

Chapter 1, Introduction to Human Anatomy/physiology

Textbook Chapter: _____

ANATOMY:

ANATOMY is the study of the **STRUCTURES** and the relationships among structures.

PHYSIOLOGY:

PHYSIOLOGY is the study of the **FUNCTIONS** of those structures.

A. SUBDIVISIONS OF ANATOMY:

1. **GROSS ANATOMY:** A type of anatomy that can be undertaken WITHOUT a MICROSCOPE.
2. **MICROSCOPIC ANATOMY:** Requires the use of a MICROSCOPE (e.g. LIGHT or PHASE microscope)
 - * **ULTRAMICROSCOPIC ANATOMY:** requires the use of T.E.M. (TRANSMISSION ELECTRON MICROSCOPY) or S.E.M. (SCANNING ELECTRON MICROSCOPY)
3. **REGIONAL ANATOMY:** Studies specific REGIONS of the body. e.g. HEAD and NECK
4. **SYSTEMIC ANATOMY:** Study of specific SYSTEM. e.g. DIGESTIVE and REPRODUCTIVE SYSTEMS.
5. **RADIOGRAPHIC ANATOMY:** Study of the structure of the body using X -RAYS.
6. **CYTOLOGY:** Microscopic study of the CELLS.
7. **HISTOLOGY:** Microscopic study of the TISSUES; also known as microscopic anatomy.
8. **EMBRYOLOGICAL ANATOMY:** Study of PRENATAL DEVELOPMENT.
9. **NON-INVASIVE IMAGING TECHNIQUES:** MRI, CAT SCAN, PETSCAN, etc.
10. **PATHOLOGICAL ANATOMY:** Study of STRUCTURAL CHANGE associated with DISEASE.

B. SUBDIVISIONS OF PHYSIOLOGY:

1. **SYSTEMIC PHYSIOLOGY:** Study of the FUNCTION of the SYSTEMS. e.g. RESPIRATORY SYSTEM, REPRODUCTIVE SYSTEM, CARDIOVASCULAR SYSTEM.
2. **CELL PHYSIOLOGY:** Study FUNCTION of the CELL.
3. **NEUROPHYSIOLOGY:** Study the FUNCTION of NERVE CELLS.

4. **ENDOCRINOLOGY**: Study of HORMONES and how they control BODY FUNCTIONS.
 5. **IMMUNOLOGY**: Study of the BODY DEFENSE MECHANISMS.
- C. **HOMEOSTASIS**: HOMEOSTASIS is an inner STABILITY of the body, even if the ENVIRONMENT OUTSIDE the BODY CHANGES.
1. It is achieved when STRUCTURES and FUNCTIONS are properly COORDINATED.
 2. The entire regulation process of HOMEOSTASIS is made possible by the COORDINATED ACTION of many ORGANS and TISSUES under the control of the NERVOUS and ENDOCRINE SYSTEMS.
 3. NOTE THAT when HOMEOSTASIS breaks down, we become SICK or DIE.
 4. **STRESS**:
 - a. One way to disrupt HOMEOSTASIS is to introduce STRESS.
 - b. **STRESS** is the overall disruption that forces the body to make ADAPTIVE CHANGES.
 - c. **Factors causing stress are called STRESSORS.**
e.g. HEAT, COLD, VIRUSES, MENTAL DISTURBANCES, HORMONES.
 5. **FEEDBACK SYSTEM**: is a response to the INITIATING STIMULUS It can be POSITIVE OR NEGATIVE.
 - a. **NEGATIVE FEEDBACK**: When the response is OPPOSITE to the initiating stimulus. e.g. Increased production of HEAT by the body to oppose the effect of COLD weather.
 - b. **POSITIVE FEEDBACK**: When the response REINFORCES the initial stimulus. e.g. When blood glucose level DECREASES, the response of positive feedback is to DECREASE it further.

