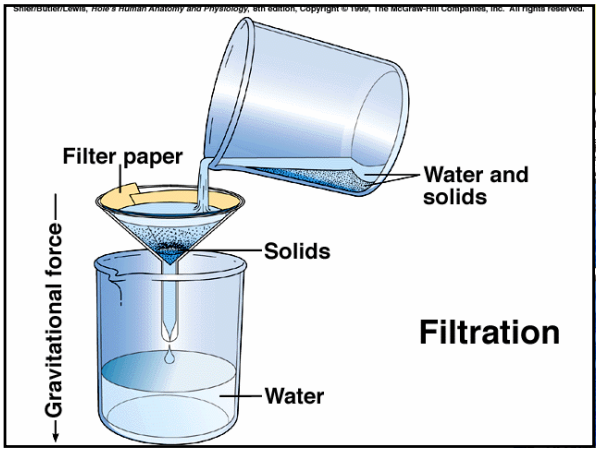


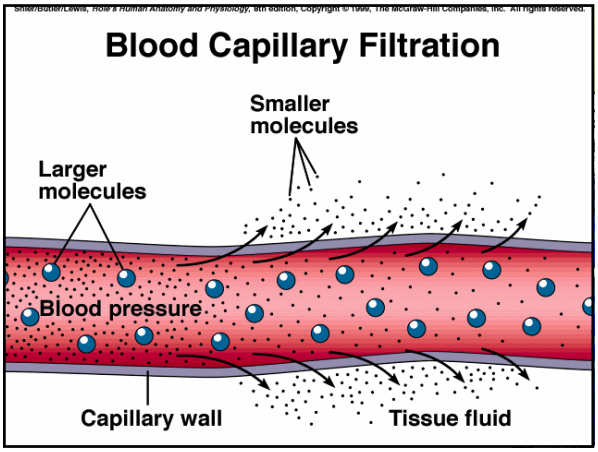
isotonic hypertonic hypotonic

4. FILTRATION – process which forces molecules through membranes

hydrostatic pressure – created by the weight of water due to gravity

Blood pressure forces water through the thin walls of blood capillaries.



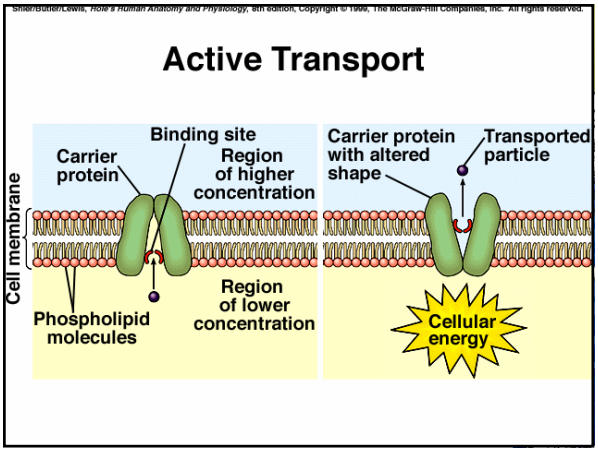


ACTIVE TRANSPORT – net movement of particles from a region of lower concentration to a region of higher concentration

Active transport - cell uses energy of ATP to move substances against a concentration gradient; also uses carrier molecules (proteins) that have binding sites that combine with the particles needing to be transported across the cell membrane

***sugars, amino acids, Na, K, Ca, & H ions are transported as "passenger molecules" by "carrier proteins"**

Passive transport - substances move into or out of cells down concentration gradients



ENDOCYTOSIS – process in which cells use energy to move particles across cell membrane by forming a vesicle from the cell membrane for transporting molecules (occurs without crossing cell membrane)

3 forms of endocytosis:

1. pinocytosis – cell membrane invaginates, seals off, produces a small vesicle for liquids that detaches & moves into the cytoplasm
2. phagocytosis – cell membrane takes in solids
phagocytes – cells that take in particles (dust) combine with lysosomes to get rid of vesicular contents

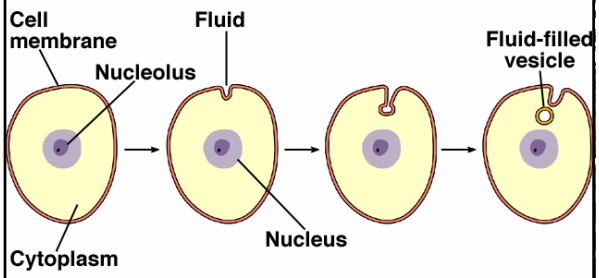
(cont. next slide)

