OMICS IN HUMAN DISEASE (4CFU)

Human physiology

Prof. Denis Martinvalet
Department of Biomedical Sciences
Veneto Institute for Molecular Medicine

	Prof. Martinvalet	Prof. Leonardi
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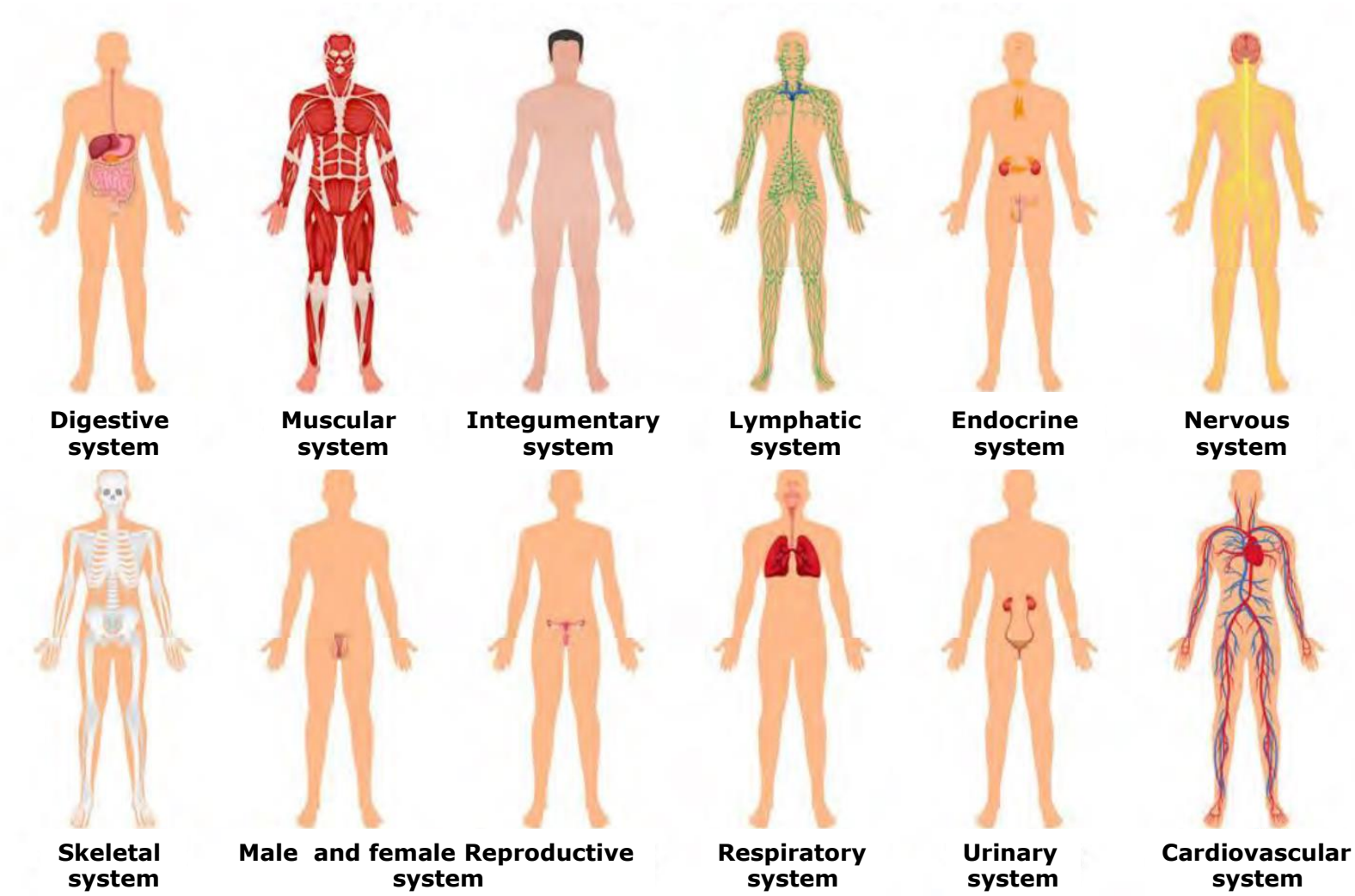
THE HUMAN BODY

A series of 11 integrated systems. Each system carries out one major role or task.



Each system depends directly or indirectly, on all of the others.

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These systems are composed of main parts known as organs.

The organs consist of tissues, and tissues are made up of cells.

Physiology is the study of the chemistry and physics of the structures of the body and the ways in which they work together to support the functions of life.
In other words physiology is the study of how do organs work.

Anatomy deals with the structure of the body and its organs (names and description of the organs).

Physiology and anatomy are closely interrelated because the function of an organ depends on its structure.

Fundamental characteristic of Life are traits shared by all organisms

1. **Movement**–change in position of the body or a body part; motion of an internal organ
2. **Responsiveness** –reaction to internal or external changes
3. **Growth**–increase in size without change in shape
4. **Reproduction**–new organisms or new cells
5. **Respiration**–use of oxygen; removal of Carbon Dioxide
6. **Digestion**–breakdown of food into simpler forms
7. **Absorption**–movement of substances through membranes and into fluids
8. **Circulation**–movement within body fluids
9. **Assimilation**–changing nutrients into chemically different forms
10. **Excretion**–removal of metabolic wastes

The Main characteristics of organisms

1. **Made of CELLS**
2. **Require ENERGY**
3. **Reproduce**
4. **Maintain HOMEOSTASIS** (keeping the body systems in balance)
5. **Organized**
6. **Respond to environment**
7. **Grow and develop**
8. **Exchange materials with their surroundings (water, wastes, gases)**

Functions and Requirements of Life

The different organ systems have different functions and therefore unique roles to perform in physiology. One of the fundamental processes is metabolism.

Basic function of an organism is to consume (ingest) energy and molecules from foods and convert some of it into fuel for movement, sustain the body's functions, build and maintain the body structures.

There are two types of reactions that accomplish this: Anabolism and Catabolism.

Anabolism is the process whereby smaller, simpler molecules are combined into larger, more complex substances. Anabolism requires energy.

Catabolism is the process by which larger more complex substances are broken down into smaller simpler molecules releasing energy.

Both anabolism and catabolism occur simultaneously and continuously to maintain life.

Taken together, these two processes are called metabolism. Metabolism is the sum of all anabolic and catabolic reactions that take place in the body.

Functions and Requirements of Life

Every cell in the human organism makes use of a chemical compound, *adenosine triphosphate (**ATP**)*, to store and release energy.

The cell stores energy in the synthesis (anabolism) of ATP.

ATP can be moved where the energy is needed to fuel cellular activities.

ATP is broken down (catabolism) release the energy which is used by the cell to perform other tasks.

MAINTENANCE OF LIFE

Life depends on the availability of the followings:

A) WATER: The most vital compound in the body. The body's functional chemicals are dissolved and transported in water, and the chemistry of life take place in water.

1) The most abundant chemical in the body
2) Required for many metabolic processes
3) Transportation of cells and body materials
4) Regulates body temperature
5) Makes up intracellular and extracellular fluid compartments

B) Nutrients: Substances in foods and beverages that are essential to human survival.

1) Carbohydrates ⇒⇒ energy
2) Lipids ⇒⇒ energy)
3) Proteins ⇒⇒ amino-acid building blocks
4) Nucleic acids ⇒⇒ building blocks
5) Vitamins ⇒⇒ catalysts of reaction
6) Minerals ⇒⇒ catalysts of reaction

MAINTENANCE OF LIFE

Life depends on the availability of the following

C) Oxygen: Key component of the chemical reactions that keep the body alive, including the reactions that produce ATP.

D) Body Temperature.

1) Chemical reactions upon which the body depends can only take place within the narrow range of body temperature, from just below to just above 37°C (98.6°F).
2) Result from metabolic reactions and muscle movements that controls and maintains the body temperature

E) PRESSURE

1) Atmospheric pressure is needed for breathing allowing gaze exchange in lungs.
2) Atmospheric pressure is also needed to keep N2 dissolve in body fluids.
2) Hydrostatic (water) pressure is needed to move blood through blood vessels –our blood pressure

Homeostasis: Maintenance of a stable internal environment in the body.

All organisms must maintain a constant internal environment to function.

Homeostasis is regulated through control systems which have **receptors (sensors), a set point**, and **effectors** in common.

Receptors are of many types whose job is to monitor for changes.

Set point is the normal value or range of values.

Effectors are muscles or glands that respond to the changes to return to set points.

- Temperature
- pH (acidic or basic)
- Salinity (salt level)
- Fluid levels

Set point is the physiological value around which the normal range fluctuates.

Normal range is the restricted set of values that is optimally healthful and stable.

Control centers in the brain play a roles in regulating physiological parameters and keeping them within the normal range.
As the body works to maintain homeostasis, any significant deviation from the normal range will be resisted and homeostasis restored through a process called a **feedback loop.**

There are two types of Feedback Loops: Negative and Positive feedbacks.

A feedback loop has three basic components

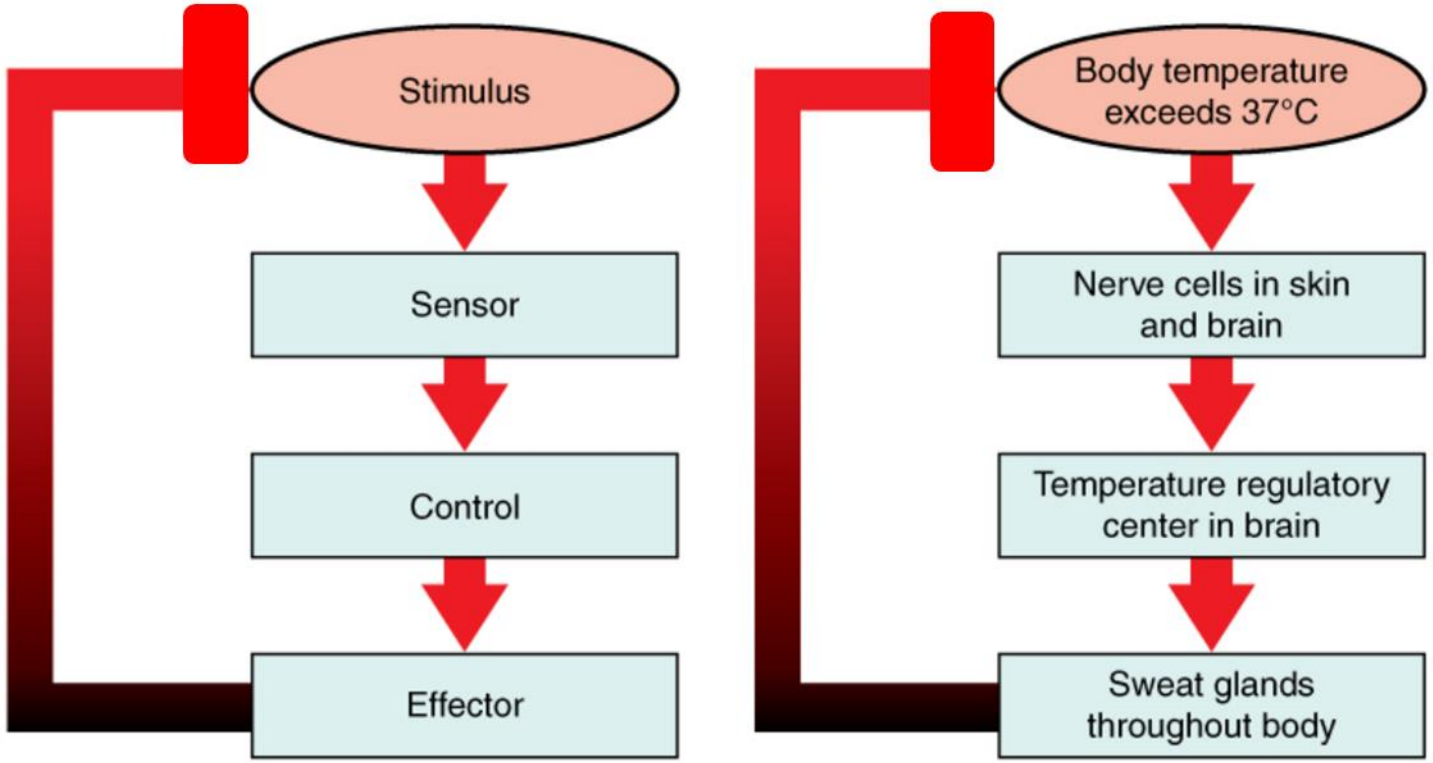
1) **A *sensor*** *(*receptor):monitors a physiological value.
2) **A *control center:*** compares the value to the normal range.
3) **An *effector:*** return the value to the normal range.

Integrating Systems: Organ systems must work together to allow the body maintain homeostasis.

Negative feedback loop:

The response is to shut off the original stimulus or reduce its intensity.

- The most common mechanisms used to maintain homeostasis.
- Fundamental to an understanding of human physiology.



(a) Negative feedback loop

(b) Body temperature regulation

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During heat exposure: the brain's "heat-loss center" is activated:

1) Blood vessels in the skin begin to dilate allowing more blood from the body core to flow to the surface of the skin allowing the heat to radiate into the environment.

2) Sweat glands are activated to increase their output. Sweat evaporates from the skin surface taking heat with it.

3) The depth of respiration increases, breathing through open mouth further increases heat loss.

During cold exposure the brain's heat-gain center is activated:

1) Reduces blood flow to the skin, blood returning from the limbs is diverted into a network of deep veins to traps heat closer to the body core and restricts heat loss.

2) If heat loss is severe, the brain triggers increase in random signals to skeletal muscles to contract and produce shivering to release heat while using up ATP.

3) The brain triggers the thyroid gland to release thyroid hormone to increases metabolic activity and heat production in cells throughout the body.

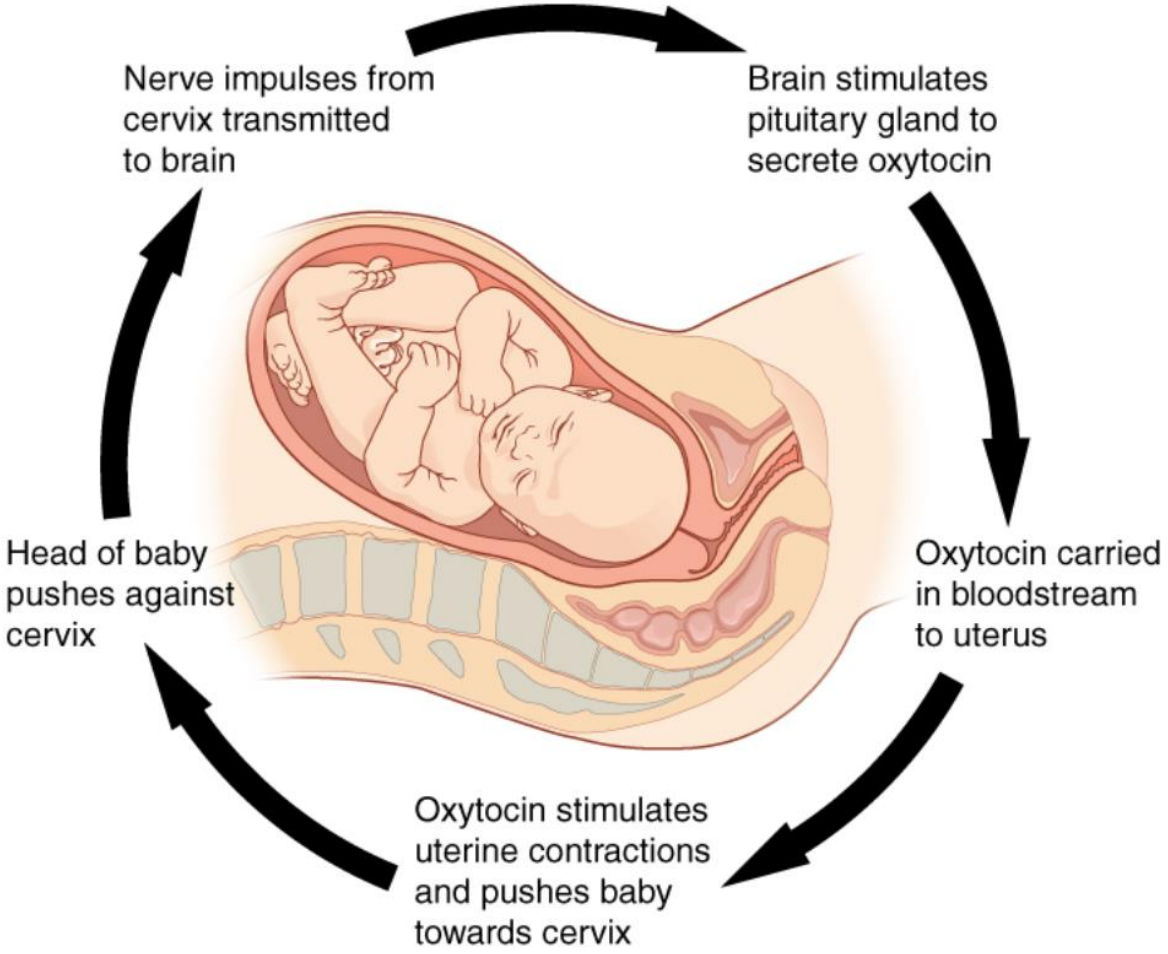
4) The brain also signals the adrenal glands to release epinephrine (adrenaline), to breakdown glycogen into glucose resulting in increased metabolism and heat production.

Positive feedback **loop**:

The response is to intensifies a change in the body's physiological condition.

Take place only when there is a definite end point.

Are activated only when needed.



1) The first contractions poushe the baby toward the cervix.

2) The cervix stretch-sensitive nerve cells monitor the stretching (sensors) to signal to the brain to causes the pituitary gland to release oxytocin into the bloodstream.

3) Oxytocin causes stronger contractions of the smooth muscles of the uterus (the effectors), pushing the baby further down the birth canal causing even greater stretching of the cervix.

4) With baby's birth, the stretching of the cervix halts, stopping the release of oxytocin.

From Lumen Learning

***Positive feedback* loop**:

Excessive blood loss means reduced blood pressure and perfusion (penetration of blood) to the brain and other vital organs.

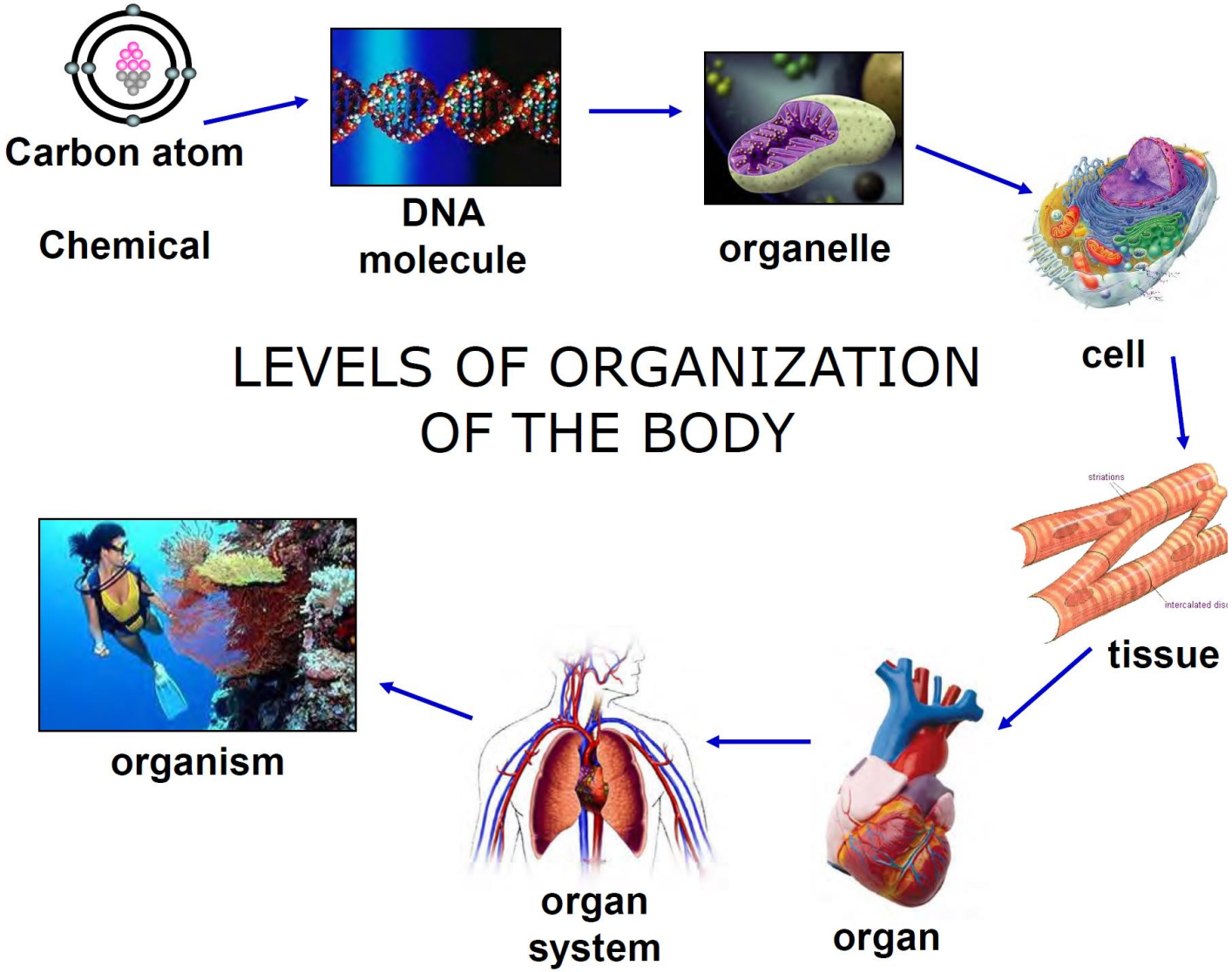
Sever perfusion reduction triggers vital organs to shut down and the person will die.

The body responds by releasing substances in the injured blood vessel to form a blood clot.

Each step of clotting stimulates the release of more clotting substances accelerating the processes of clotting and sealing off the damaged area.

Clotting is contained in a local area based on the tightly controlled availability of clotting proteins. This is an adaptive, life-saving cascade of events.