* POSITIVE FEEDBACK LEADS TO DEATH, EXCEPT IN CASES SUCH AS CHILD DELIVERY and a few other examples.
- D. **ORGANIZATIONAL LEVELS OF THE BODY**:
1. **ATOMS**: Basic UNITS of all MATTER.
 2. **ELEMENTS**: Each kind of ATOM. e.g. OXYGEN, HYDROGEN, NITROGEN, SULFUR, CARBON.
 3. **MOLECULE**: Combination of TWO or MORE ATOMS. e.g. O₂.

A COMPOUND IS A MOLECULE containing atoms of MORE THAN ONE ELEMENT: e.g. H ₂ O, CO ₂ , PROTEIN, LIPID, CARBOHYDRATE.

4. **CELLS**: Smallest INDEPENDENT UNITS of LIFE.
5. **TISSUES**: Group of SIMILAR CELLS that perform a SPECIFIC FUNCTION. **THERE ARE FOUR TYPES OF TISSUES**:
 - a. **EPITHELIAL TISSUE**: Found in SKIN and LINING of ORGANS FUNCTION: PROTECTION, SECRETION, EXCRETION, ABSORPTION.
 - b. **CONNECTIVE TISSUE**: found in many ORGANS. e.g. SKIN, BLOOD VESSELS FUNCTION: SUPPORT, REPAIR. (EX.) TENDONS, LIGAMENTS, FAT, CARTILAGE, BLOOD, BONE
 - c. **MUSCLE TISSUE**:
 - 1.) **SKELETAL MUSCLE**--in the LIMBS, FACE, ABDOMEN, ETC.; (VOLUNTARY)
 - 2.) **SMOOTH MUSCLE**-- in the DIGESTIVE SYSTEM, BLOOD VESSEL, UTERUS, ETC.

* IT IS INVOLUNTARY
 - 3.) **CARDIAC MUSCLE**--in the HEART.

* IT IS INVOLUNTARY
 - d. **NERVE TISSUE**
 - 1.) Found in the BRAIN, SPINAL CORD, and NERVES.
 - 2.) **FUNCTION**: responds to various STIMULI and transports NERVE IMPULSES from one area of the body to another.
6. **ORGAN**: Group of TWO or MORE KINDS of TISSUE bound together to form a structure. (e.g. STOMACH, LIVER, SKIN.)
7. **SYSTEM**: A group of ORGANS with their tissues that work TOGETHER to perform a MAJOR FUNCTION.
 - a. **INTEGUMENTARY SYSTEM**: Made of SKIN, NAILS, HAIR, SWEAT GLANDS and OIL GLANDS. Function: PROTECTION, REGULATE BODY TEMPERATURE CONTAINS SENSORY RECEPTORS.
 - b. **SKELETAL SYSTEM**: Made of BONE and CARTILAGE. Function: SUPPORT BODY, PROTECT ORGANS, MANUFACTURE RED BLOOD CELLS, PROVIDE LEVEL MECHANISM FOR MOVEMENT.
 - c. **MUSCULAR SYSTEM** (SKELETAL--SMOOTH--CARDIAC). Function: BODY MOVEMENT PRODUCE BODY HEAT.
 - d. **NERVOUS SYSTEM**: Made of BRAIN--SPINAL CORD--

PERIPHERAL NERVES--SENSORY ORGANS. Function: REGULATES BODY ACTIVITIES, INITIATES ACTION OF MUSCLES.

- e. **ENDOCRINE SYSTEM**: Made of DUCTLESS GLANDS. Function: SECRETE HORMONES.
 - f. **CARDIOVASCULAR SYSTEM**: Made of HEART, BLOOD, BLOOD VESSELS. Function: PUMPS BLOOD THROUGH VESSELS, TRANSPORT OF GASES.
 - g. **RESPIRATORY SYSTEM**: Made up AIRWAYS and LUNGS. Function: BREATHING EXCHANGE OF GASES BETWEEN AIR and BLOOD.
 - h. **DIGESTIVE SYSTEM**: Made up of organs from MOUTH to ANUS and ACCESSORY STRUCTURES (LIVER, PANCREAS, ETC) Function: BREAK DOWN FOOD, REMOVE SOLID WASTE.
 - i. **URINARY SYSTEM**: Made of KIDNEYS, URETERS, BLADDER, URETHRA. Function: ELIMINATE METABOLIC WASTES, REGULATE BLOOD PRESSURE, REGULATE WATER-SALT BALANCE.
 - j. **REPRODUCTIVE SYSTEM**: Made of OVARIES, TESTES, GERM CELLS, ACCESSORY GLANDS and DUCTS. FUNCTION: REPRODUCTION.
 - k. **LYMPHATIC SYSTEM**: Made of LYMPH NODES, LYMPHATIC BLOOD VESSELS, TONSILS. Function IMMUNE SYSTEM DEFENSE, FAT TRANSPORT
 - l. **IMMUNE SYSTEM**: Made of LYMPHOCYTES (T AND B). FUNCTION: DEFENSE
8. **Organism** - the complete human (the animal); the highest level of organization