3. receptor-mediated endocytosis – moves specific kinds of particles which bind to proteins into cells, cholesterol enters cells this way

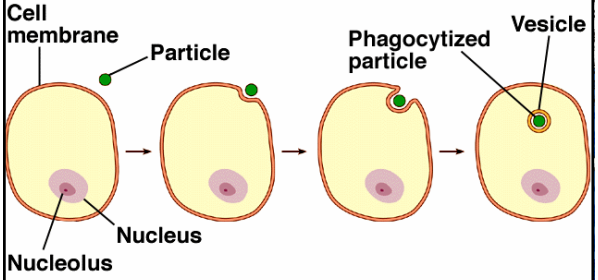
low-density lipoproteins (LDL) (made in the liver), enter cell by binding to protein apoprotein-B

receptor-mediated endocytosis provides specificity, only cells with specific receptors can remove and process specific kinds of substances from their surroundings

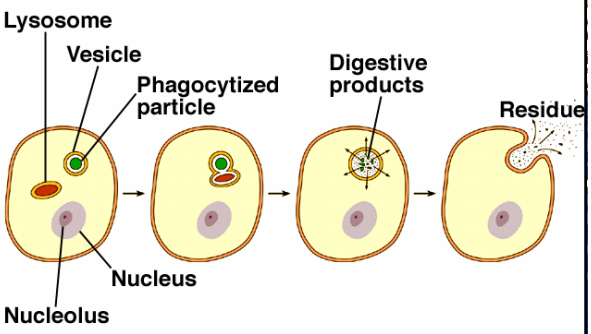
Pinocytosis



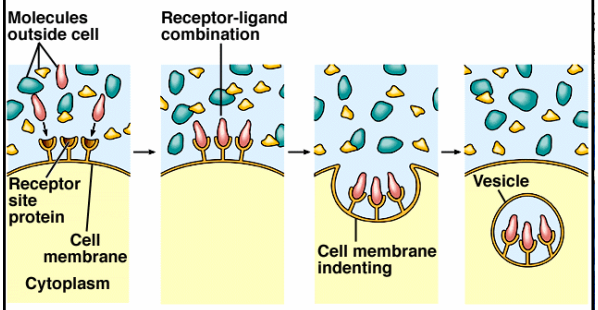
Phagocytosis



Lysosomal Activity in Phagocytosis



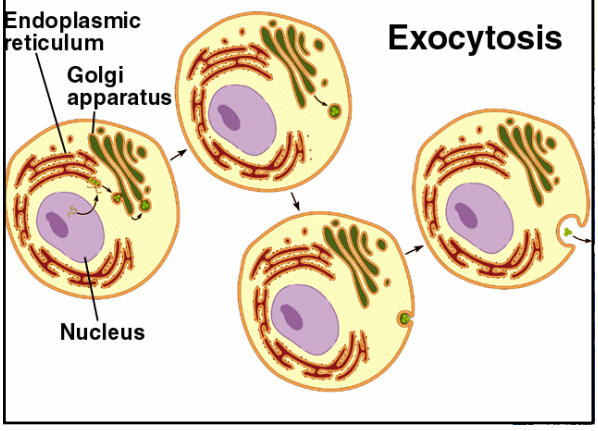
Receptor-Mediated Endocytosis



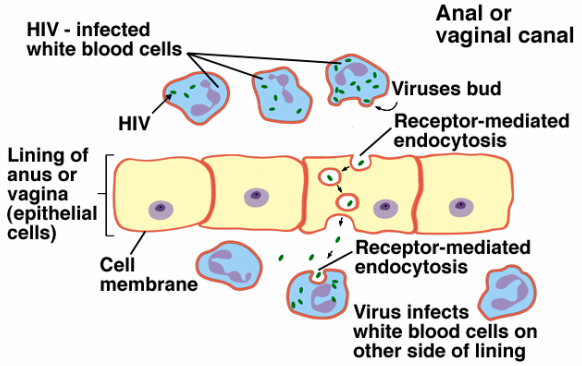
EXOCYTOSIS – reverse process(endocytosis) in which substance made inside cell are packaged in a vesicle that fuses with the cell membrane so can be released to outside

TRANSCYTOSIS – transports a particle from one side to another in a cell, substances can cross barriers made by tightly connected cells as a result, HIV virus uses this method

Exocytosis



Transcytosis



IV. The Cell Cycle

A. A series of changes a cell undergoes from the time it is formed until it divides, or reproduces, is called the cell cycle.