Levels of Organization of the Body



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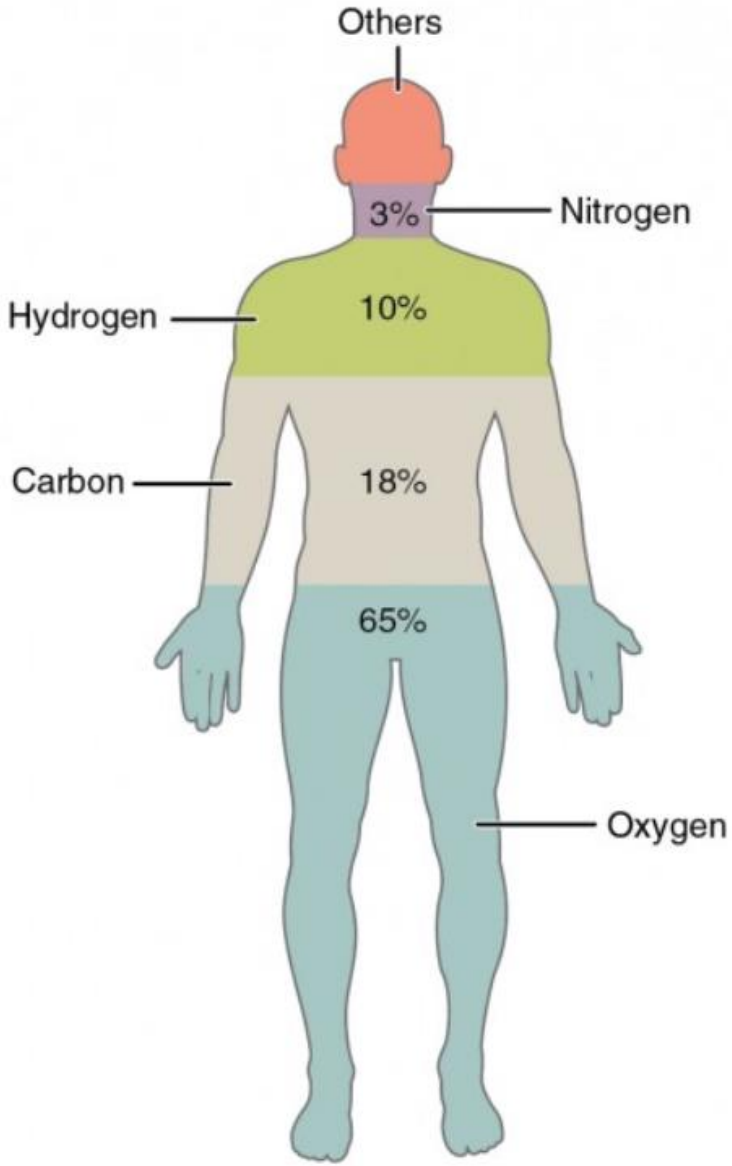
The integration of each of these elements will allow the human Body to function as an all to accomplish particular task.

92 natural elements (pure substances that cannot be created or broken down by ordinary chemical means), **25** are found in the human body .



Element	Symbol	Percentage in Body
Oxygen	O	65.0
Carbon	C	18.5
Hydrogen	H	9.5
Nitrogen	N	3.2
Calcium	Ca	1.5
Phosphorus	P	1.0
Potassium	K	0.4
Sulfur	S	0.3
Sodium	Na	0.2
Chlorine	Cl	0.2
Magnesium	Mg	0.1
Trace elements include boron (B), chromium (Cr), cobalt (Co), copper (Cu), fluorine (F), iodine (I), iron (Fe), manganese (Mn), molybdenum (Mo), selenium (Se), silicon (Si), tin (Sn), vanadium (V), and zinc (Zn).		less than 1.0

From Lumen Learning

Chemistry of carbon (^{12}C):

Atomic number 6, Mass number 12: Carbon atom is formed of 6 protons, 6 neutrons and 6 electrons

Electron configuration of ^{12}C: [He] $2s^2 2p^2$ or $1s^2$ $2s^2 2p^2$

To fulfil the octet rule, ^{12}C needs 4 more electrons on its outer shell.

1. This is met by engaging in 4 covalent single-bounds.
2. This gives carbon many possible combinations to fill its four "vacancies".
3. High affinity covalent bounding.

Many distinct and relatively stable organic molecules can readily form larger, more complex molecules referred to as ***macromolecule.***
Some macromolecules are made up of several "copies" of single units called monomer (mono- = "one"; -mer = "part").

Monomers link by covalent bonds to form long polymers (poly- = "many").

Chemistry and biochemistry of life

Four major type of macromolecules enter in the composition of living organism.

1. Carbohydrates
2. Lipids
3. Proteins
4. Nucleic acids

1. **Carbohydrates:** “hydrated carbon.”

C***arbohydrates*** are composed of carbon, hydrogen, and oxygen;

- Hydrogen and oxygen are found in the same two-to-one relative proportions they have in water.
- Generic chemical formula is $(CH_2O)_n$.

Carbohydrates are referred to as saccharides, meaning “sugars.”

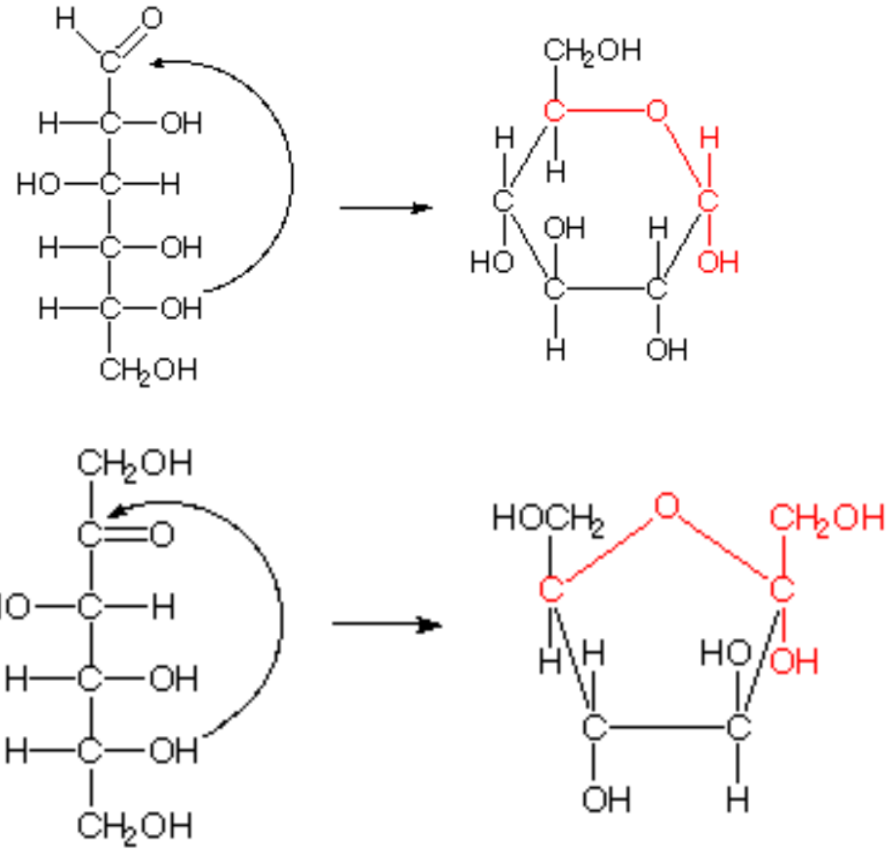
Three forms are important in the body.

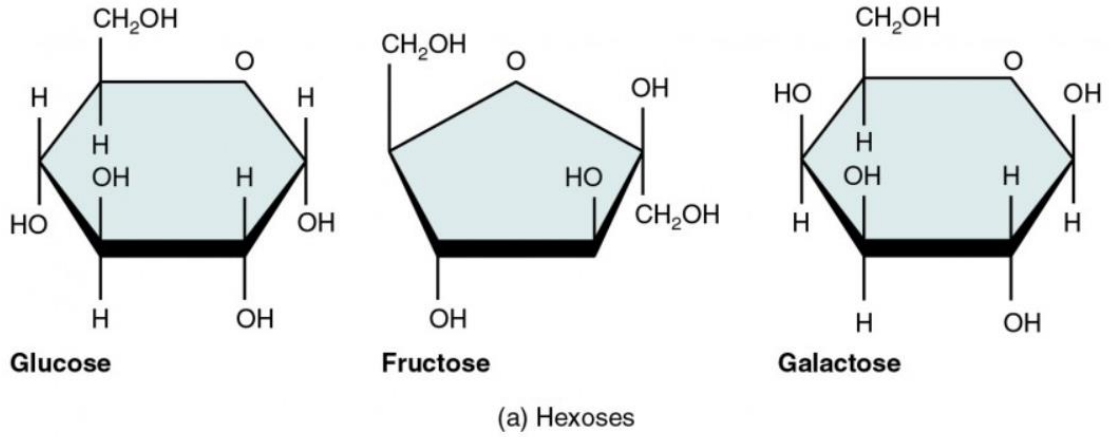
Monosaccharides are the monomers of carbohydrates.
Disaccharides (di- = “two”) are made up of two monomers.
Polysaccharides are the polymers, and can consist of hundreds to thousands of monomers.

Monosaccharides

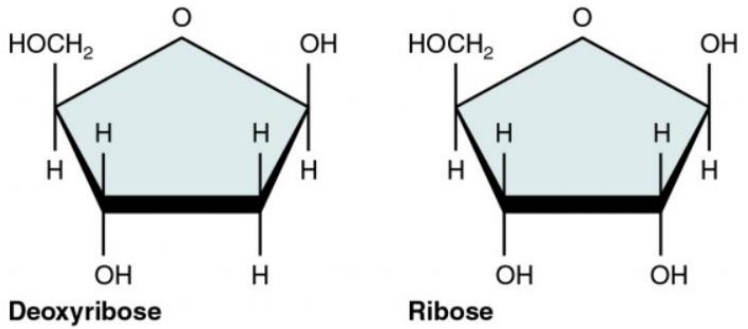
A *monosaccharide* is a monomer, or building block, of carbohydrates.

Glucose – **the body's main source of energy**
Fructose – a sweet sugar found in fruits
Galactose – a sugar found in milk





(a) Hexoses



(b) Pentoses

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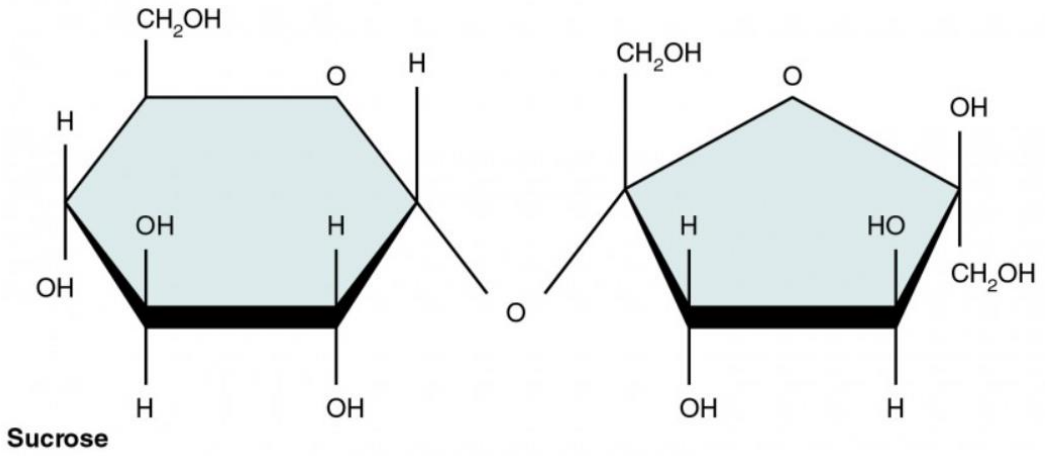
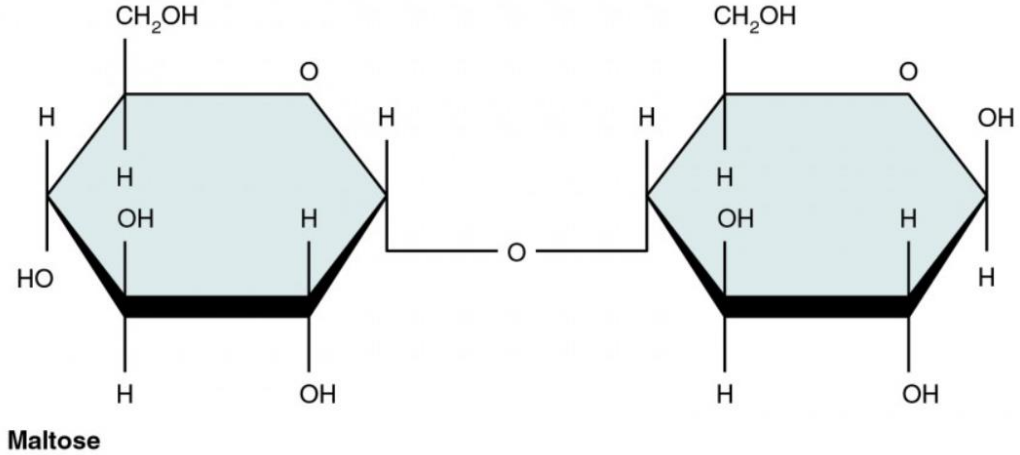
Disaccharides

A *disaccharide* is a pair of monosaccharides.

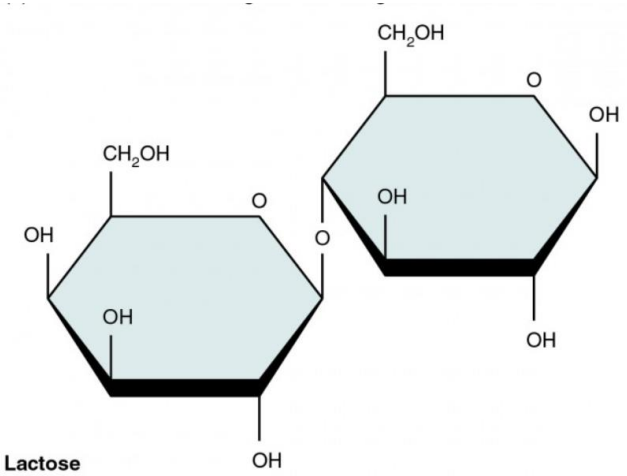
- sucrose – table sugar (glucose + fructose)
- lactose – milk sugar (glucose + galactose)
- maltose –malt sugar (glucose + glucose)



Sucrose



Maltose



Lactose

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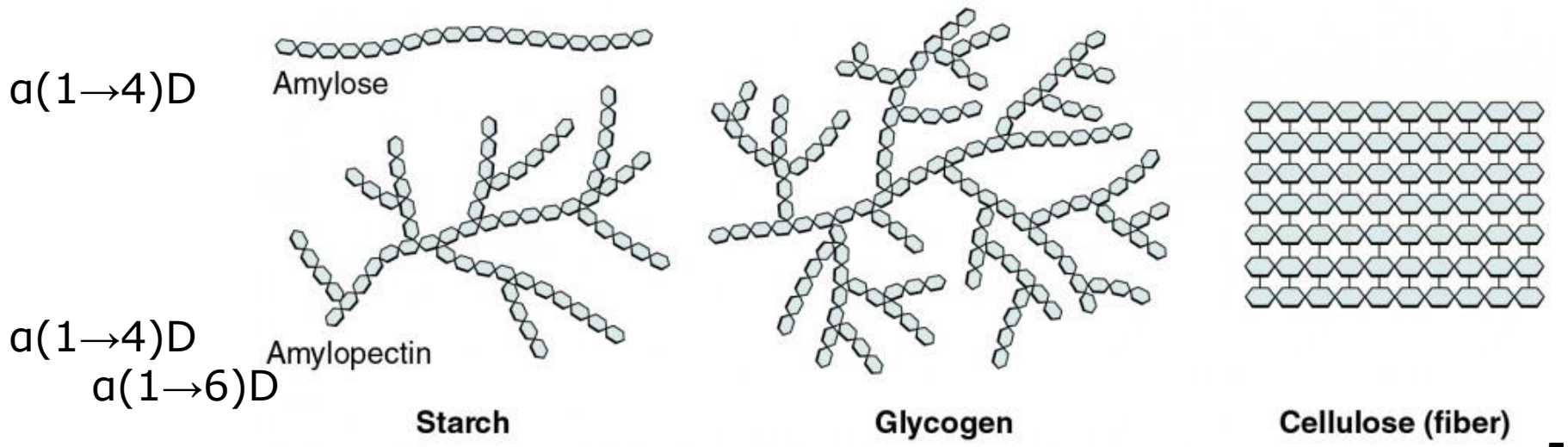
Polysaccharides

Polysaccharides can contain a few to a thousand or more monosaccharides. Three are important to the body.

• Starches – polymers of glucose that are stored in plants (relatively easy to digest good source of energy).

• Glycogen – polymer of glucose stored in animals tissues (muscles and liver). Human body stores excess glucose as glycogen.

• Cellulose – polysaccharide primary component of green plants cell wall. (Dietary fibers).



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Functions of Carbohydrates

Energy source:

- All the cells of the body can use glucose as a source of energy.

- Nerve cells (neurons) in the brain, spinal cord, and through the peripheral nervous system, as well as red blood cells, **can only use** glucose as an energy source to produce ATP.

Structural function:

- Carbohydrates have also structural function in the cells.
- Carbohydrate molecules can bind with proteins or lipid to produce glycoproteins or glycolipids which are constituent of the membrane that encloses the cells.

2. Lipids

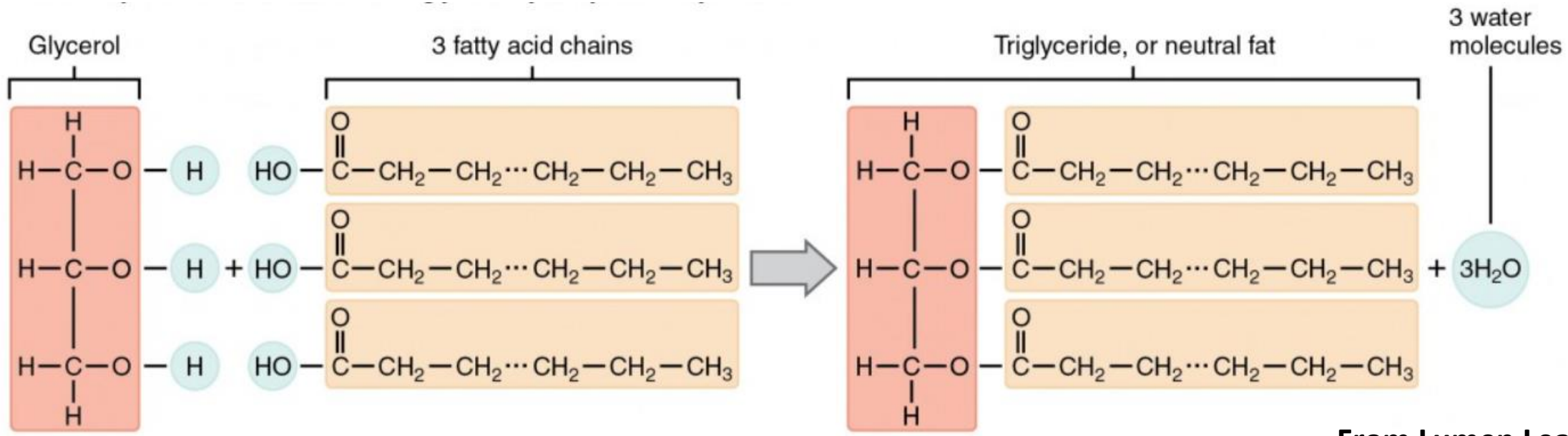
Highly diverse group of compounds made up mostly of hydrocarbons with few oxygen atoms at one end of the molecule.

Their nonpolar properties make all lipids hydrophobic (don't like water).

Triglycerides

One of the most common dietary lipid groups, and most abundant type of lipid in human tissues.

- A glycerol backbone.
- Three fatty acids (long chains of hydrocarbons with a carboxyl group and a methyl group at opposite ends).