E. ANATOMICAL POSITION:

In the ANATOMICAL POSITION, the BODY is STANDING ERECT and FACING FORWARD, the FEET ARE TOGETHER, and the ARMS ARE HANGING at the SIDES WITH THE PALMS FACING FORWARD.

F. PLANES: IMAGINARY FLAT SURFACES.

- 1. **MIDSAGITTAL OR MEDIAN PLANE**: Divides the body SYMMETRICALLY into LEFT and RIGHT halves.
- 2. **PARASAGITTAL OR SAGITTAL PLANE**: Divides the body ASYMMETRICALLY into LEFT and RIGHT PARTS. Can be any number of these.
- 3. **FRONTAL OR CORONAL PLANE**: Divides the body ASYMMETRICALLY into ANTERIOR and POSTERIOR SECTIONS.
- 4. **TRANSVERSE OR HORIZONTAL PLANE**: Divides the body HORIZONTALLY into SUPERIOR and INFERIOR SECTIONS.

G. DIRECTIONAL TERMS:

1.	CRANIAL OR CEPHALIC (toward the head)	CAUDAL (toward the tail)
2.	SUPERIOR (above; to move <u>up</u> on a human)	INFERIOR (below; to move <u>down</u> on a human)
3.	ANTERIOR = VENTRAL (toward the front)	POSTERIOR = DORSAL (toward the back)
4.	MEDIAL (toward the midline)	LATERAL (away from the midline)
5.	PROXIMAL (nearer to the trunk)	DISTAL (farther from the trunk)
6.	SUPERFICIAL = EXTERNAL (near the surface)	DEEP = INTERNAL (farther from surface)
7.	PLANTER (sole of foot)	DORSAL OF FOOT (upper surface of foot)
8.	PALMAR (palm of hand)	DORSAL OF HAND (back of the hand)
9.	PARIETAL (related to body walls)	VISCERAL (related to anterior organs)
10.	SUPINE (to recline on one's back)	PRONE (to recline on one's front; e.g. - to lie down on one's stomach)
11.	OBLIQUE (at an angle)	

H. MAIN REGIONS OF THE BODY:

1. **AXIAL PART:** HEAD, NECK, THORAX, ABDOMEN, PELVIS.
2. **APPENDICULAR PART:** UPPER LIMBS, LOWER LIMBS.

I. BODY CAVITIES:

The BODY CAVITIES house and protect the internal organs.
The TWO MAIN BODY CAVITIES are: **VENTRAL AND DORSAL.**

1. **THE VENTRAL (ANTERIOR) BODY CAVITY** is located in the front aspect of the body and divided into:

a. **THORACIC CAVITY**: = UPPER CAVITY. It is composed of:

- 1.) **PERICARDIAL CAVITY**: Contains the **HEART**. It is lined by the PERICARDIUM (= SEROUS MEMBRANE).
- 2.) **PLEURAL CAVITIES** (2): Contains the **LUNGS**. It is lined by the PLEURA (= SEROUS MEMBRANE).
- 3.) **The MEDIASTINUM**: Region or space between the lungs, the thoracic inlet, and the diaphragm. It contains the **esophagus, trachea, primary bronchi, thymus gland, heart (pericardial cavity), large blood vessels and lymphatic vessels**.