B. The cell cycle consists of interphase, mitosis, and cytokinesis.

C. Interphase

D. Mitosis

E. Cytoplasmic Division

F. Cell Differentiation

CELL DIVISION

Figure 4-16

A cut on the arm, the next day (A). The cut after 10 days (B). After 20 days, the cut is nearly healed (C).

INTERPHASE – period in which cells mature & prepare for division, a time of synthetic activity, & chromosomes are copied

3 phases:

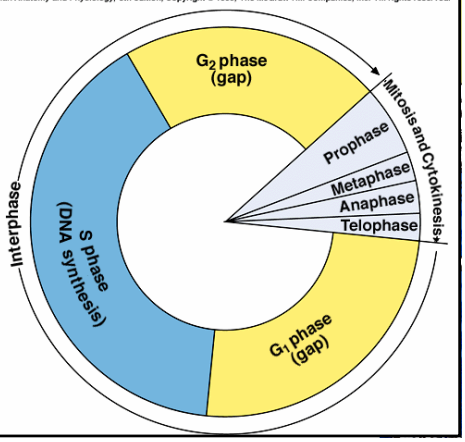
S phase = DNA replicates

G1 and G2 = gap & growth periods

Mitosis

includes division of nucleus & cytoplasm, mitosis is continuous in its steps

Cell Cycle



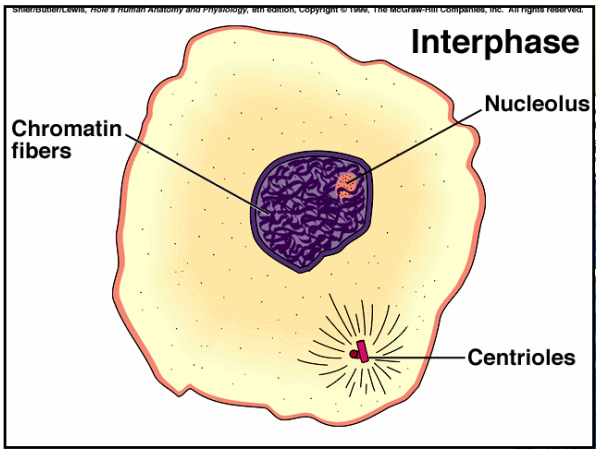
PROPHASE – 2 centrioles move to sides of cell, nuclear envelope & nucleolus disappear, microtubules are formed that move centrioles apart

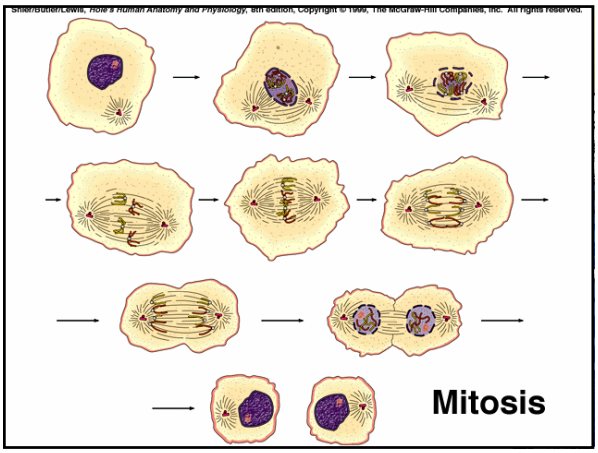
METAPHASE – chromosomes are aligned midway between centrioles