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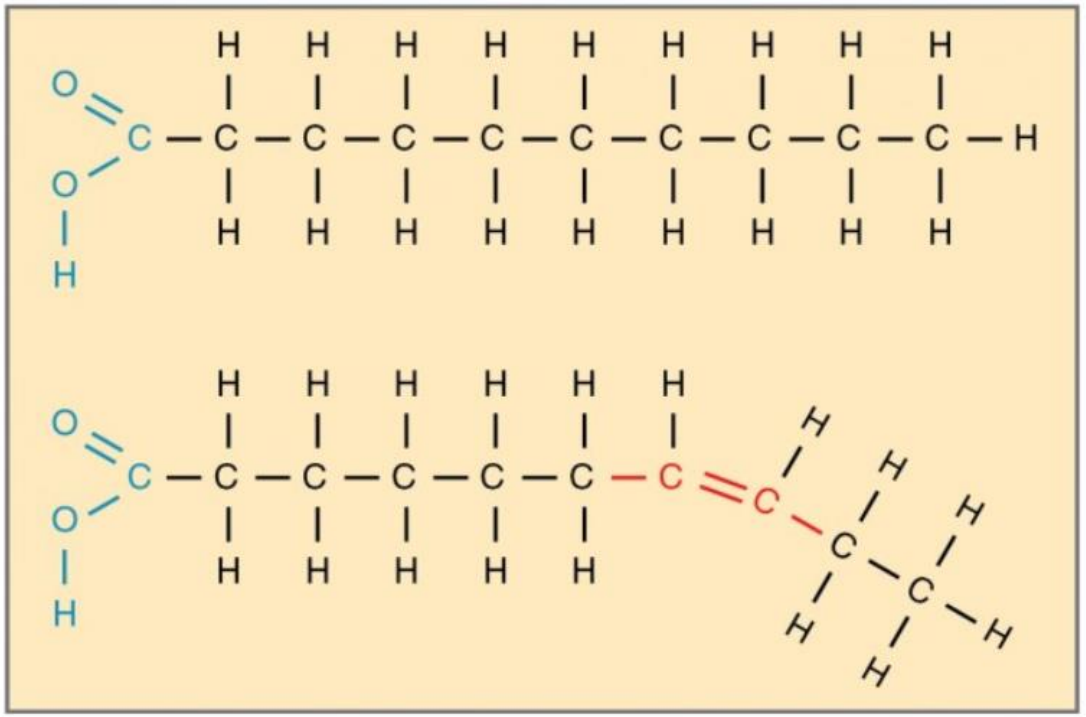
Fatty acids



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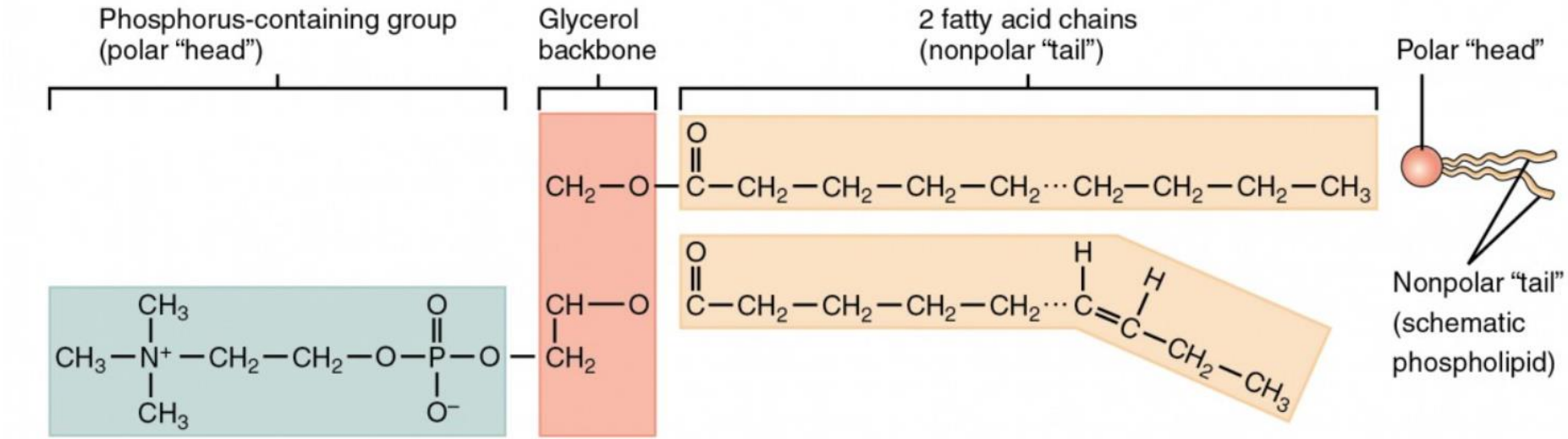
Phospholipids: they are the major constituents of the cell plasma membrane



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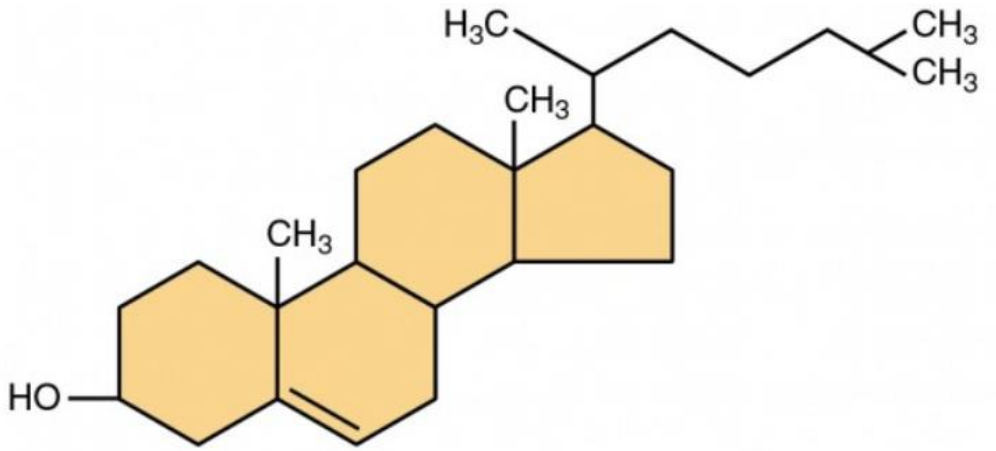
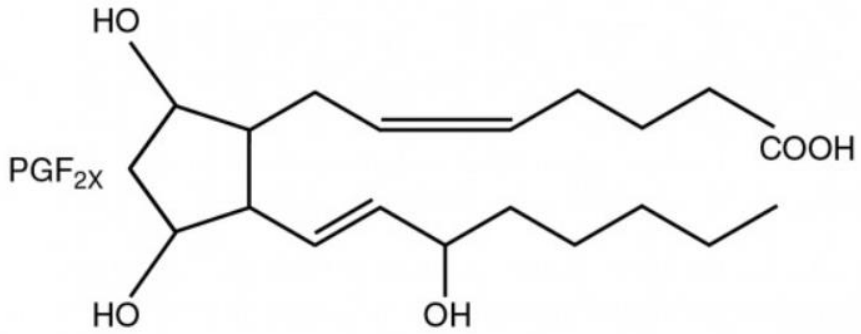
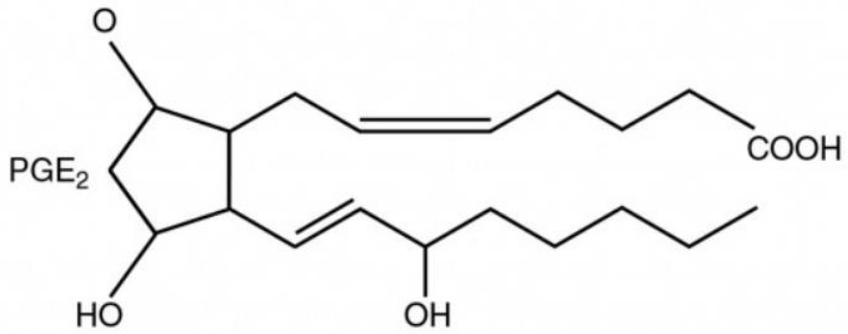
Sterol: Four interlocking rings of hydrocarbon form a steroid

- Cholesterol is the base of all the steroid made in the body.



- Prostaglandins (lipid messengers)





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- **Functions of Lipids**

Energy source:
- Triglycerides, stored in fat (adipose) tissues, are a major energy source.

Structural function:
- Phospholipids are the major constituents of the cells membrane.

Physical functions
- Fat tissues protect and cushions the body's bones and internal organs.
- Fat tissues act as insulation to retain body heat.
- Assist the absorption and transport of fat-soluble vitamins A, D, E, and K.

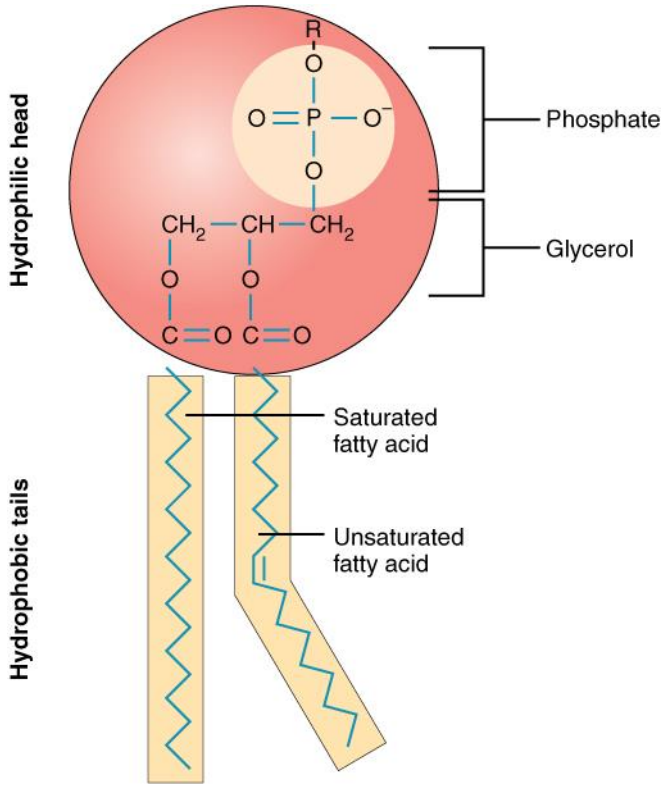
Communications

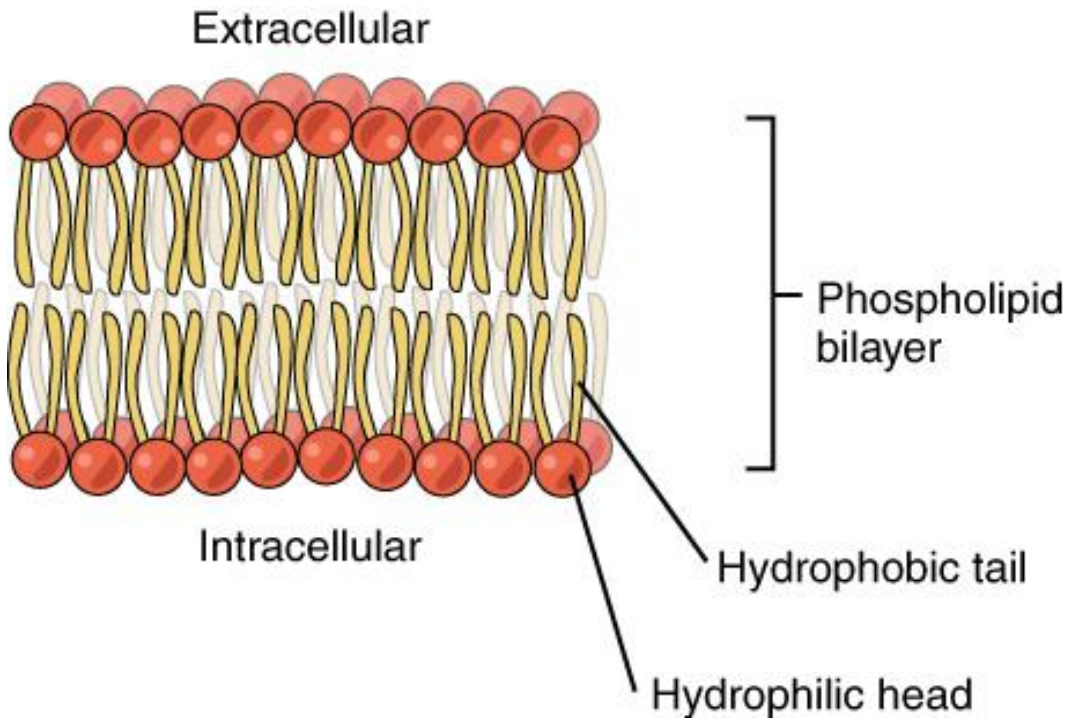
Act as second messengers e.g. prostaglandins, steroid hormones (corticosteroids).

Glossary:

A *hydrophilic* molecule (or region of a molecule) is one that is attracted to water.
A polar molecule (or region of a molecule) is positively or negatively charged
A nonpolar molecule is uncharged.
A *hydrophobic* molecule (or region of a molecule) repels and is repelled by water.
An *amphipathic* molecule is one that contains both a hydrophilic and a hydrophobic region.
The glycocalyx is a fuzzy-appearing coating around the cell formed from glycoproteins and other carbohydrates attached to the cell membrane.

Function of Lipids: Organization of biological membrane





Biological membranes are extremely pliable 2 layers of back-to-back phospholipids (a "bilayer").
Cholesterol intercalation add to the fluidity of the bilayer.

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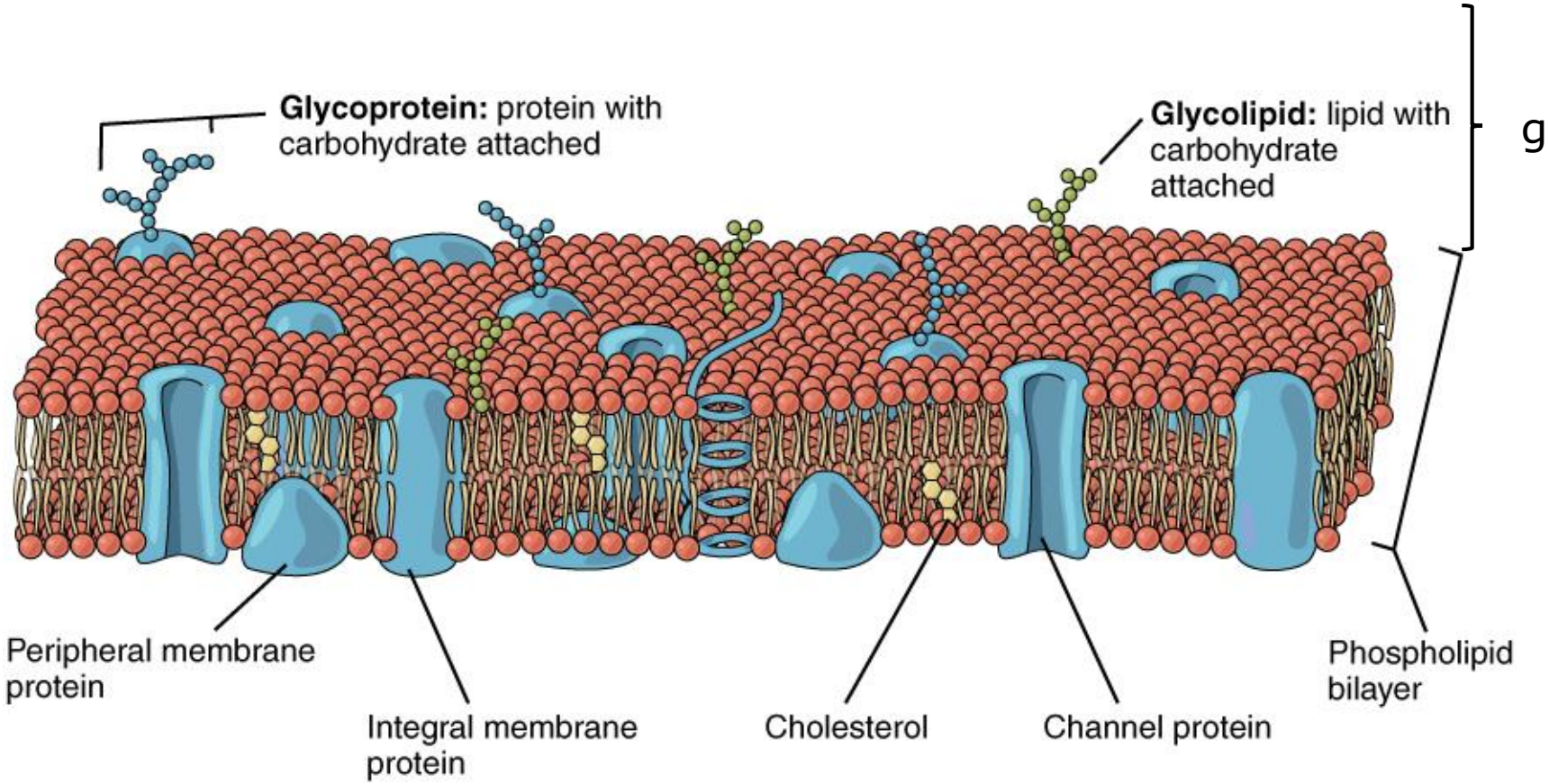
Function of Lipids: Organization of biological membrane



The **plasma *membrane*** lipid bilayer with a mix lipid composition. Various proteins are embedded within the bilayer contributing to the functionality of the plasmas membrane.

Lipids and proteins can be decorated with glycan motifs (carbohydrate aids in cell-to-cell recognition). The carbohydrates that extend from membrane proteins and lipids form the glycocalyx.

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Membrane Specializations

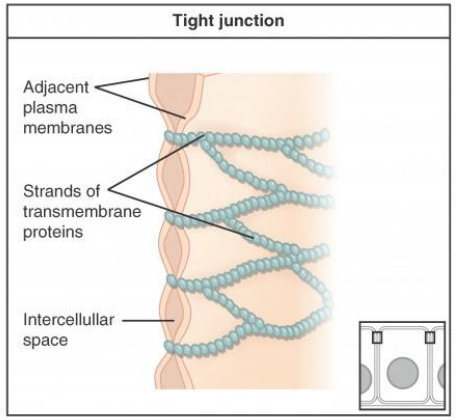
Some membranes have components that are specialized for a specific purpose.

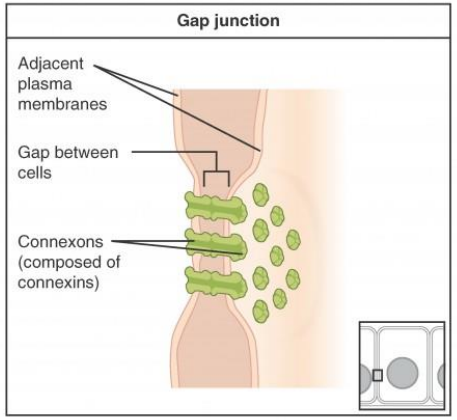
Microvilli are finger-like projections on the surface of some cells. These projections increase the surface area to improve absorption/exchanges.

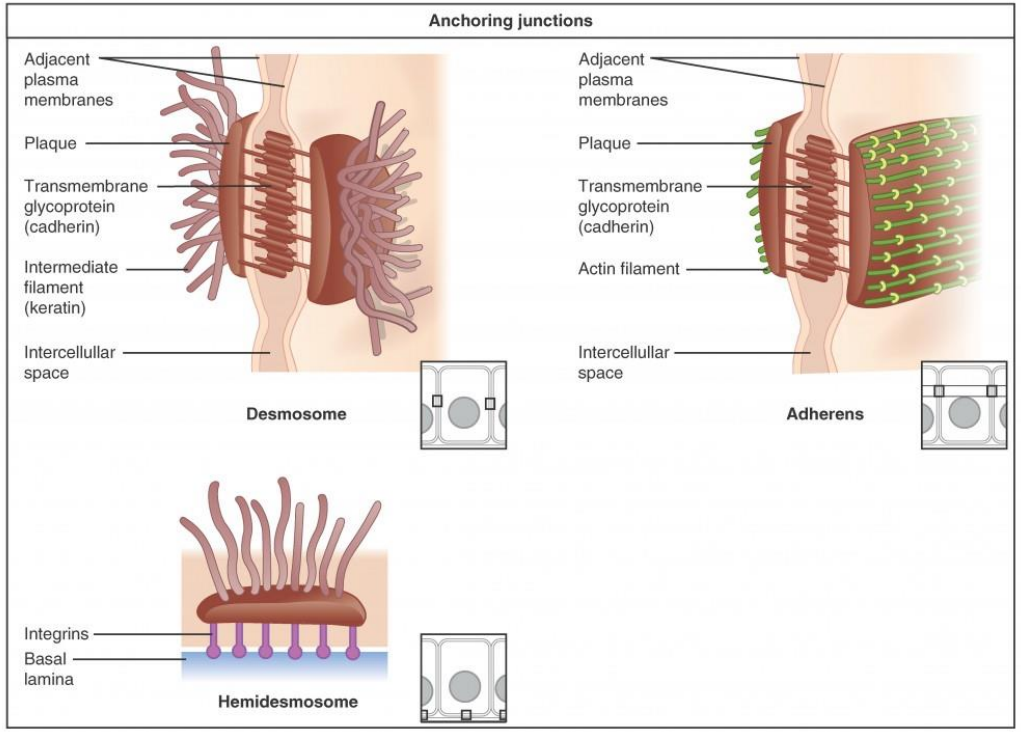
Tight junctions are proteins structures holding adjacent cells together very tightly so nothing can penetrate between them (Cells lining the digestive and urinary tract).

Desmosomes or anchoring junctions, hold cells together by protein fibers allowing movement without separation (muscle tissue and the skin).

Gap junctions are open areas within the plasma membrane found between two adjacent cells. The proteins connect two cells while allowing chemicals to pass between the cells.







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Membrane Transport

Because all plasma membranes are selective permeable, they can regulate the cellular concentration of ions (Ca^{2+}, Na^{+}, K^{+}, and Cl^{-}) nutrients (sugars, fatty acids, and amino acids) and waste products (CO_2).

Only relatively small, nonpolar materials can move through the lipid bilayer (lipids, oxygen and carbon dioxide gases and alcohol).

Water-soluble materials, like glucose, amino acids, and electrolytes, require assistance to cross the membrane.

Movement through the membrane are categorized based on whether or not energy is required.
Passive transport is the movement of substances across the membrane without the expenditure of cellular energy.

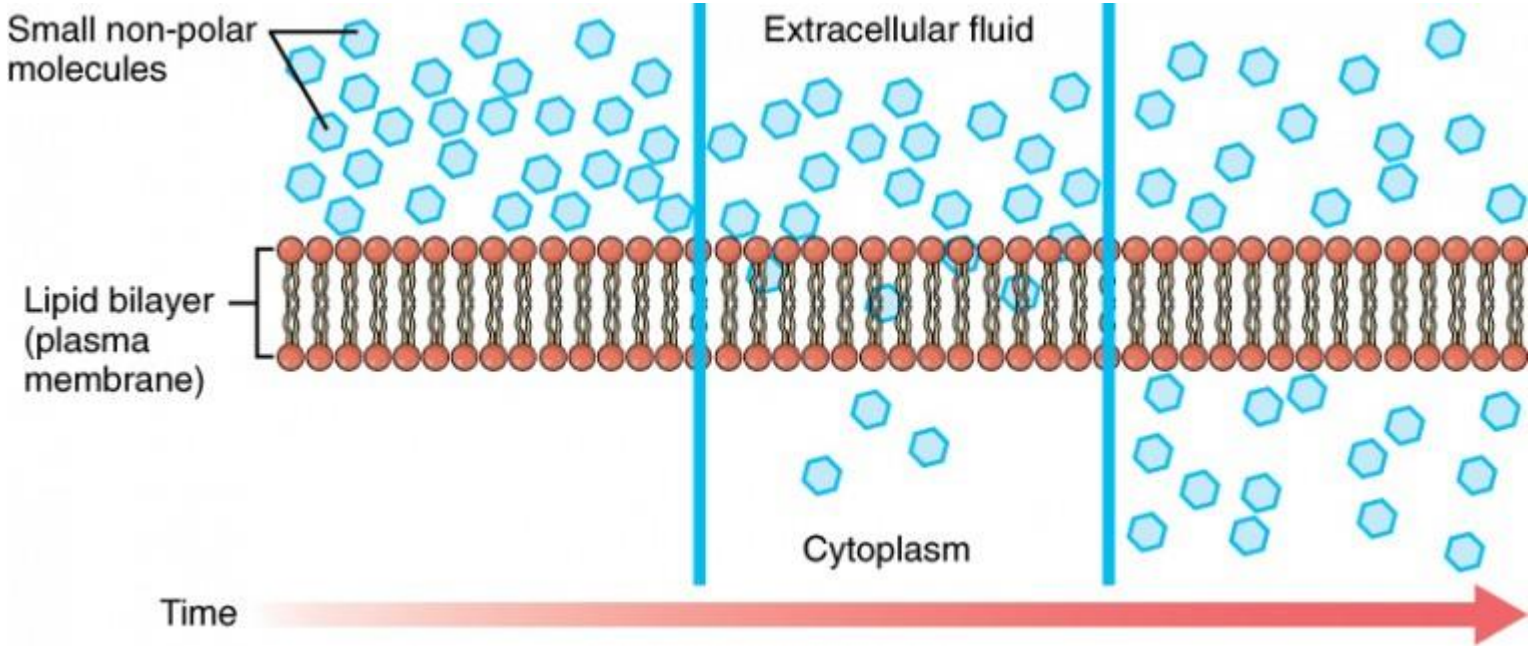
Active transport is the movement of substances across the membrane using energy from adenosine triphosphate (ATP).