b. **ABDOMINOPELVIC CAVITY** = LOWER VENTRAL CAVITY. It is lined by a serous membrane called the **PERITONEUM**. It is subdivided into two portions:

- 1.) **The Abdominal Cavity**: It is separated from the thoracic cavity by the diaphragm muscle. It contains stomach, spleen, liver, gallbladder, pancreas, most of the small intestine, most of the large intestine, kidneys, adrenal glands, ureters, and many major blood vessels.
- 2.) **The Pelvic Cavity**: Contains urinary bladder, the remainder of the small and large intestines, remainder of the ureters, vermiform appendix, and internal portions of the reproductive organs of the male () and female (); **male reproductive organs** (seminal vesicles, prostate) and **female reproductive organs** (ovaries, fallopian tubes, uterus, cervix, upper vagina).

* **NOTE**: The abdominopelvic cavity can be subdivided either into 4 quadrants or into 9 regions.

a.) **Quadrants**: used by clinicians or surgeons.

- (1.) right upper quadrant
- (2.) left upper quadrant
- (3.) right lower quadrant
- (4.) left lower quadrant

b.) **Regions**: used by anatomists:

- (1.) right hypochondriac region
- (2.) epigastric region -
- (3.) left hypochondriac region

- (4.) right lumbar region
- (5.) umbilical region -
- (6.) left lumbar region
- (7.) right iliac region -
- (8.) hypogastric region
- (9.) left iliac region

2. **THE DORSAL (POSTERIOR) BODY CAVITY**: is located near the back of the body. It is divided into TWO CAVITIES:
- a. **CRANIAL CAVITY**: Formed by the CRANIAL BONES; it houses the BRAIN.
 - b. **VERTEBRAL (SPINAL) CAVITY**: Formed by VERTEBRAE of the backbone, it contains SPINAL CORD, and ROOTS of SPINAL NERVES.

J. Practice on Body Regions

<u>(Medical/Anatomical Region)</u>	<u>(Reference Area)</u>
1. AXILLARY (AXILLA)	1. ARMPIT
2. BUCCAL	2.
3. CARPAL	3.
4. CELIAC	4.
5. CERVICAL	5.
6. COSTAL	6.
7. GLUTEAL	7.
8. LOIN	8.
9. PALMAR (METACARPAL)	9.
10. PECTORAL	10.
11. PEDAL (PDIS)	11.
12. PERINEAL	12.
13. PLANTAR	13.
14. POPLITEAL	14.
15. CEPHALIC (CRANIAL) (CAPUT)	15.
16. BRACHIAL	16.

17.	ANTECUBITAL	17.
18.	ANTEBRACHIAL	18.
19.	CRURAL	19.
20.	TARSAL	20.
21.	INGUINAL	21.
22.	COXAL	22.
23.	UMBILICAL	23.
24.	MENTAL	24.
25.	ACROMIAL	25.
26.	SURAL	26.
27.	CALCANEAL	27.
28.	CAUDAL	28
29.	PERITONEUM	29.

K. SOME PROPERTIES (CHARACTERISTICS) OF LIVING FORMS (OR LIVING CELLS):

1. **METABOLISM**: Sum of all CHEMICAL PROCESSES that keep our bodies alive and healthy. It is **divided into** 2 phases (parts):

a. **CATABOLISM**: Phase of metabolism that provides energy by BREAKING DOWN COMPLEX MOLECULES into SIMPLE MOLECULES. (e.g.) PROTEINS → AMINO ACIDS.

b. **ANABOLISM**: Phase of metabolism that uses the energy from CATABOLISM to build up the BODY'S STRUCTURAL and FUNCTIONAL COMPONENTS. It is also called BIOSYNTHESIS. (e.g.) AMINO ACIDS → PROTEINS.

2. **RESPONSIVENESS**: Response to CHANGES.

3. **MOVEMENT**: Motion of BODY, ORGANS, or CELLS.

4. **GROWTH**: Increase in SIZE and COMPLEXITY

5. **DIFFERENTIATION**: SPECIALIZATION of the CELLS.

6. **REPRODUCTION**: FORMATION of new CELLS; or FORMATION of new INDIVIDUAL.