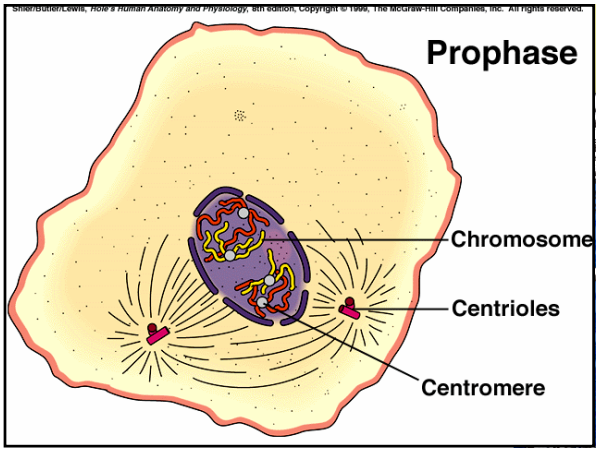
ANAPHASE – separated chromosomes move in opposite directions

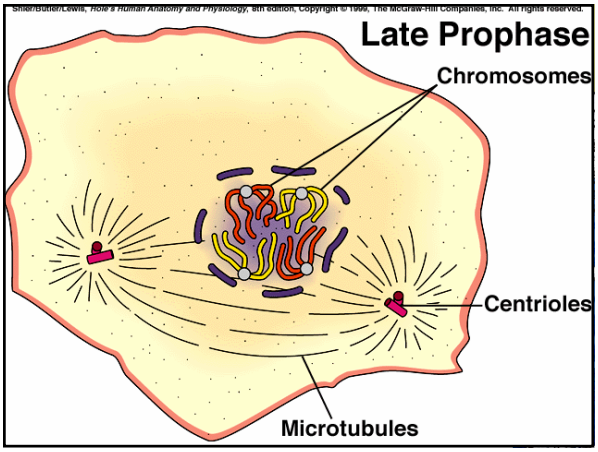
TELOPHASE (final stage) - chromosomes become threadlike, nuclear envelope surrounds each one, nucleoli appear with new nuclei

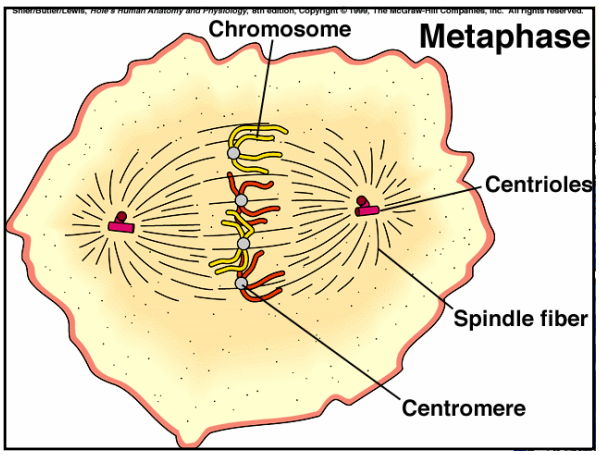
CYTOPLASMIC DIVISION – cell membrane constricts around middle and forms 2 new identical cells