Passive Transport

Concentration gradient: difference in concentration of a substance across a space. Molecules (or ions) move *down* their concentration gradient: from the more concentrated to less concentrated until equilibrium.

Three common types of passive transport.

1) ***Simple Diffusion:*** movement of particles from an area of higher concentration to an area of lower concentration. Exemples, oxygen (O_2) goes inside cells, CO_2 leave the cells.



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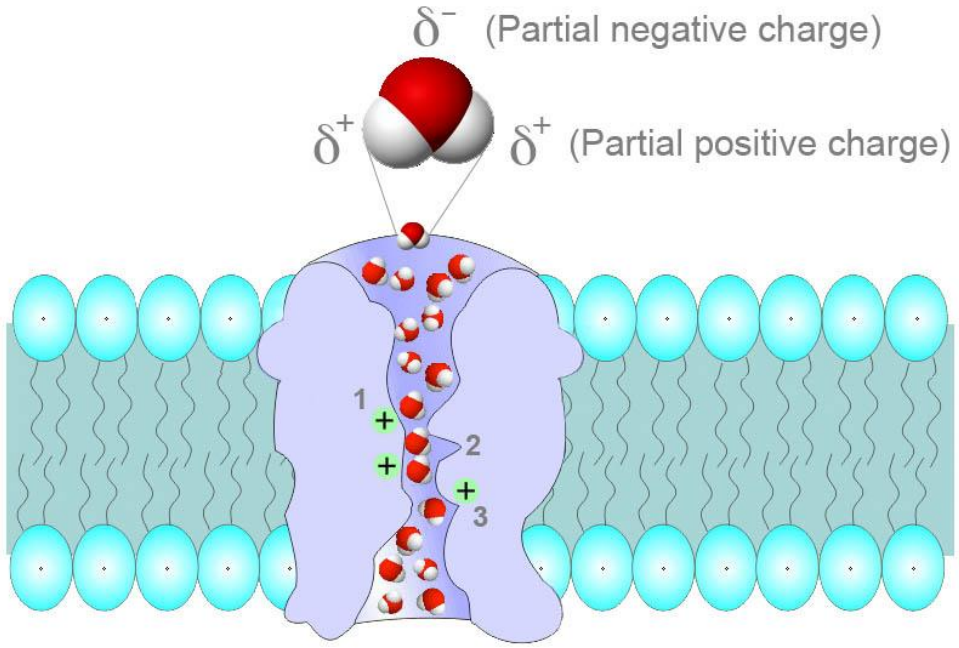
Water can **diffuse** through the lipid bilayer even though it's polar because it's a very small molecule.

Water can also pass through the cell membrane by **osmosis**, because of the high osmotic pressure difference between the inside and the outside the cell.

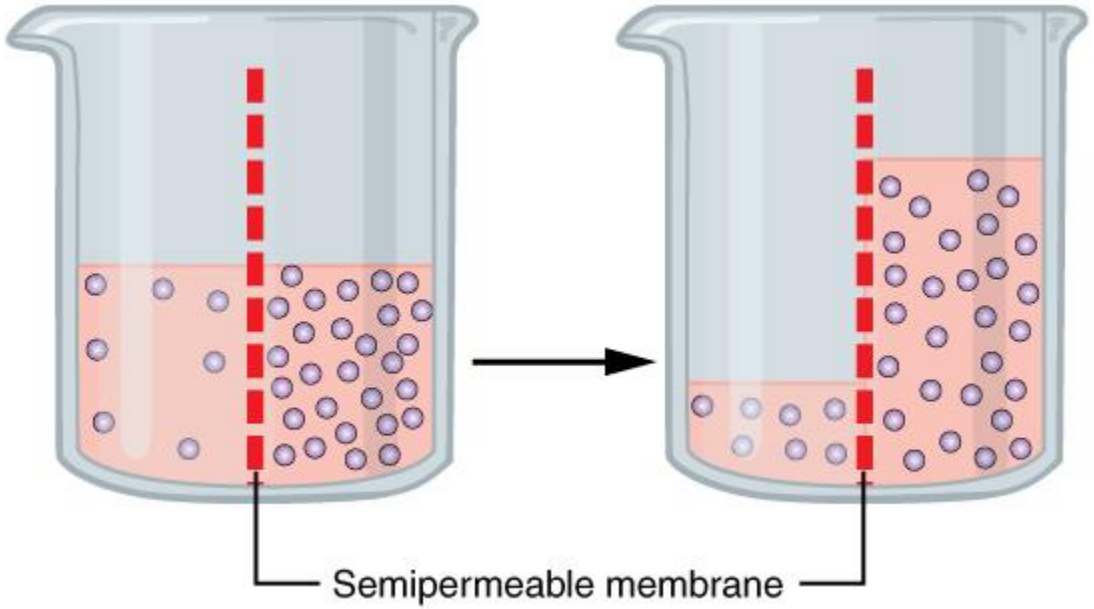
That doesn't mean that it's an easy process, because the solubility of water in lipid is about 1 molecule of water per million molecules of lipid.

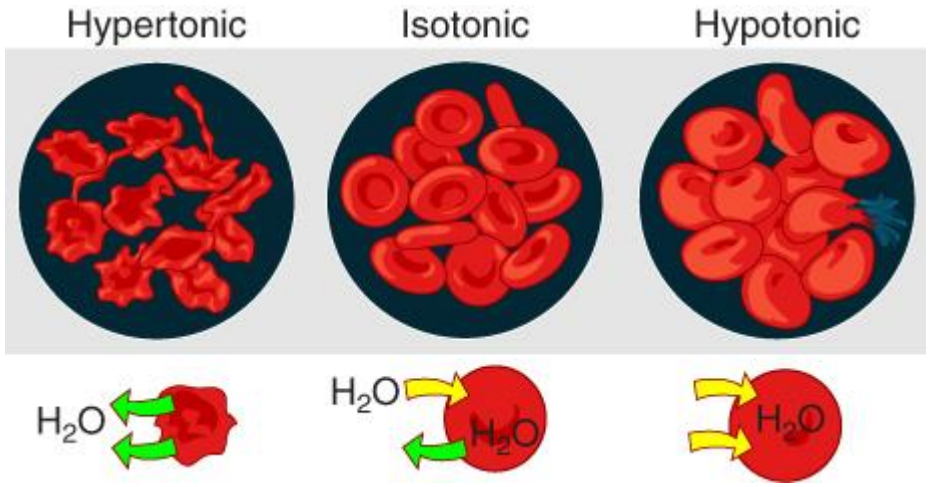
But the outside concentration of water is very high (about 50 mol/L), and the surface area to volume ratio of the cell is very large, so this is an important cellular process.



Passive Transport

2) **Osmosis:** The diffusion of water through a semipermeable membrane. Water can move freely across the cell membrane either through protein channels or by slipping between the lipid tails of the membrane. Water move from the less concentrated compartment to the more concentrated one.

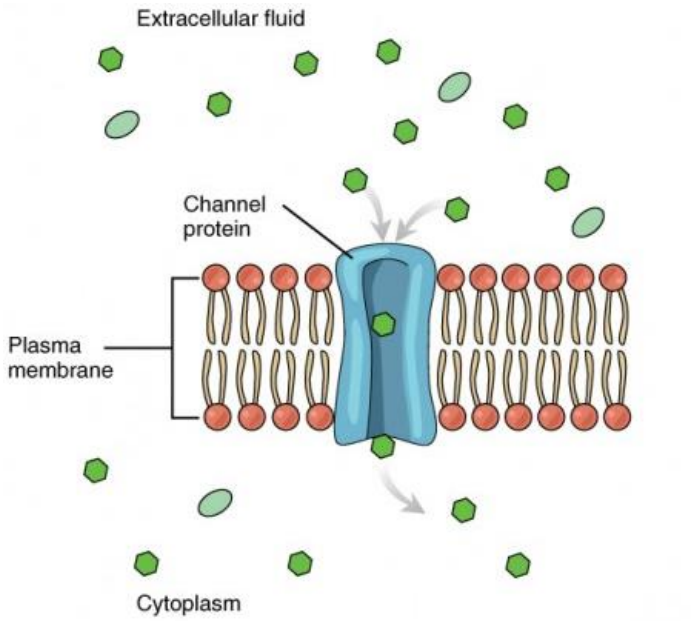


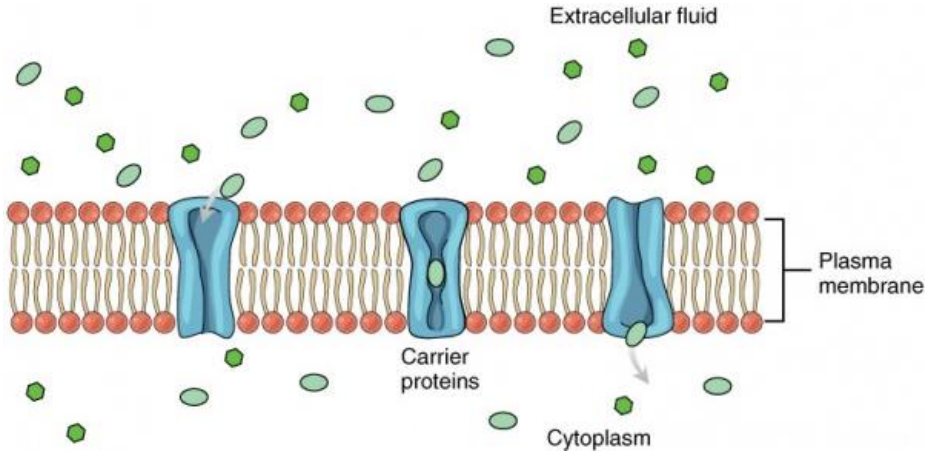


From Lumen Learning

Passive Transport

3) **Facilitated diffusion:** It is used by substances that cannot cross the lipid bilayer because of their size and/or polarity . It involved specialized carrier protein called the transporter. Facilitated diffusion is a passive process, it does not require energy expenditure by the cell and the movement of substance is down the concentration gradient.



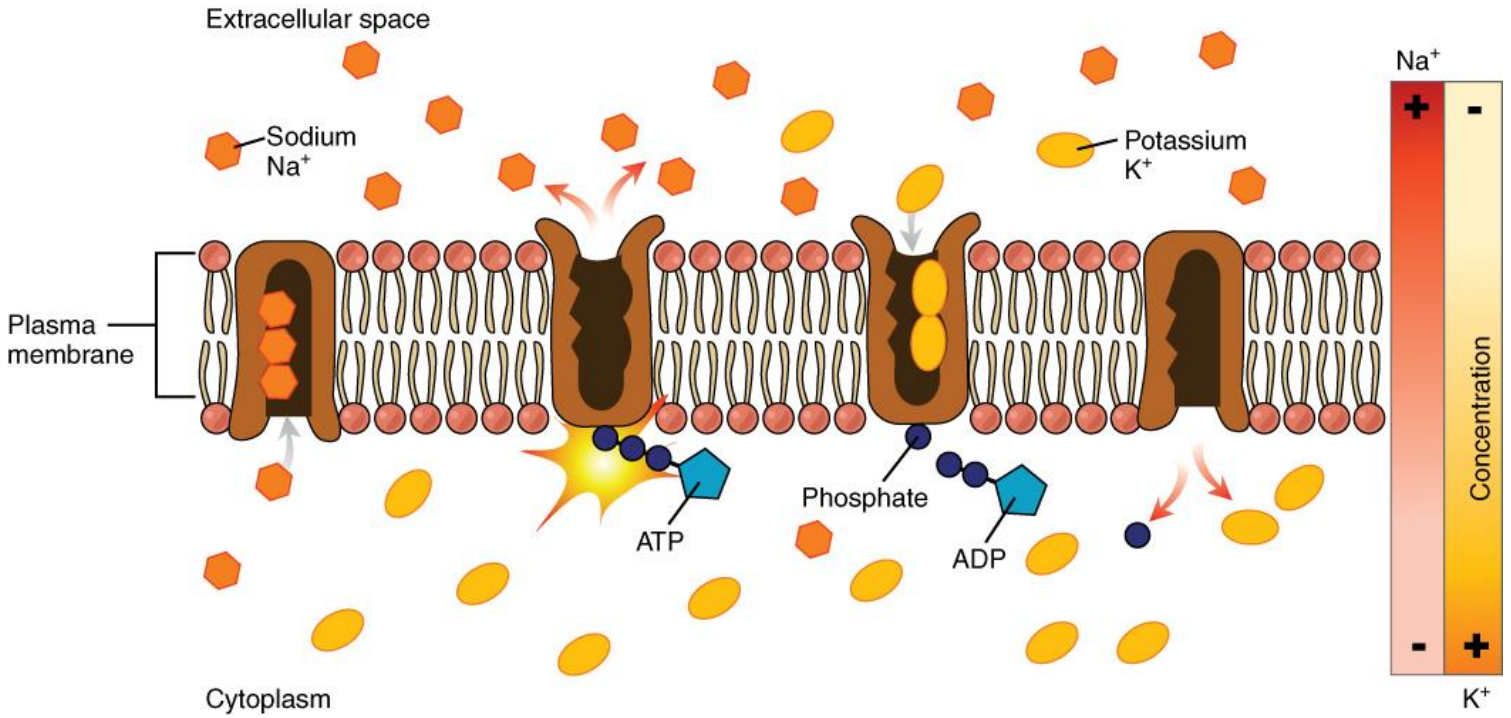


From Lumen Learning

Active Transport

Active transport **consume energy (ATP)** to move a substance across a membrane usually **against the concentration gradient** (from an area of low concentration to an area of high concentration).

1) Protein carriers/transporters/pumps. Example: The *sodium-potassium pump*, (N^+/K^+ ATPase) transports 3 sodium ions out of a cell while moving 2 potassium ions into the cell for each ATP molecule used. The action of this pumps create and maintain an electrical gradient across the cell membranes of about -70 mV.



From Lumen Learning

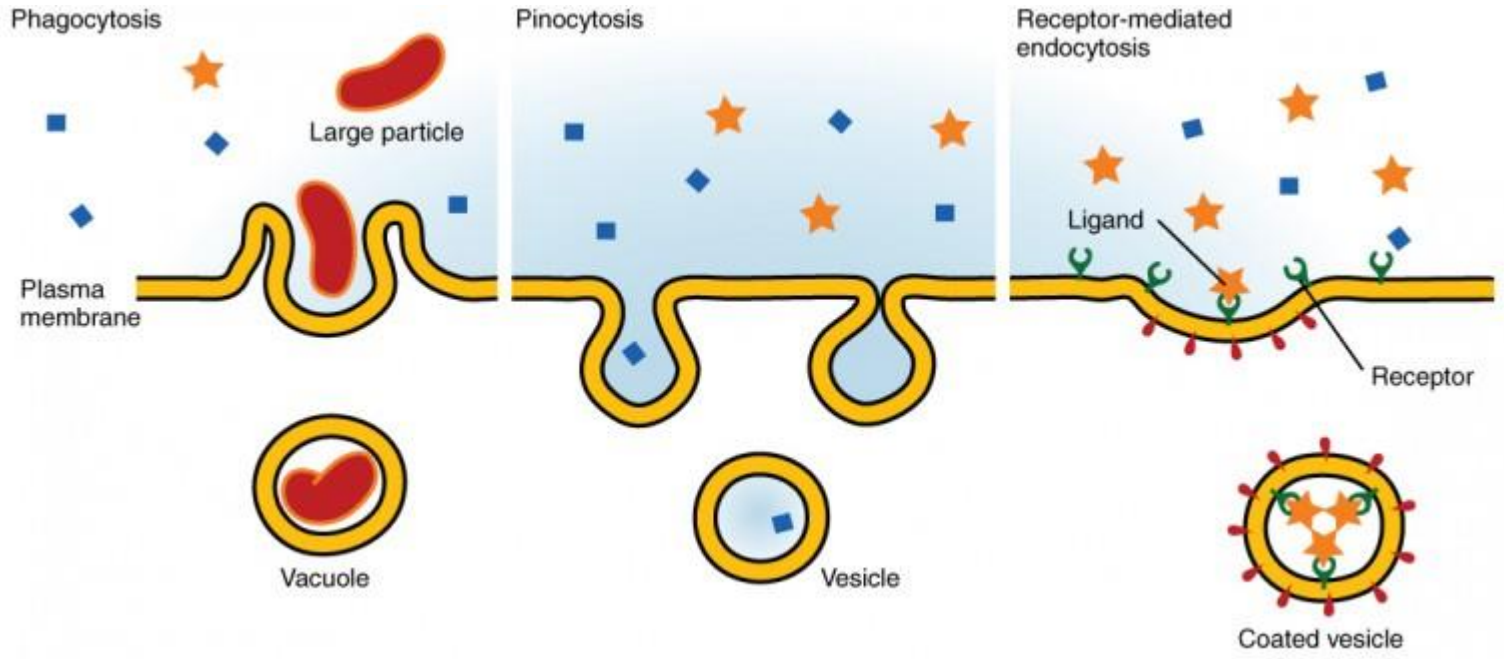
Active Transport

2) Endocytosis: The process of ingestion of material into the cells by enveloping it in a portion of cell membrane and pinching it off to become and intracellular vesicle.

Phagocytosis ("cell eating") is the endocytosis of large particles. Many immune cells engage in phagocytosis of invading pathogens.

pinocytosis ("cell drinking") brings fluid containing dissolved substances into a cell through membrane vesicles.

Phagocytosis and pinocytosis take in large portions of extracellular material, not highly selective. Cells regulate the endocytosis of specific substances via receptor-mediated endocytosis



From Lumen Learning

Proteins

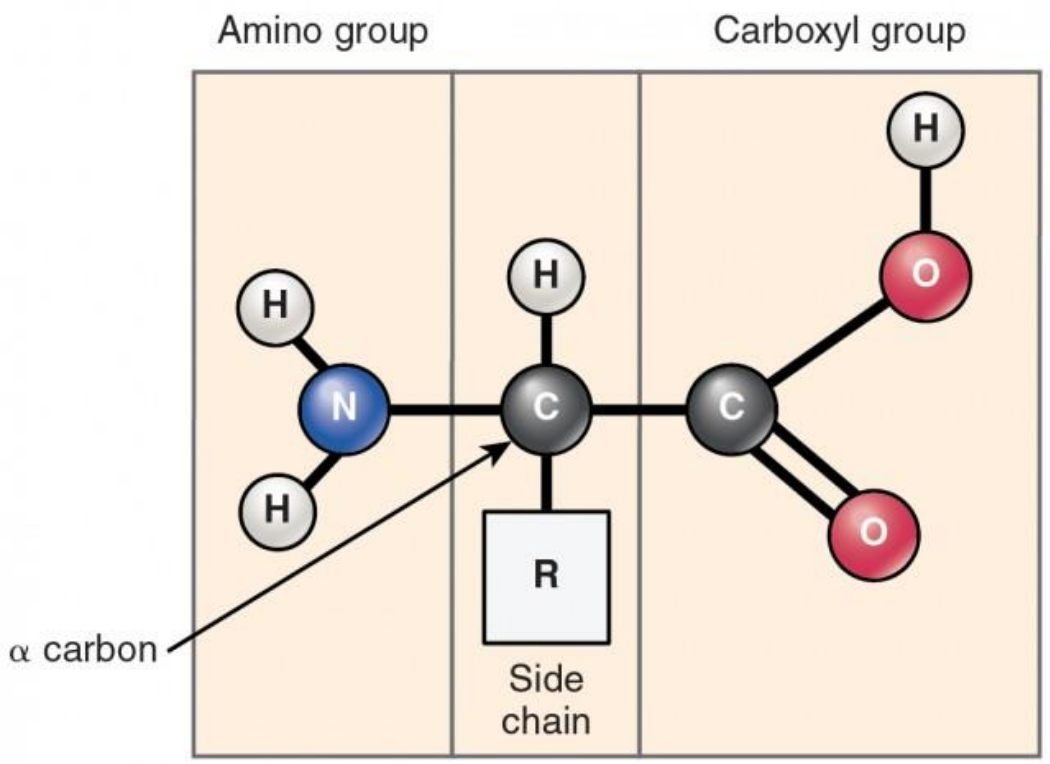
Proteins are critical components of all tissues and organs. They are polymer of amino acids linked by peptide bonds.

There are 20 essential amino acids (AA) that enter in the composition of proteins.