7. **ADAPTATION**:

Chapter 2, Chemistry

Textbook Chapter: _____

I. Definitions:

- A. **Chemistry:** the study of the composition of matter
- B. **Matter:** anything that takes up space and has mass. Matter consists of chemical elements in pure form and in combinations called compounds.
 - 1. Exists in three states
 - a. Solid
 - b. Liquid
 - c. Gas
- C. **Mass:** a measure of the amount of matter an object contains
- D. **Weight:** a measure of the pull of gravity on a mass

II. Chemical elements

- A. **Element:** a substance that cannot be broken down into other substances by chemical means
 - 1. There are 92 naturally occurring elements.
 - 2. 25 of these are essential for life.
 - 3. 4 elements make up 96% of living matter.
 - a. Carbon (C)
 - b. Oxygen (O)
 - c. Hydrogen (H)
 - d. Nitrogen (N)
 - 4. Remaining 4% of living matter is composed of: potassium (K), sulfur (S), sodium (Na), chlorine (Cl), magnesium (Mg) and trace elements.

III. **Energy:** the ability to do work

A. **Categories of energy:**

1. **Potential Energy:** the energy stored in matter because of its position
 - a. Chemical energy: energy stored in the chemical bonds of molecules
 - b. Electrical energy: energy of charged particle stored in a particular location, for example a battery
2. **Kinetic energy:** the energy of motion
 - a. Heat: energy of molecular motion
 - b. Electromagnetic energy: energy of moving photons, for example light
 - c. Electrical energy: energy of charged particles moving and creating an electrical current

B. **First law of thermodynamics:** Energy can be neither created nor destroyed, but it can be converted from one form to another.

C. **Second law of thermodynamics:** As energy forms convert from one form to another, the universe increases in disorder.

IV. Atoms and Molecules

A. **Atom:** smallest possible unit of matter that retains the physical and chemical properties of that element.

B. The structure of atoms determine their chemical behavior

1. Subatomic particles:
 - a. Neutrons (no charge)
 - b. Protons (+1 charge)
 - c. Electrons (-1 charge)
2. **Atomic number:** the number of protons an element contains (this is

equal to the number of electrons in a neutral atom)

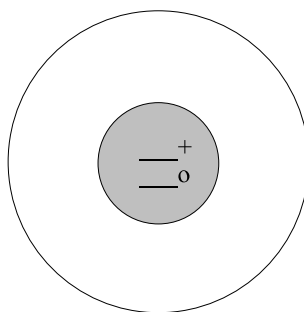
3. **Mass number:** the sum of the number of protons and the number of neutrons in an atom
4. **Atomic weight:** the average of the mass numbers of an elements isotopes
5. Energy levels of electrons:
 - a. Electrons have potential energy due to their position relative to the nucleus of the atom.
 - b. Energy levels are also called electron shells or orbitals.
 - c. First electron shell:
 - (1) closest to the nucleus
 - (2) can hold a maximum of 2 electrons
 - d. Second electron shell:
 - (1) further from the nucleus than the first electron shell
 - (2) can hold a maximum of 8 electrons
 - e. Third electron shell:
 - (1) further from the nucleus than the second electron shell
 - (2) can hold a maximum of 8 electrons
 - f. Remaining electron shells have similar characteristics. The electron shells become more complex.
6. The chemical behavior of atoms is determined by the configuration of its electrons.
 - a. Electrons are arranged in the electron shells in a specific order.

The atomic number tells the number of protons in an atom's nucleus, which is equal to the number of electrons in the

electron shells.

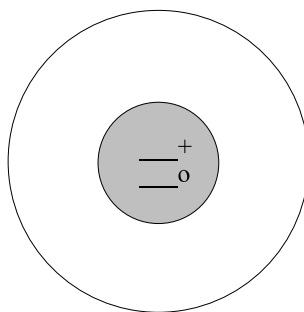
- b. Electrons fill the first energy level first. For example, hydrogen has 1 electron (The atomic number of Hydrogen is 1).