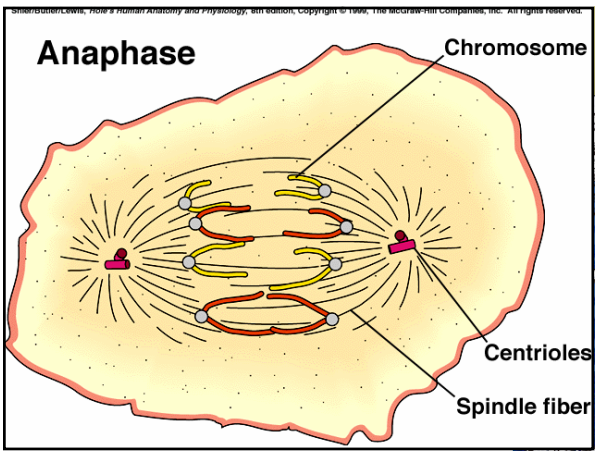


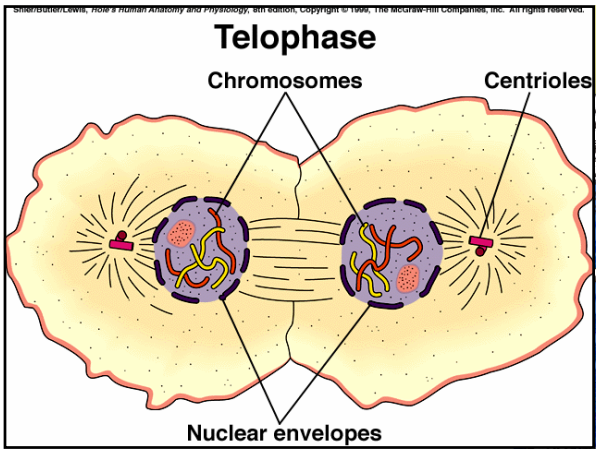










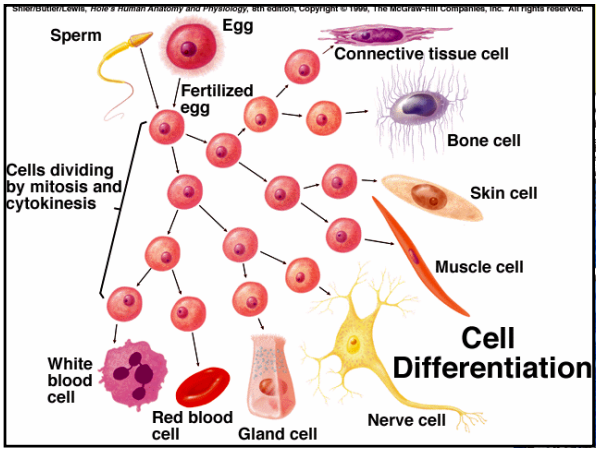


CELL DIFFERENTIATION – cells specialize into different cell types by genetic control

All cells contain the same DNA information.

differentiation – the process by which cells develop different structures and specialized functions

All cells contain a complete collection of information but only some of that information is accessed.



V. Control of Cell Reproduction

A. *Most human cells divide up to 50 times in the laboratory, but can divide no further.*

B. *A physical basis for this limitation in number of cell divisions appears to be the telomeres lost from the chromosome tips with each cell division.*

C. *Proteins called kinases and cyclins appear to control the rate and timing of cell division.*

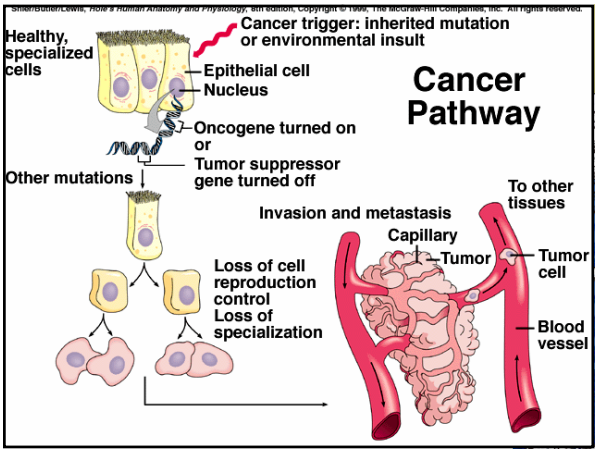
D. External controls of cell division include hormones, growth factors, and space availability (contact inhibition).

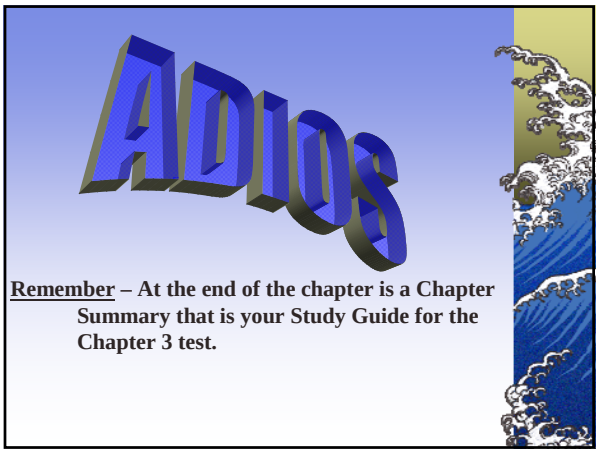
E. Health Consequences of Loss of Cell Reproduction Control

tumor – caused by too frequent mitosis,
benign – can interfere with healthy tissue
malignant – can metastasize to other sites

genes that cause cancer:
oncogenes – activate other genes to increase cell reproduction
tumor suppressor genes – genes that hold mitosis in check

"Good Health depends upon both the quality and quantity of the cells that comprise the human body."





<u>Remember</u> – At the end of the chapter is a Chapter Summary that is your Study Guide for the Chapter 3 test.