Each proteins contain a unique combination or **sequences** of these 20 amino acid monomers.
Polypeptide < 100 AA, Proteins >100 AA

All 20 of these AA share a similar structure
A carbon-α directly bonded:

- a hydrogen atom **-H**
- an alkaline (basic) amino group **-NH2**
- an acidic carboxyl group **-COOH**
- a variable group **-R**



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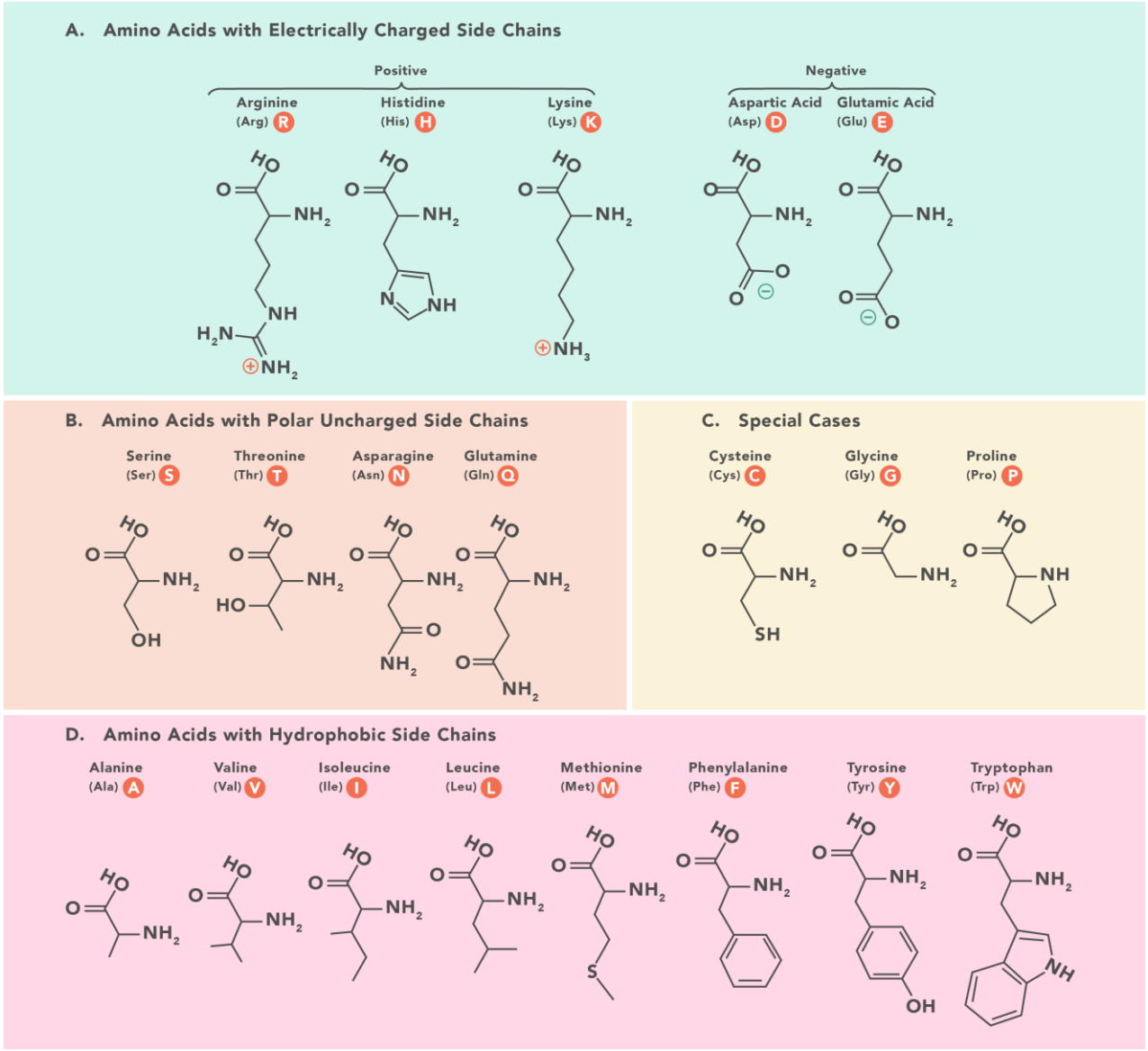
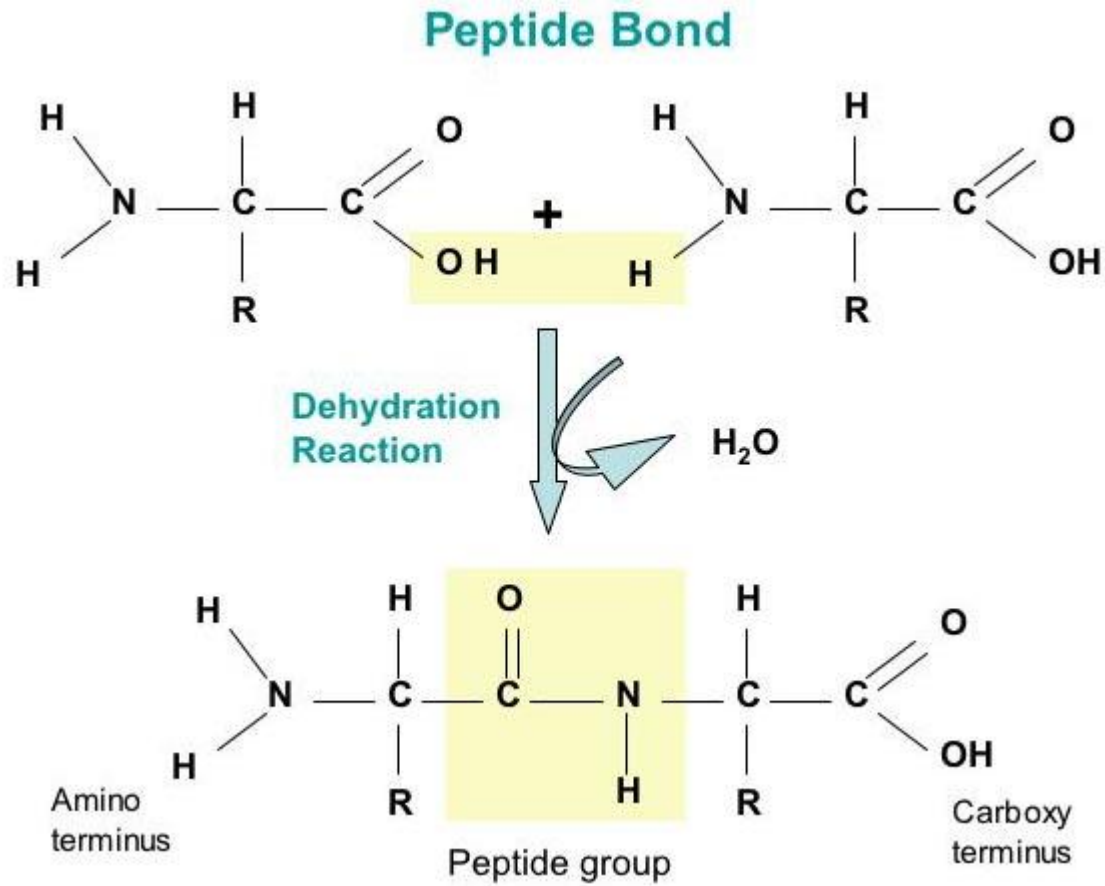
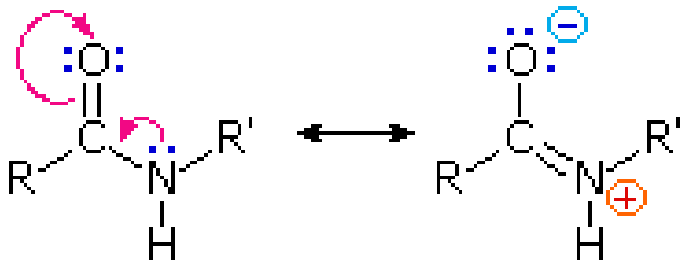
20 essential amino acids that differ by their lateral chain

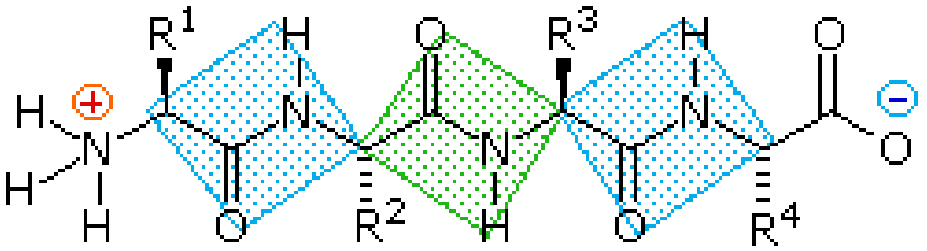


Peptide bond formation: dehydration synthesis

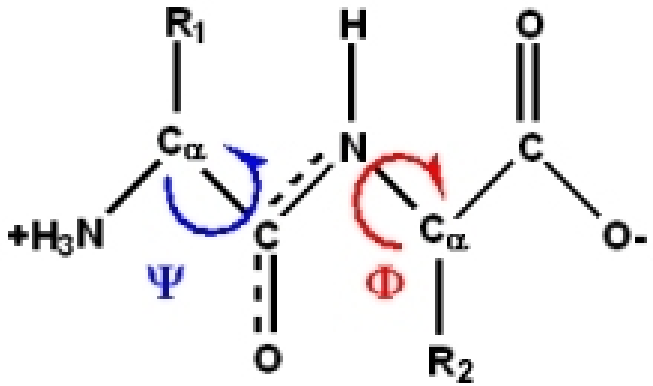


Peptide bonds have planar structure

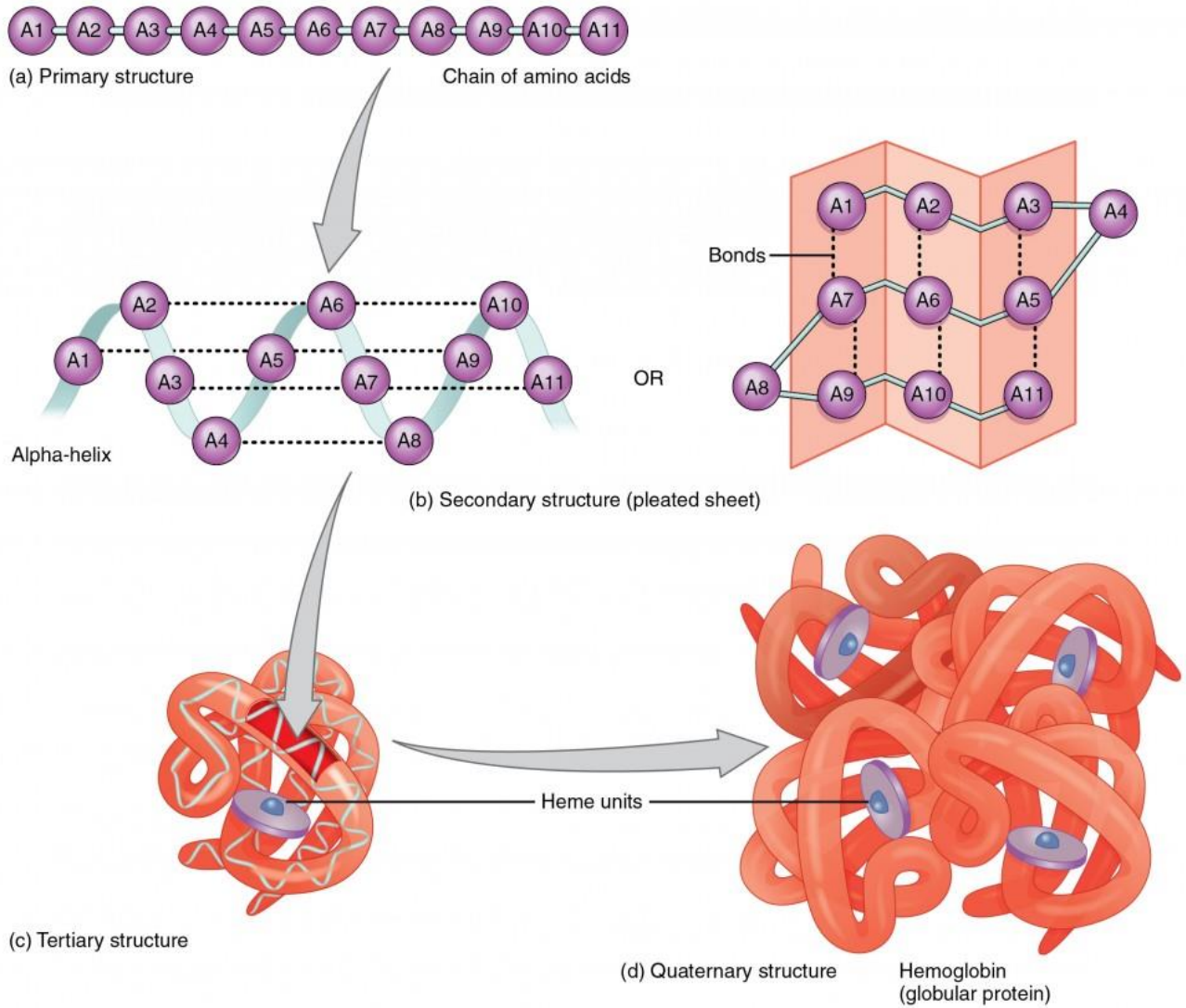




planar peptide bond segments



The AA sequence fundamentally determine the protein folding.



The folding (the structure) of the protein dictate the function

From Lumen Learning

Protein functions

Structural:
Maintains the structure of the cells or organ
Cytoskeletal protein, collagen of the boon

Catalyst:
Enzymes increase the speed of the biochemical reactions in the cells and make them compatible with life.

Transport:
Facilitates the transport of solutes or other proteins

Nucleic Acids

They are involved in the storage of the genetic information of living organisms.

They are polymer of nucleic acids

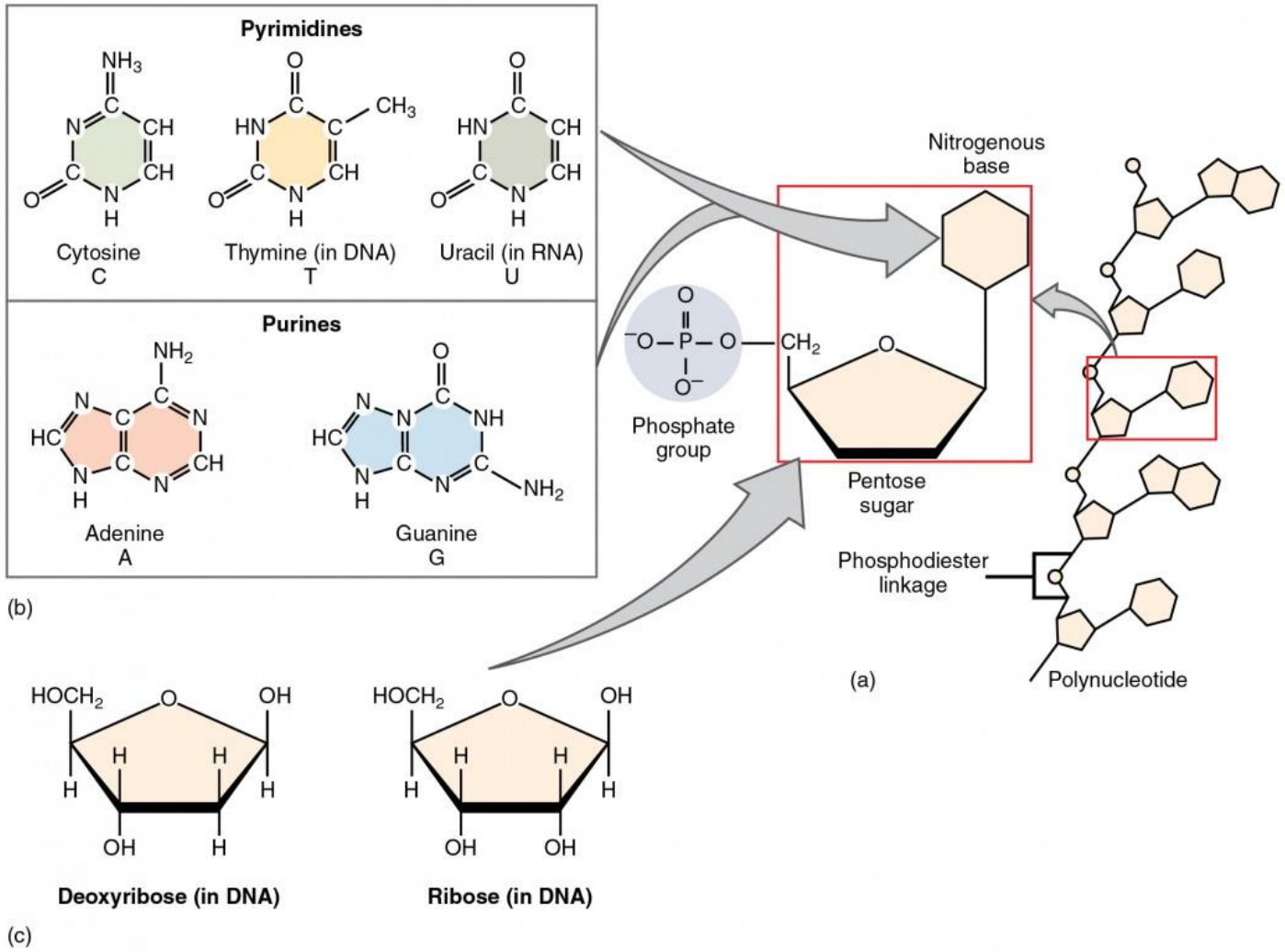
- Deoxyribonucleic acids are nucleotide that stores genetic information of DNA

- *Ribonucleic acids* are nucleotides of RNA that helps express the genetic information contain in the DNA as proteins.

- The difference lies in the sugar composition Deoxyribose /Ribose

Nucleotide structure

- phosphate groups
- A sugar: either deoxyribose or ribose (pentose)
- A nitrogen-containing base: adenine, cytosine, guanine, thymine, or uracil



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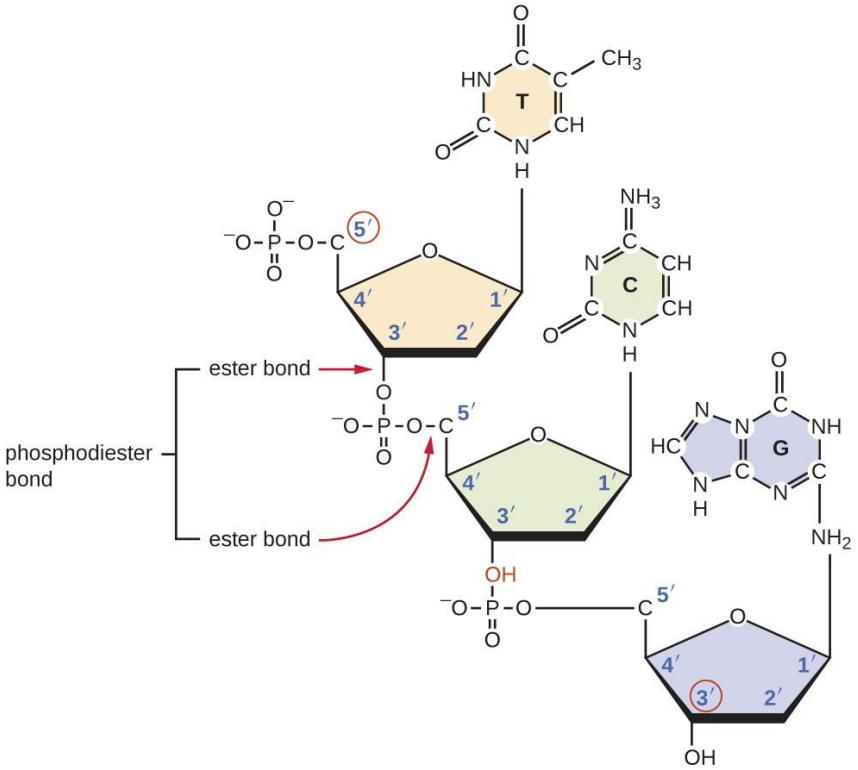
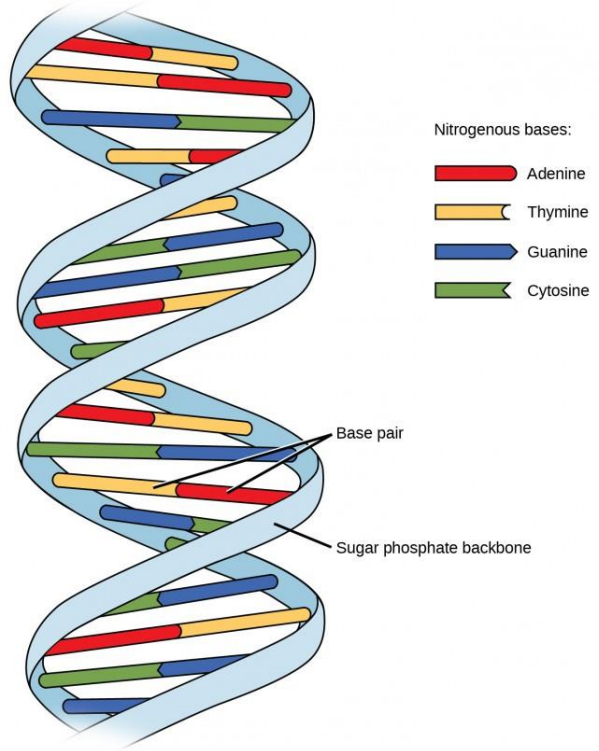
Nucleic Acids: polymer of nucleotides





- The sequence of bases within a strand of DNA form the genes.
- Gene are a molecular code instruction for assembly of AA to build proteins.
- Humans have about 22,000 genes in their DNA, locked up in the 46 chromosomes stored inside the nucleus of each cell.
- These genes carry the unique genetic code to build one's body.