(1) Draw a Hydrogen atom:



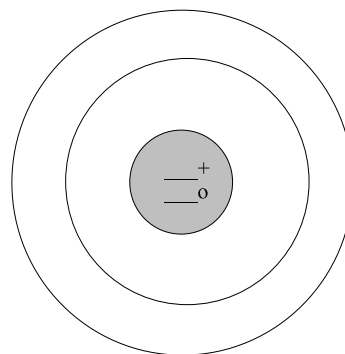
Hydrogen: ${}^1\text{H}$

(2) Draw a Helium atom:



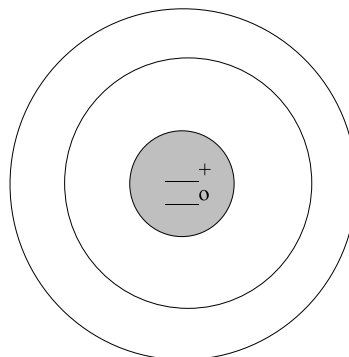
Helium: ${}^2\text{He}$

(3) Draw a Lithium atom:



Lithium: ${}^3\text{Li}$

(4) Draw a carbon atom:



Carbon: ${}^6\text{C}$

- c. **Valence electrons:** electrons in the outermost electron shell, called the valence shell.

(1) How many valence electrons are in:

- (a) Hydrogen _____
- (b) Helium _____
- (c) Lithium _____
- (d) Carbon _____
- (e) Oxygen _____
- (f) Chlorine _____
- (g) Sodium _____

(2) Chemical bonds form between atoms involve the valence electrons.

C. **Isotope:** atoms of an element the have the same number of protons, but different numbers of neutrons

1. **Radioactive isotopes:** isotopes that are 'decaying' to a more stable configuration. As they decay they emit radiation. Some radioactive isotopes have medical uses.

a. Iodine-131 is used to detect the size and activity of the thyroid gland.

b. Radium-226 is used for radiation therapy for some cancers

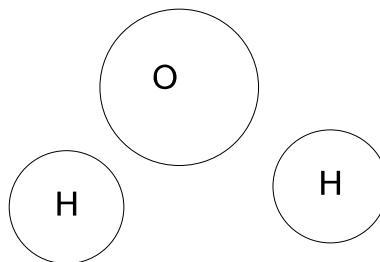
2. **Half life:** the amount of time for half of the radioactive isotope te decay and disappear

D. **Molecules:** two or more atoms chemically combined (forming bonds)

V. **Chemical Bonds:** attractions between atoms that hold molecules together

A. Covalent bond: chemical bond formed by atoms sharing a pair of electrons

1. **Nonpolar covalent bond:** covalent bond formed when atoms share an electron pair equally
2. **Polar covalent bond:** covalent bond form by unequal sharing of a pair of electrons. Example: water

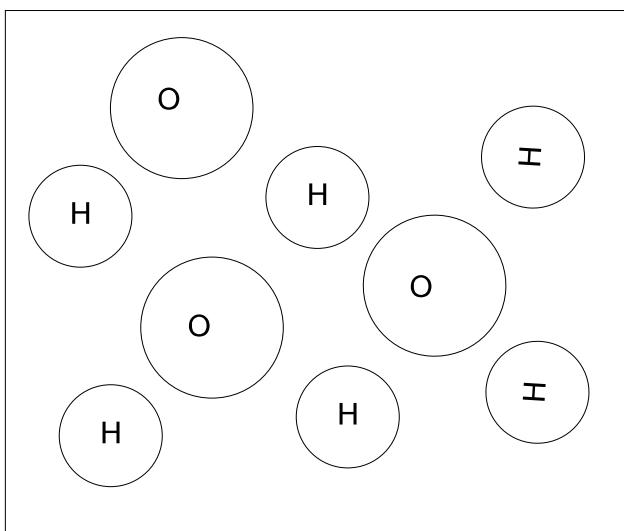


B. **Ions:** a charged atom or molecule

1. **Anion:** an atom that has gained one or more electrons from another atom and has become negatively charged. Example: Cl^-
2. **Cation:** an atom that has lost one or more electrons and has become positively charged. Example: Na^+

C. **Ionic bond:** bond formed by the attraction between an atom with a positive electrical charge (cation) and an atom of a negative electrical charge (anion).