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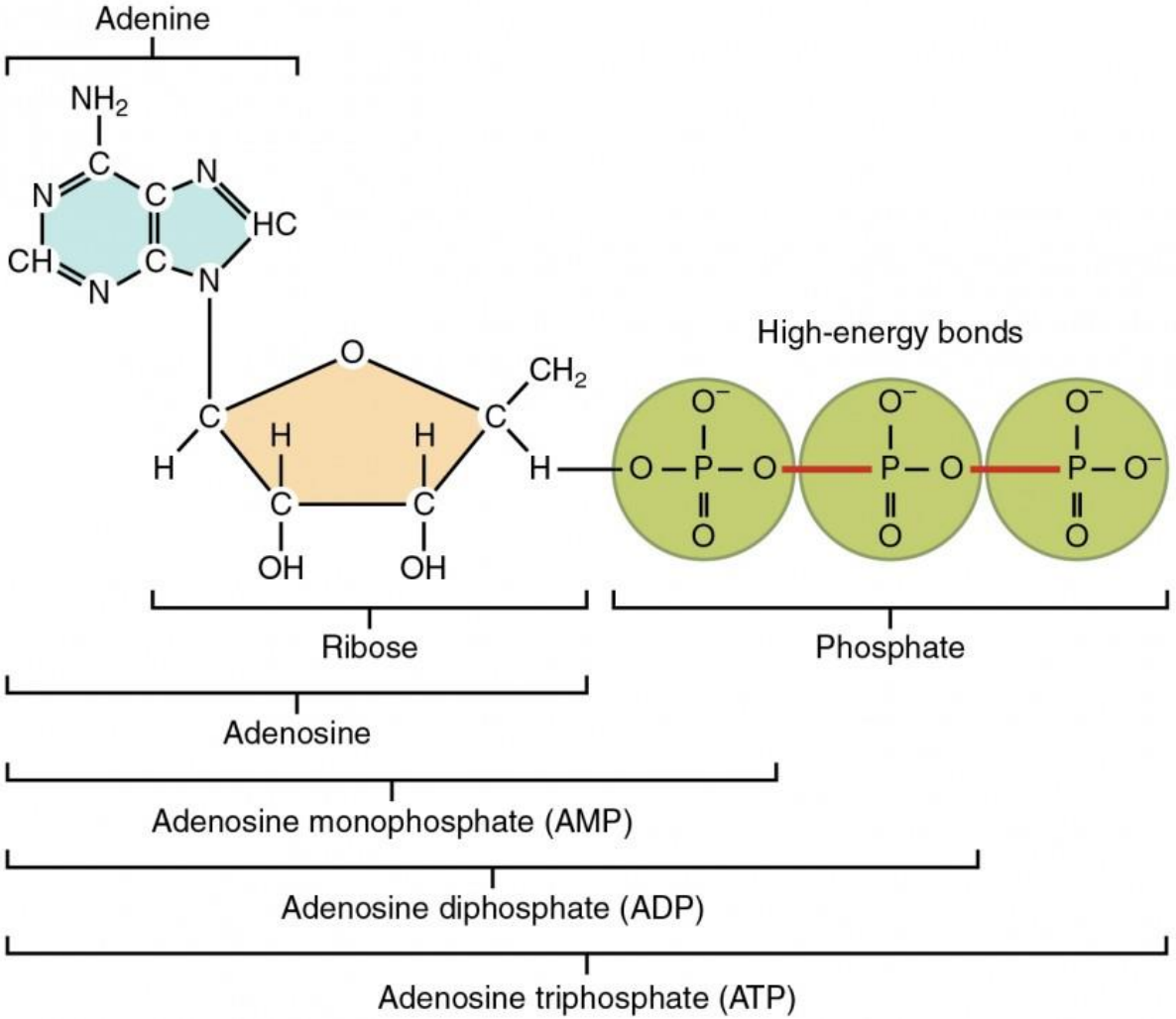
Adenosine Triphosphate (ATP) structure



- The covalent bonds linking its three phosphates store a good amount of potential energy.
- Hydrolysis of these high energy bonds release this energy to fuel cellular activities.
- Reforming these bonds provide a mean to re-store the energy in the form of ATP.

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Animal cells contain three main regions

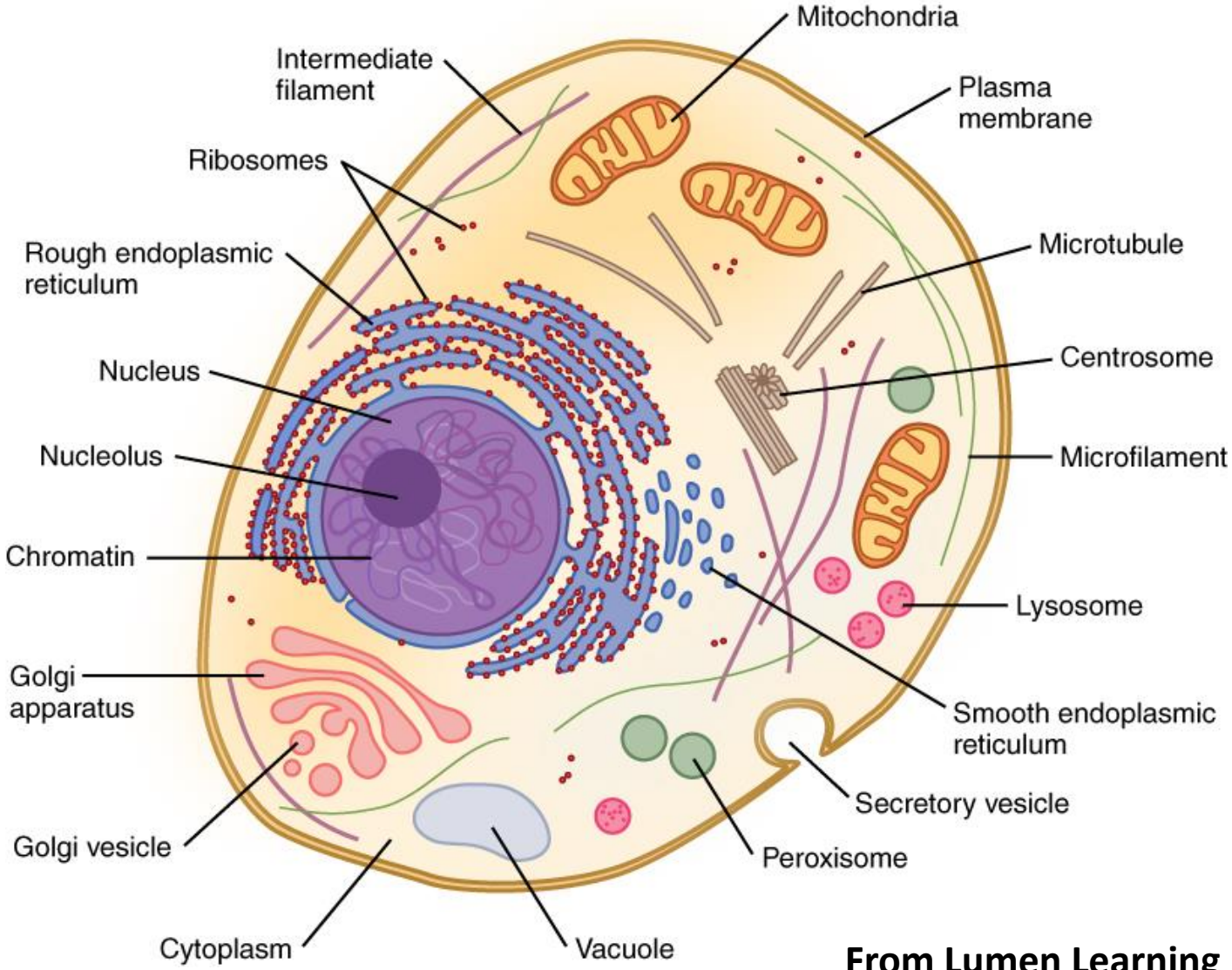
1) The plasma membrane surrounds the cells.

2) The *nucleus* central organelle, which contains the cell's DNA.

3) The cytoplasm is composed of two parts, the cytosol and organelles.

    1) *Cytosol*, the jelly-like substance within the cell, provides the fluid medium necessary for biochemical reactions.

    2) *Organelles* ("little organ") one of several different membrane-enclosed bodies performing a unique function. Work together to keep the cell healthy.



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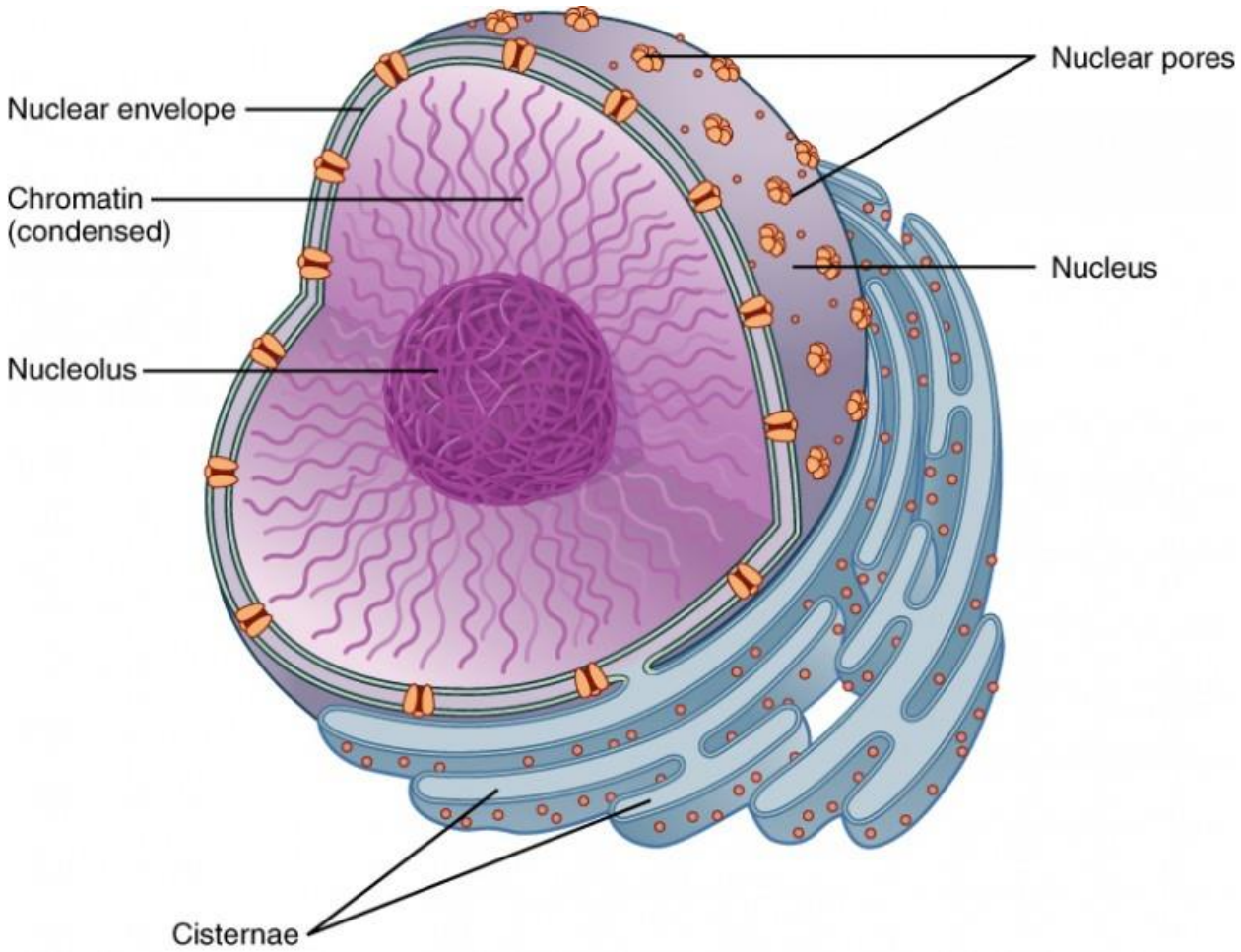
The nucleus



The nucleus, the largest of a cell's organelles, stores all of the genetic instructions for manufacturing proteins.
This information is stored within the DNA. Each cell in the body contains a complete set of DNA.

When a cell divides, the DNA must be duplicated so that the each new cell receives a full complement of DNA.

the nucleus is surrounded by the *nuclear envelope* consisting of two adjacent lipid bilayers with a thin fluid space in between them.
Nuclear pores, tiny passageways spanning these two bilayers. Allow communication between the nucleus and the cytoplasm.

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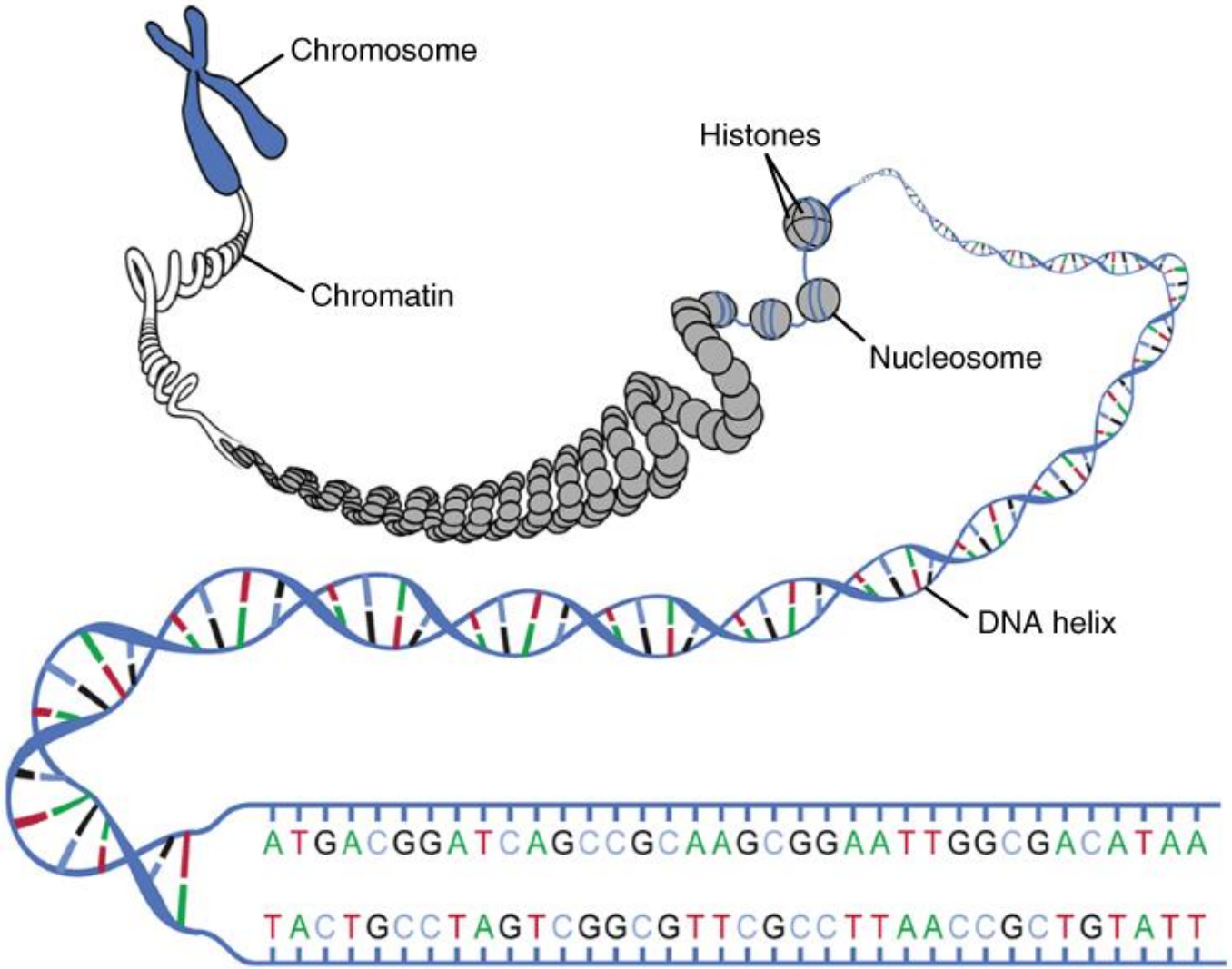
Organization of the DNA



Chromatin, the DNA and associated proteins (histones), allows efficient packaging of DNA within the nucleus while maintaining a structure for early stages of proteins synthesis.

Along the chromatin threads, the DNA is wrapped around set of *histone* proteins.

During cell division, the chromatin condenses into chromosomes, so that the DNA can be safely transported to the "daughter cells.

Humans have almost 22,000 genes distributed on 46 chromosomes.

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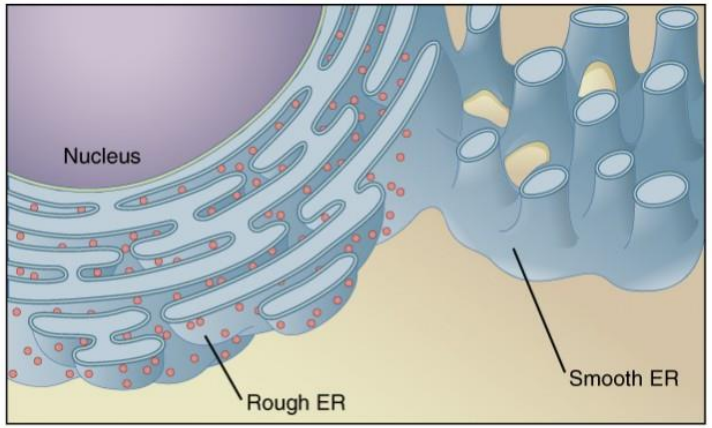
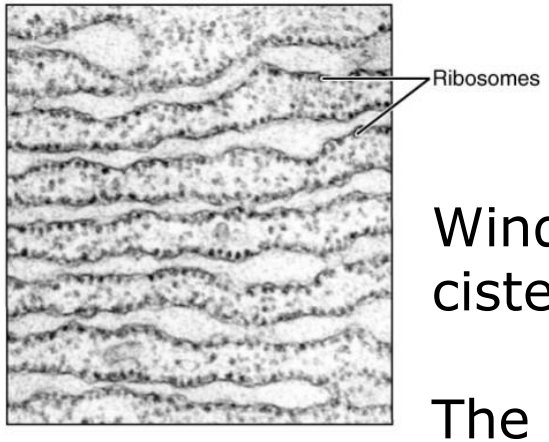
Endoplasmic Reticulum (ER)



(a)



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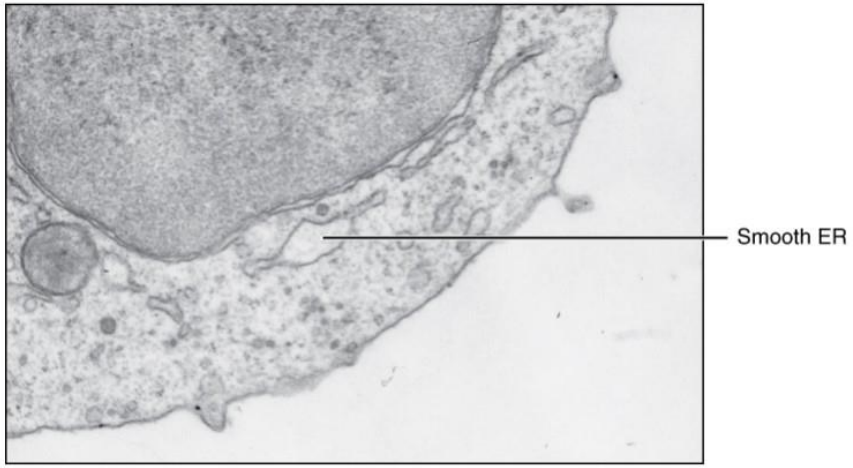

(c)

Winding network of thin membranous sacs or cisternae continuous with the nuclear envelope.

The ER function in transporting, synthesizing, and storing materials. The ER has large membranous surface area that supports its many functions.

Rough ER is studded with numerous ribosomes, which are sites of protein synthesis.

Smooth ER synthesizes phospholipids, steroid hormones, regulates the concentration of cellular Ca^{2+}, metabolizes some carbohydrates, and breaks down certain toxins.

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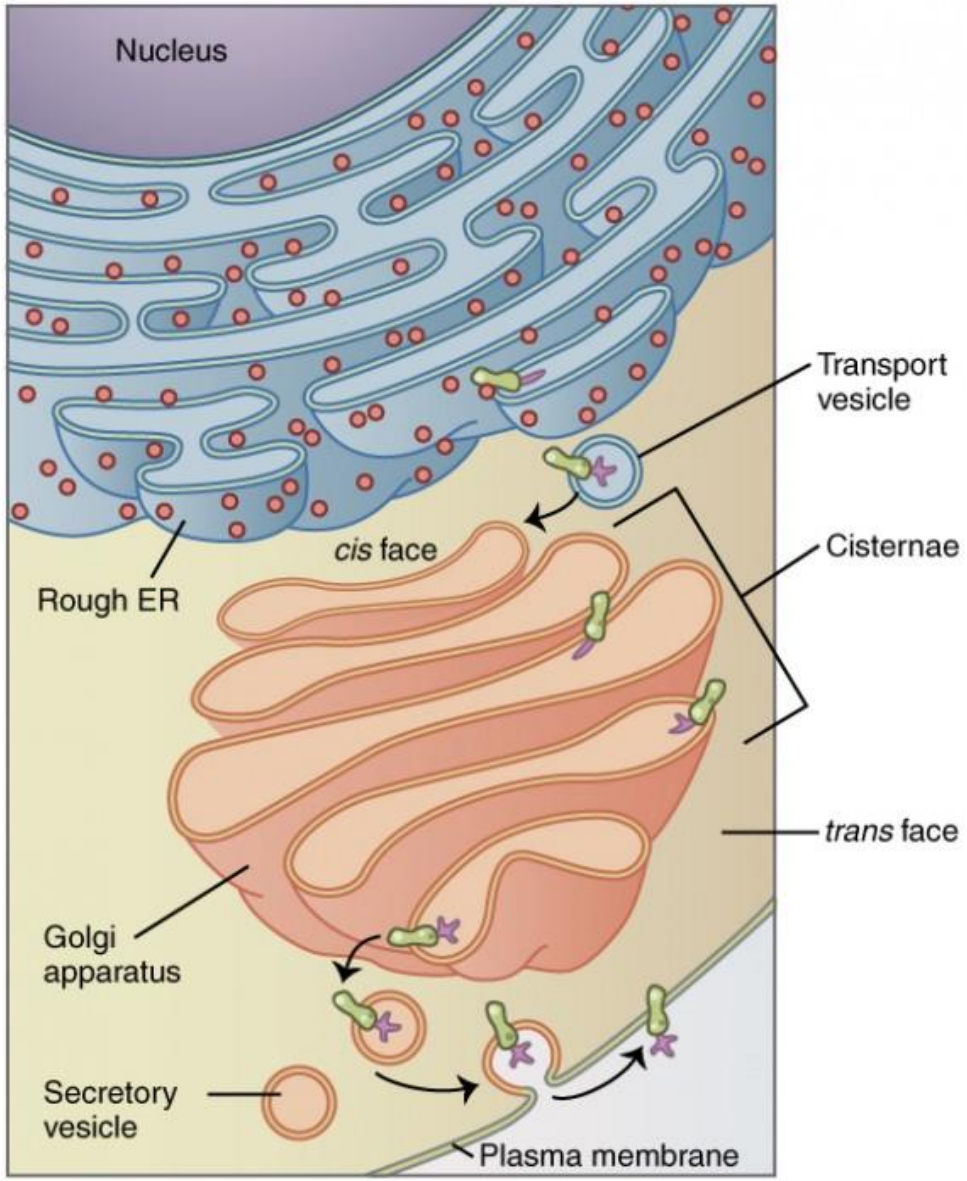
The *Golgi apparatus*



The Golgi apparatus, a stacked flattened cisternae, sorts, modifies, and ships off the products that come from the rough ER.

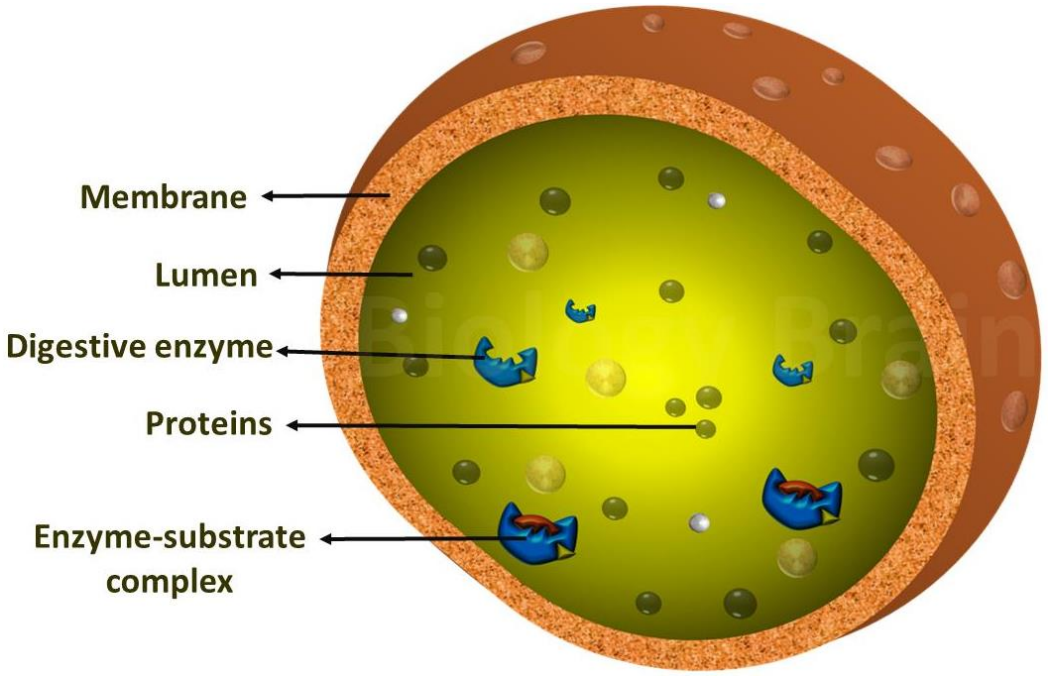
The cis side of the Golgi apparatus receives products from the ER in vesicles.

The trans side releases these product after being repackaged into new vesicles.

If the product is to be exported from the cell, the vesicle migrates to the cell surface and fuses to the cell membrane, and the cargo is secreted.

From Lumen Learning

Lysosomes

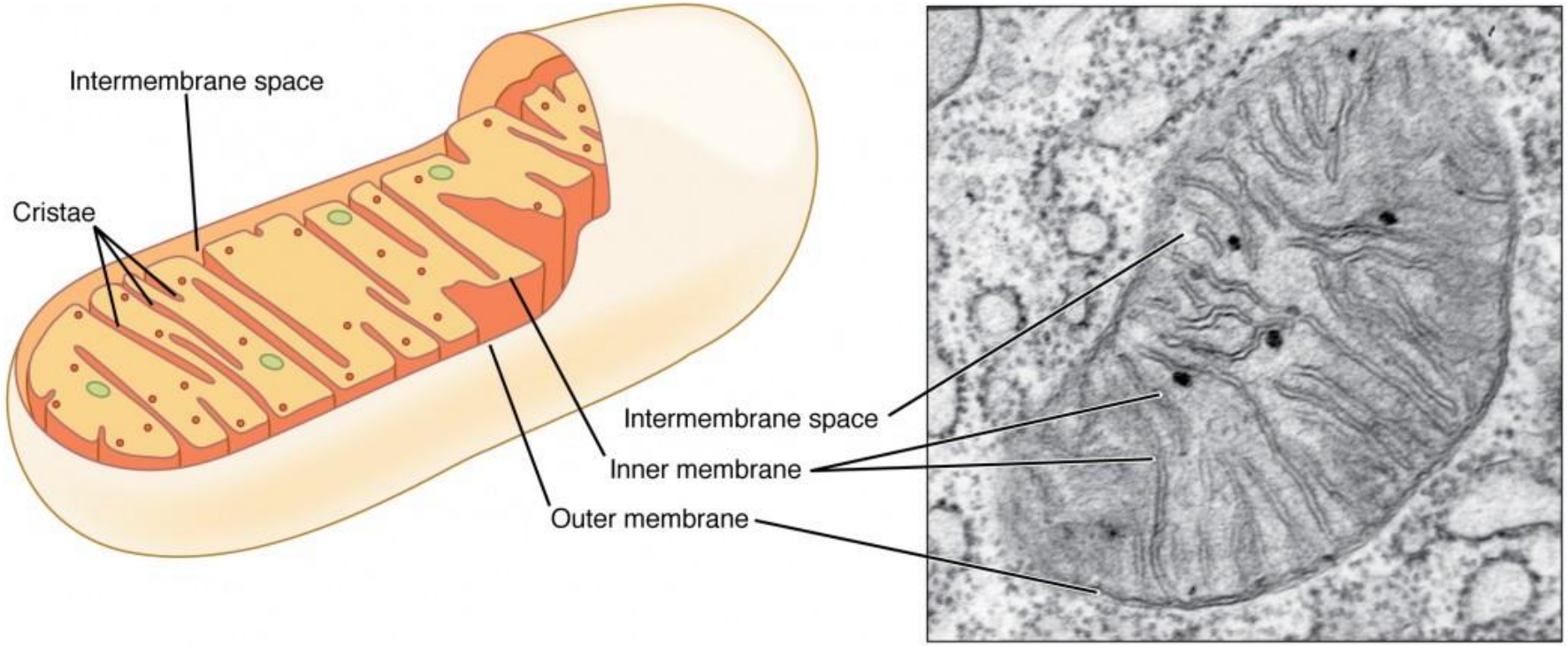


Organelle that containing digestive enzymes that break down and digest unneeded cellular components, such as a damaged organelle.

Lysosomes are also important for breaking down foreign material (when immune defense cells (white blood cells) phagocytize bacteria, the bacterial cell is transported into a lysosome and digested by the enzymes inside)

Under certain circumstances, when cells are damaged or unhealthy, lysosomes can be triggered to open up and release their digestive enzymes into the cytoplasm of the cell, killing the cell.

Mitochondrion



Mitochondria consist of an outer and an inner membrane separated by an inter membrane space. The inner membrane is highly folded into winding structures called cristae.
The inner membrane harbour enzymes complexes performing the biochemical reactions of cellular respiration. These reactions convert energy stored in nutrient molecules ATP.

Oxygen molecules are required during cellular respiration, which is why you must constantly breathe it in. The muscular system uses huge amounts of ATP to sustain muscle contraction. Muscle cells are packed full of mitochondria.

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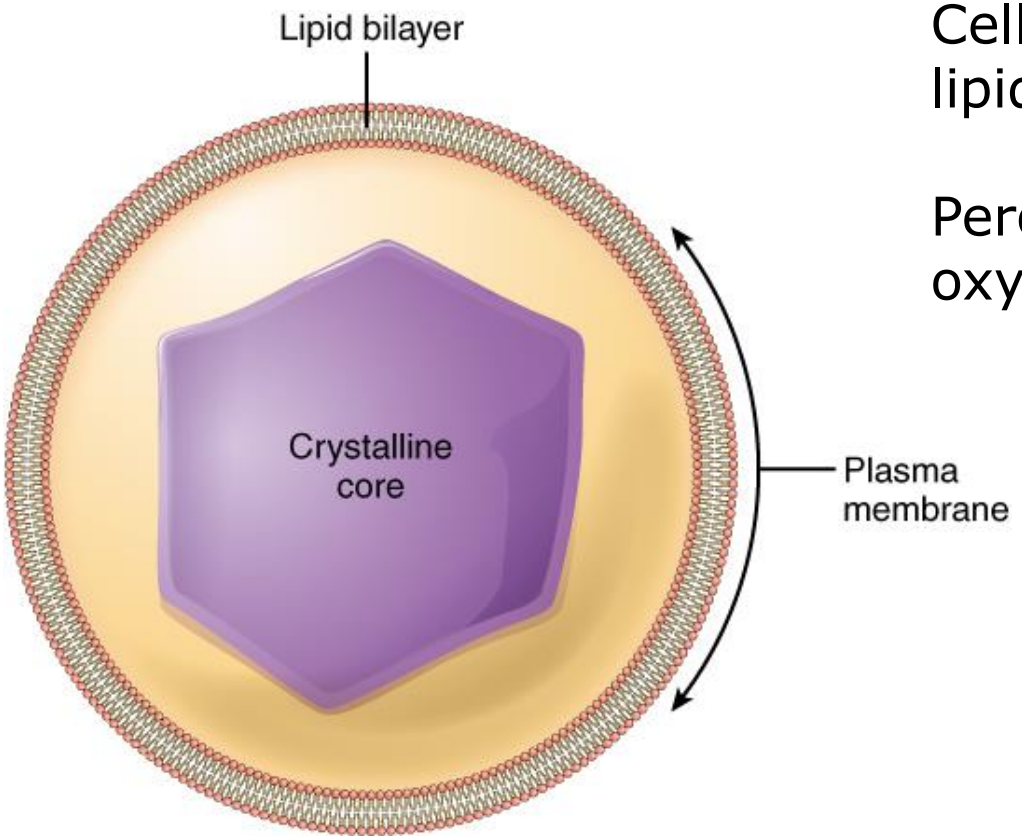
Peroxisomes



Cellular organelle mostly containing enzymes involved in lipid metabolism and chemical detoxification.

Peroxisomes are specialized in metabolism of reactive oxygen species.

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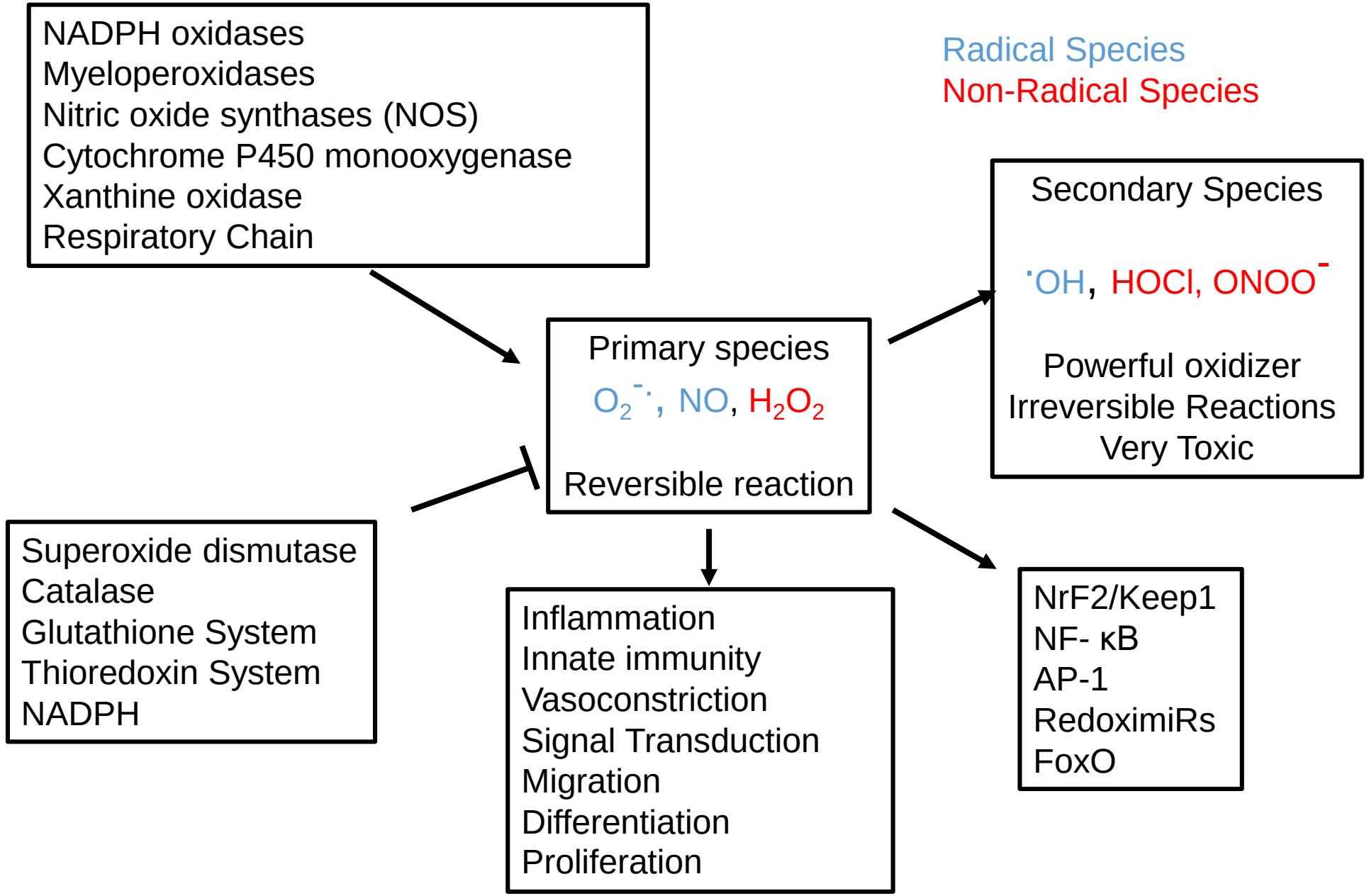
Reactive Oxygen Species (ROS)



Tissues of the Body

There are at least 200 distinct cell types in the body that vary enormously in shape and function. These cell type are organized in tissues.

Tissue is used to describe a group of cells found together in the body arranged in an orderly pattern that achieves the tissue's functions.
The cells within a tissue share a common embryonic origin.

There are four broad categories of tissues: epithelial, connective, muscle, and nervous each characterized by specific functions that contribute to the overall health and maintenance of the body.

A disruption of the structure is a sign of injury or disease.

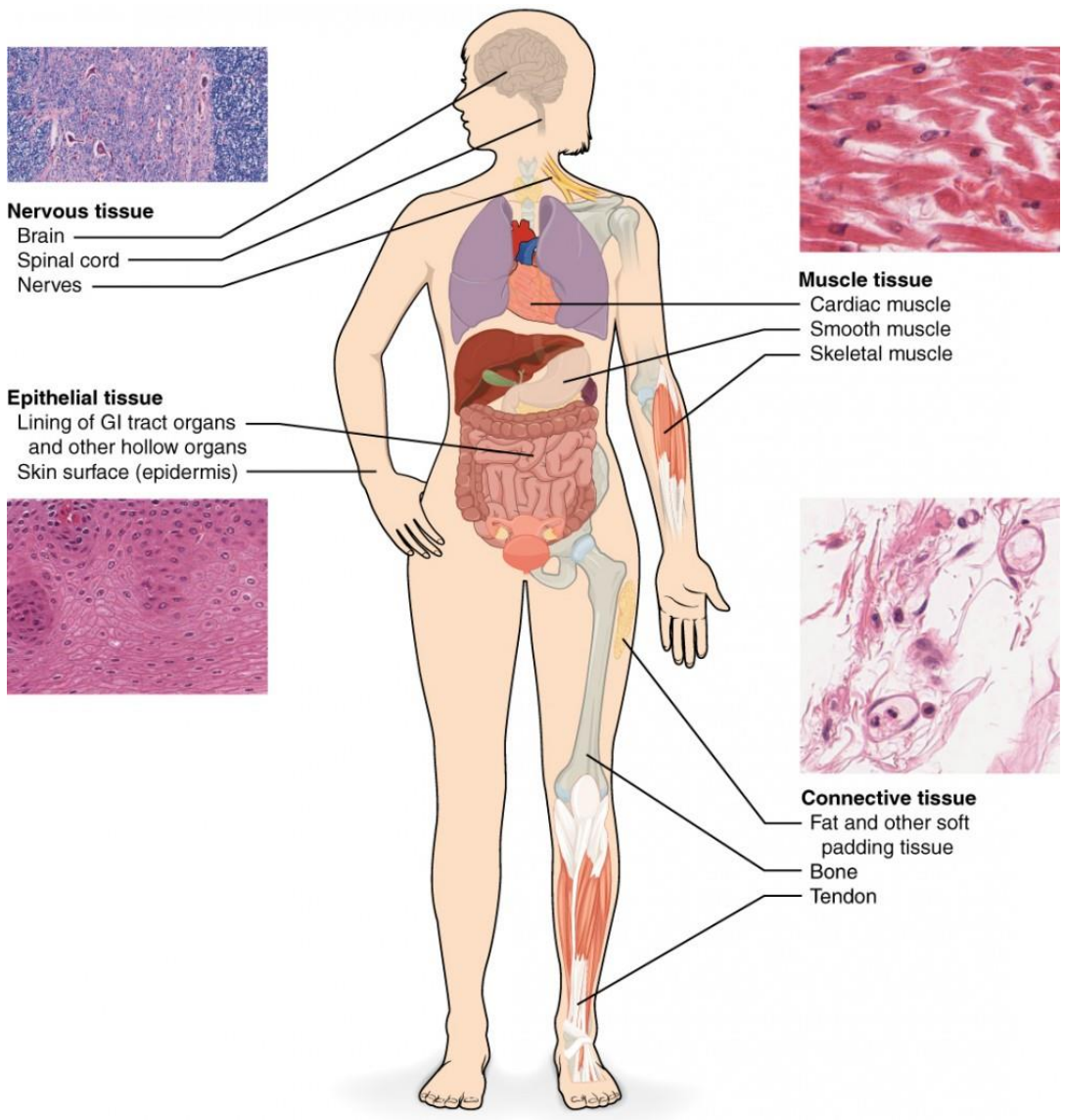
Tissues of the Body

Epithelial tissue *(*epithelium): Formed by the cells that cover exterior surfaces and lining of internal cavities, passageways and certain glands.

Connective tissue: Binds the cells and organs of the body together and functions in the protection, support, and integration of all parts of the body.

Muscle tissue: *E*xcitable cells that respond to stimulation and contracting to generate movement. Three major types: skeletal (voluntary), smooth, and cardiac muscle.

Nervous tissue: *E*xcitable, allowing the propagation of electrochemical signals as nerve impulses that communicate between different regions of the body.



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Epithelial tissue:

Highly cellular and oriented tissue, with little or no extracellular material present between cells. **Desmosomes and tight junctions** hold adjacent cells together.
The apical surface is exposed edge of epithelial tissue

The Basal surface anchor the epithelial tissue to the underlying connective tissue known as the basement membrane composed of proteins.

Epithelial tissues are nearly completely **avascular**. Nutrients arrive by diffusion or absorption from underlying tissues or the surface. Many epithelial tissues are capable of rapidly replacing damaged and dead cells.

Functions:

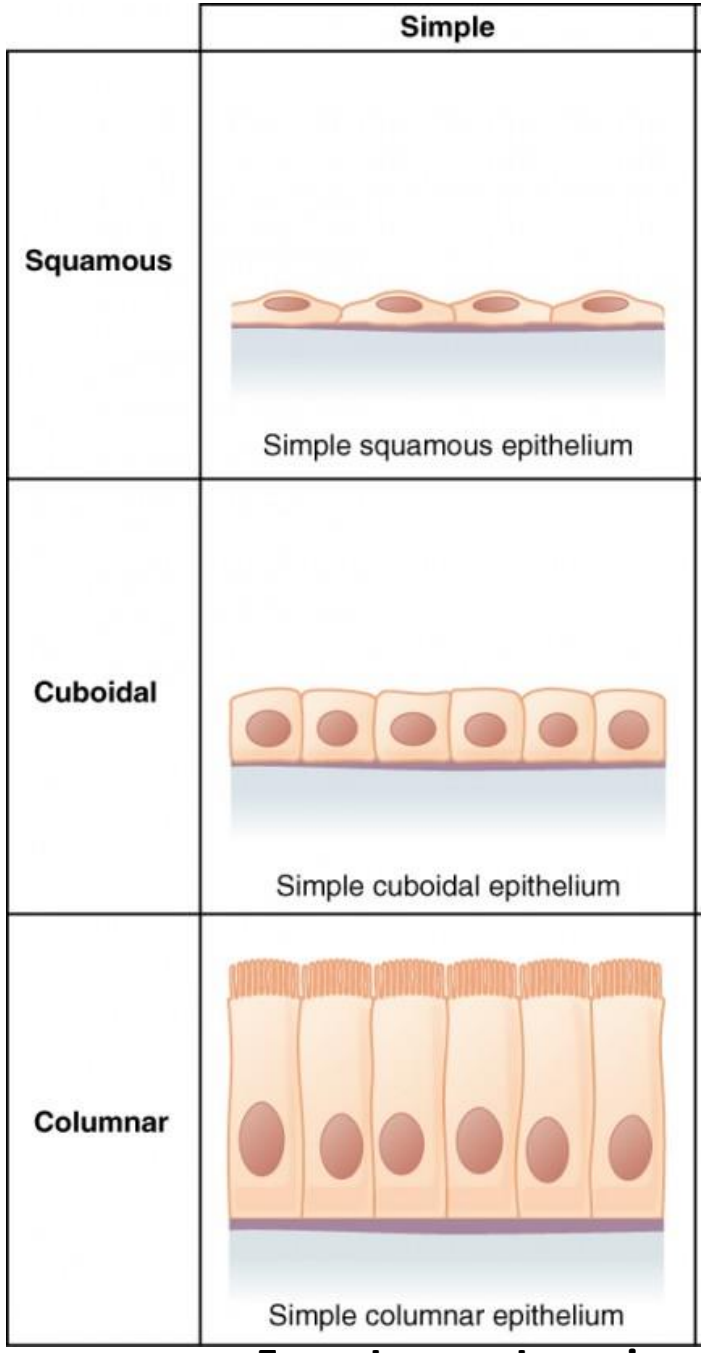
1. Provide the body's first line of protection from physical, chemical, and biological stresses. Controlling permeability and allowing selective transfer of materials across a physical barrier. All substances that enter the body must cross an epithelium.
2. Secretion and release mucous and specific chemical compounds onto their apical surfaces.
   A. The epithelium of the small intestine releases digestive enzymes.
   B. The epithelium lining the respiratory tract secrete mucous that traps incoming microorganisms and particles.
   C. Glandular epithelium contains many secretory cells.

Epithelial tissue structures

Simple squamous epithelium, where rapid passage of chemical compounds is need. The cells have the appearance of thin scales. Squamous cell nuclei are flat, horizontal, and elliptical, mirroring the form of the cell. (alveoli of lungs, segments of kidney tubules, lining of capillaries and ***mesothelium****)*.

Simple cuboidal epithelium is active in the secretion and absorptions of molecules. Box-like cells with round nucleus located near the center of the cell. (kidney tubules and in the ducts of glands).

Simple columnar epithelium is active in the absorption and secretion of molecules. Column-like cells with elongated nucleus located in the basal end of the cells. (the lining of some sections of the digestive system and parts of the female reproductive tract). Ciliated columnar epithelium in the lining of the fallopian tubes and parts of the respiratory system.



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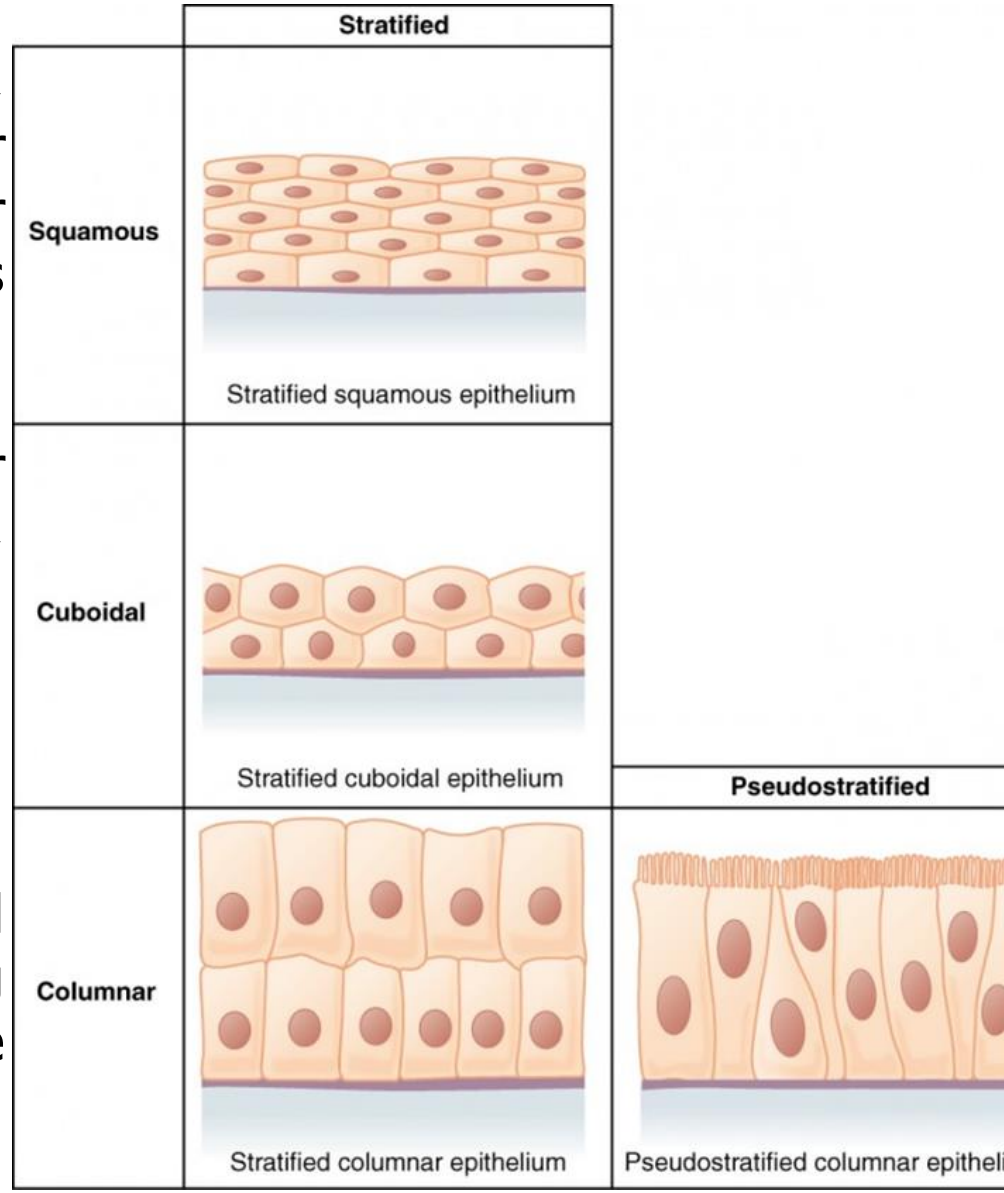
Epithelial tissue structures

Stratified squamous epithelium, the most common type, the apical cells are squamous, whereas the basal layer contains either columnar or cuboidal cells. The top layer may be covered with dead cells filled with keratin (skin is keratinized, lining of the mouth cavity unkeratinized).

Stratified cuboidal epithelium and stratified columnar epithelium can also be found in certain glands and ducts, but are uncommon in the human body.

Pseudostratified columnar epithelium appears stratified but consists of a single layer of irregularly shaped and differently sized columnar cells. Nuclei of neighboring cells appear at different levels (respiratory tract, where some of these cells have cilia).



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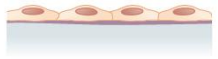
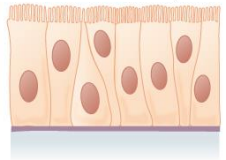
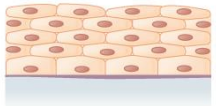
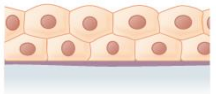
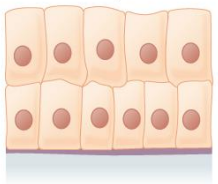
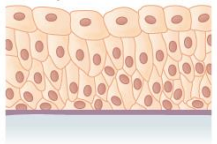
Epithelial tissue locations and functions:

Cells	Location	Function
Simple squamous epithelium 	Air sacs of lungs and the lining of the heart, blood vessels, and lymphatic vessels	Allows materials to pass through by diffusion and filtration, and secretes lubricating substance
Simple cuboidal epithelium 	In ducts and secretory portions of small glands and in kidney tubules	Secretes and absorbs
Simple columnar epithelium 	Ciliated tissues are in bronchi, uterine tubes, and uterus; smooth (nonciliated tissues) are in the digestive tract, bladder	Absorbs; it also secretes mucous and enzymes
Pseudostratified columnar epithelium 	Ciliated tissue lines the trachea and much of the upper respiratory tract	Secretes mucus; ciliated tissue moves mucus
Stratified squamous epithelium 	Lines the esophagus, mouth, and vagina	Protects against abrasion
Stratified cuboidal epithelium 	Sweat glands, salivary glands, and the mammary glands	Protective tissue
Stratified columnar epithelium 	The male urethra and the ducts of some glands	Secretes and protects
Transitional epithelium 	Lines the bladder, uretha, and the ureters	Allows the urinary organs to expand and stretch

From Lumen Learning

Connective Tissue

Connective tissues are composed of cells (mostly fibroblast), large amounts of ground substance and protein fibers. Polysaccharides and proteins secreted by fibroblasts combine with extra-cellular fluids to produce a viscous ground substance that, with embedded fibrous proteins, forms the extra-cellular matrix. Cells are very dispersed in a matrix.

Functions of Connective Tissues

- Connective tissues most importantly support and connect other tissues. Connective tissue sheath surrounds muscle cells, the tendons attach muscles to bones and to the skeleton that supports the positions of the body.

- Protection is another major function of connective tissue: Fibrous capsules and bones that protect delicate organs and, of course, the skeletal system.

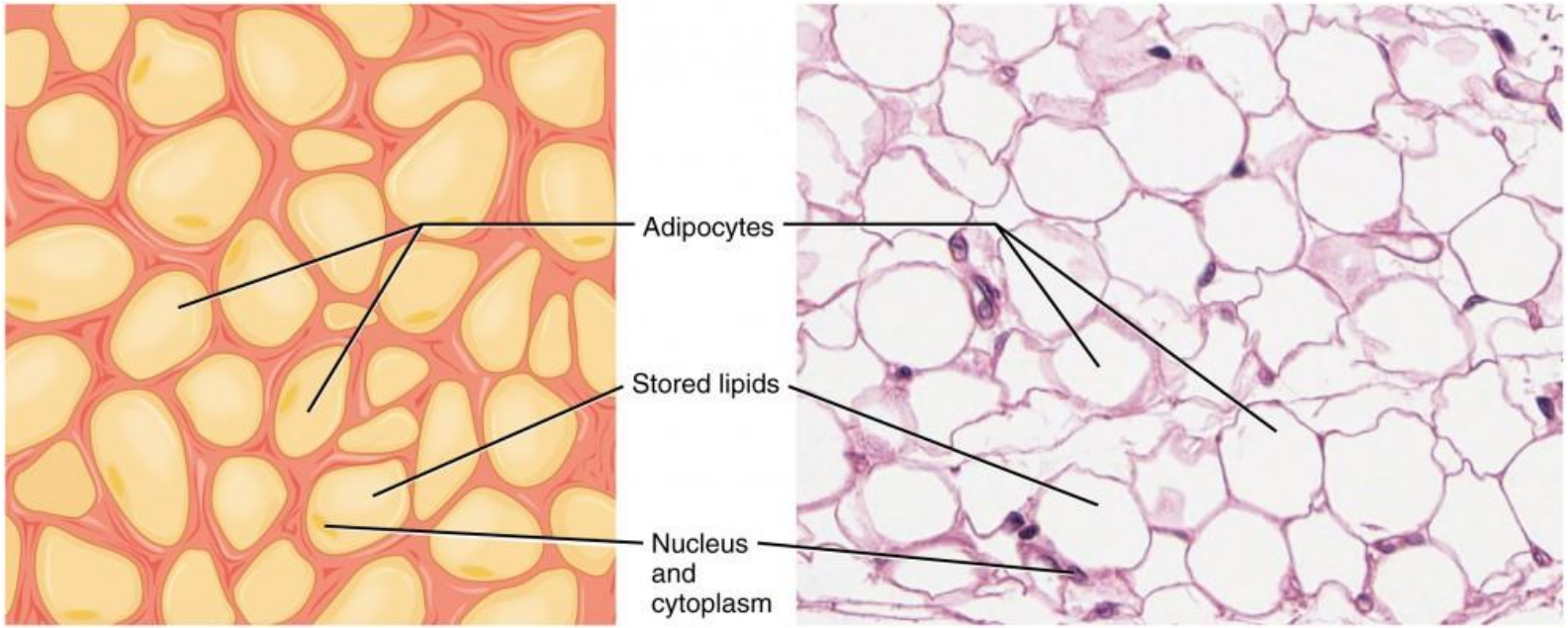
- Specialized cells in connective tissue defend the body from microorganisms that enter the body.
- Transport of fluid, nutrients, waste, and chemical messengers is ensured by specialized fluid connective tissues, such as blood and lymph.

- Adipose cells store surplus energy and contribute to the thermal insulation of the body.

Loose Connective Tissue

Loose connective tissue is found between many organs where it acts both to absorb shock and bind tissues together. It allows water, salts, and various nutrients to diffuse through to adjacent or imbedded cells and tissues.

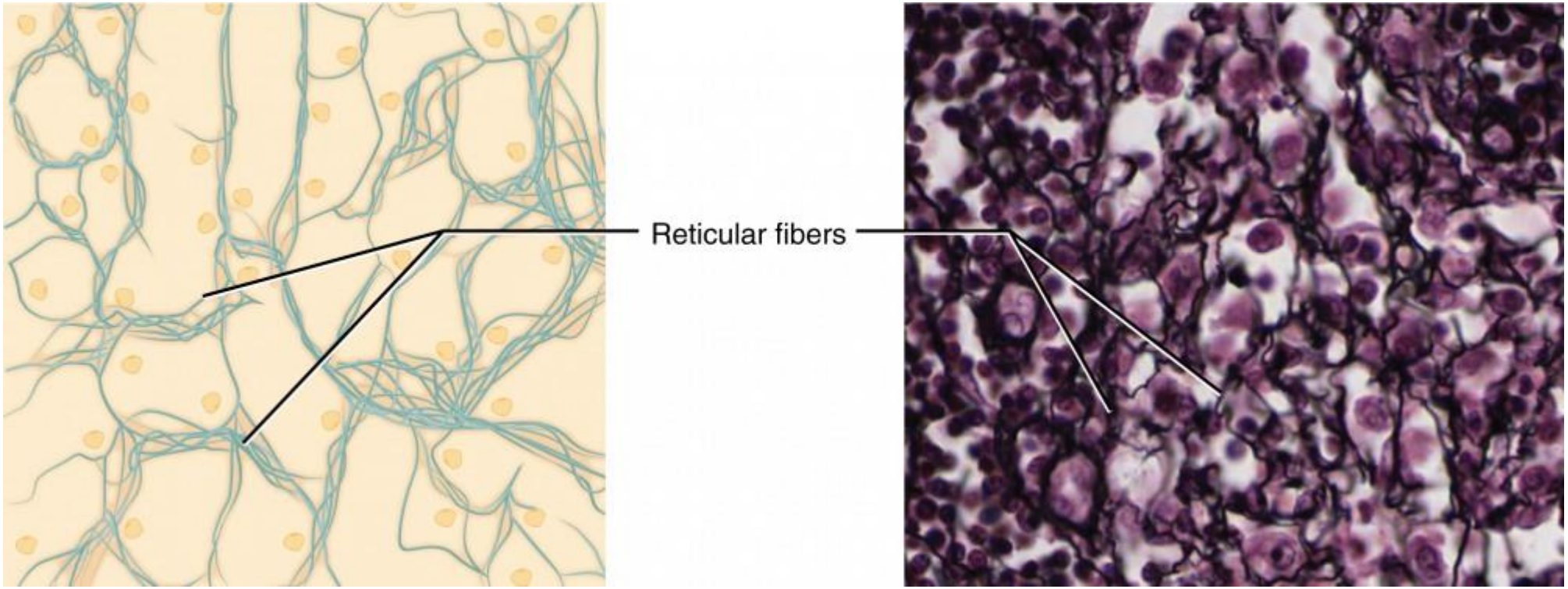
Adipose tissue: *F*at storage cells called **a*dipocytes*** that store lipids as droplets that fill most of the cytoplasm. Highly vascularized to allow rapid storage and mobilization of lipid molecules. Fat contributes mostly to lipid storage and insulation from cold temperatures and mechanical injuries (protection of the kidneys and eye).



From Lumen Learning

Loose Connective Tissue

Reticular tissue: *A* mesh-like, supportive framework for soft organs such as lymphatic tissue, the spleen, and the liver. Reticular cells produce the reticular fibers that form the network onto which other cells attach.



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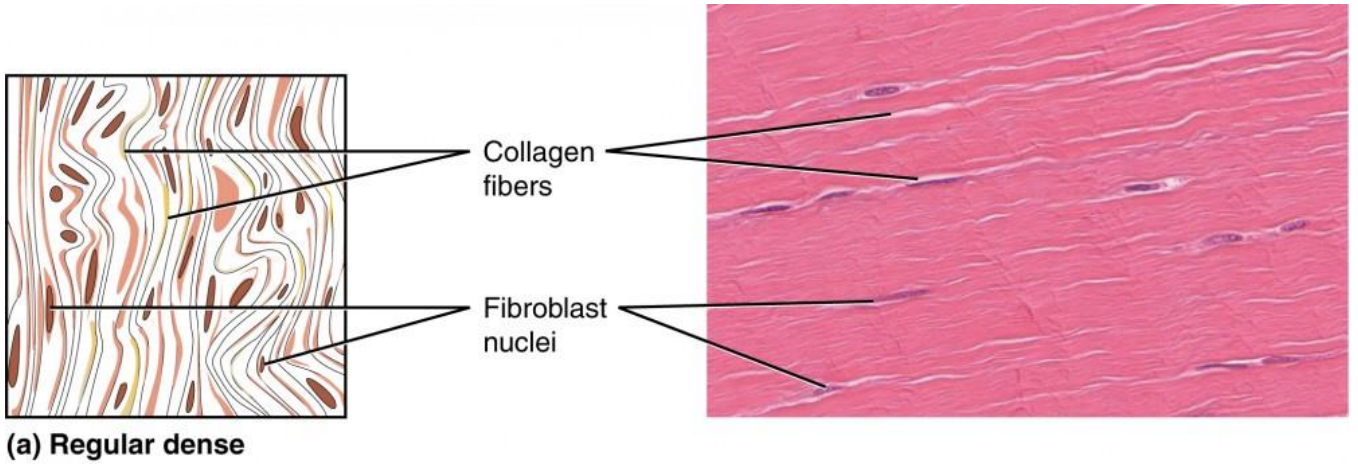
Dense Connective Tissue

Dense connective tissue contains more collagen fibers than does loose connective tissue. There are three major categories of dense connective tissue:



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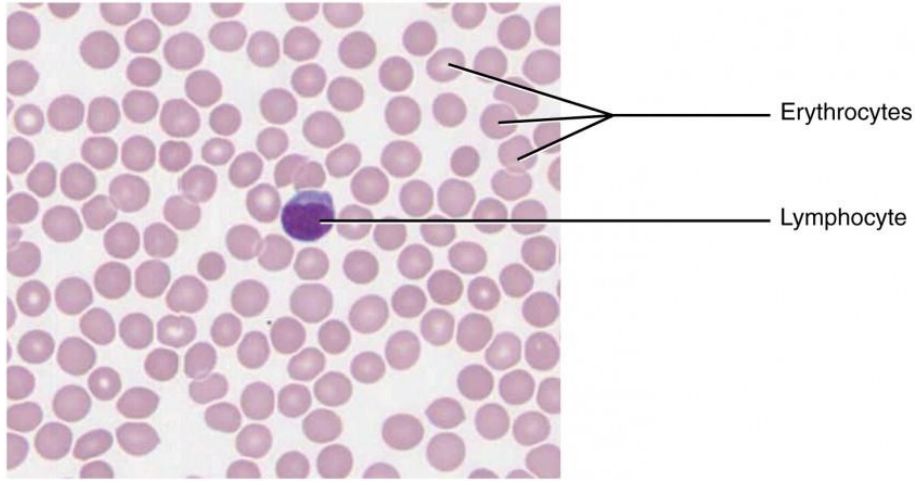
Fluid connective tissues

Blood has two components: cells and fluid matrix (plasma).

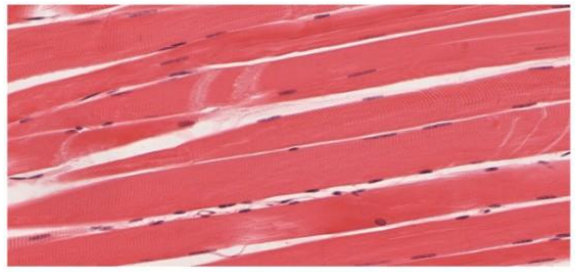
1. Erythrocytes, red blood cells, transport oxygen and some carbon dioxide.
2. Leukocytes, white blood cells, are responsible for defending against potentially harmful microorganisms or molecules.
3. Platelets are cell fragments involved in blood clotting.
4. Plasma: liquid matrix containing nutrients, salts, and wastes transported through the body.

Lymph contains a liquid matrix and white blood cells. Lymphatic capillaries are extremely permeable, allowing larger molecules and excess fluid from interstitial spaces to enter the lymphatic vessels. Lymph drains into blood vessels delivering molecules to the blood that could not otherwise directly enter the bloodstream.



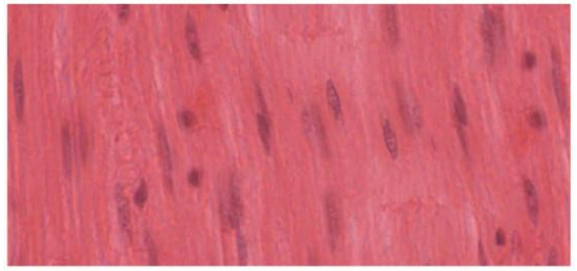
Muscle Tissue

Muscle tissue is made of excitable cells which respond to a stimulus by contraction to generate a pulling force. Contractions of the muscles cause the bones to move.
Some muscle movements are voluntary (under conscious control) while other movements are involuntary (not under conscious control). Three types according to structure and function: skeletal, cardiac, and smooth.



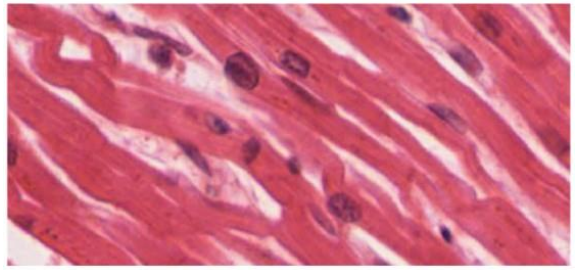
(a)

Skeletal muscle is attached to bones to makes possible locomotion. Involved in voluntary movements of the body. Represent 40% body mass. Can generate heat thus participate in thermal homeostasis. Skeletal muscle tissue is arranged in bundles surrounded by connective tissue, appear striated with many nuclei squeezed along the membranes.



(b)

Cardiac muscle forms the contractile walls of the heart. The cardiomyocytes, also appear striated under the microscope. Unlike skeletal muscle fibers, cardiomyocytes are single cells typically with a single centrally located nucleus. Contract intrinsically without any external stimulation.



Smooth muscle tissue contraction is responsible for involuntary movements in the internal organs. It forms the contractile component of the digestive, urinary, and reproductive systems as well as the airways and arteries. Each cell is spindle shaped with a single nucleus and no visible striations.

Nervous Tissue

Nervous tissue is excitable and capable of sending and receiving electrochemical signals to send information to the body.
Two main classes of cells make up nervous tissue: the ***neuron*** and ***neuroglia***.

1. Neurons propagate information via electrochemical action potentials, display distinctive morphology, a cell body includes most of the cytoplasm, the organelles, and the nucleus, dendrites branch off the cell body and appear as thin extensions and the long axon "tail" conducts impulses away from the cell body.

2. Neuroglia play an essential role in supporting neurons and modulating their information propagation.