D. **Hydrogen bond:** bond formed when a covalently bonded hydrogen acquires a slight positive charge and becomes attracted to negatively charged atoms nearby. Draw the hydrogen bonds in water:



E. A molecule's biological function is closely related to its shape.

VI. **Chemical reactions:** process of making and/or breaking chemical bonds. This leads to changes in the composition of matter.

A. Examples:

1. Reactants--->Products

2. $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$

2 hydrogen molecules + 1 oxygen molecule \rightarrow 2 water molecules

3. $6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$

6 carbon dioxide molecules + 6 water molecules \rightarrow 1 glucose molecules + 6 oxygen molecules

B. Types of chemical reactions:

1. Synthesis reactions = Anabolism: combining 2 or more atoms or molecules to form a more complex molecule.

Example: $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$

2. Decomposition reaction = Catabolism: breaking o chemical bonds to form 2 or more products

Example: $\text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O} + \text{energy}$

3. Oxidation: when an atom or molecule loses electrons or hydrogen ions

Example: $\text{K} - \text{e}^- \rightarrow \text{K}^+$

4. Reduction: when an atom or molecule gains electrons or Hydrogen ions.

Example: $\text{Cl}_2 + 2\text{e}^- \rightarrow 2\text{Cl}^-$

5. Oxidation and reduction reactions always occur together, sometimes called 'Redox' reactions

Example: Glucose is *oxidized* to for carbon dioxide AND in the same reaction, oxygen is *reduced* to form water:



6. Dehydration reaction = Condensation reaction: making a bond between molecules by removing water:
7. Hydrolysis: breaking a bond by adding water

C. To increase the rate of chemical reactions:

1. Increase the temperature
2. Decrease particle size
3. Increase the concentration of the reactants
4. Use catalysts such as enzymes.
5. Agitation, like stirring or mixing

VII. Water

A. Properties of water

1. Main regulator of homeostasis
2. Most abundant inorganic compound in the body
3. Approximately 62% of the body weight is water
4. Water is a very stable liquid at a very broad range of temperatures.
5. Water is a very polar molecule, therefore it dissolves many substances.

Fill in this chart for the temperatures for each row:

	°C	°F
Water Boils		
Water Freezes		
Body temperature		
Room temperature		

6. Water is used in the body as:

- a. Solvent
- b. Temperature regulator
- c. Transporter
- d. Lubricant
- e. Cushion

7. Hydrophilic: having an affinity for water; 'water-loving'

8. Hydrophobic: not having an affinity for water; 'water-fearing', such as an oil

B. Polarity of water

- 1. Hydrogen bonding occurs in water due to the polar covalent bonds formed between the 2 hydrogen atoms and the oxygen atom in a water molecule.
- 2. Surface tension: a measure of how difficult it is to stretch or break the surface of a liquid.
 - a. Hydrogen bonding causes water molecules to stick together leading to a high surface tension.

C. Solutions

- 1. Solution: a liquid that is a completely homogeneous mixture of two or more substances
 - a. Solvent: the dissolving agent of a solution
 - b. Solute: the substance dissolved in a solution
 - c. Aqueous solution: solution in which water is the solvent

VIII. Acids, bases, salts

- A. Acid: a substance that releases hydrogen ions (H^+) when dissolved in water; a proton donor

Example: $\text{HCl} \rightarrow \text{H}^+ + \text{Cl}^-$

B. **Base= alkali:** a substance that accepts hydrogen ions (H^+) or releases hydroxide ions (OH^-) when dissolved in water.

Examples: $\text{NH}_3 + \text{H}^+ \rightarrow \text{NH}_4^+$

$\text{KOH} \rightarrow \text{K}^+ + \text{OH}^-$

C. **Salt:** a substance that release a cation other than H^+ and an anion other than OH^- when dissolved in water.

Examples: $\text{NaCl} \rightarrow \text{Na}^+ + \text{Cl}^-$

$\text{KBr} \rightarrow \text{K}^+ + \text{Br}^-$

IX. **pH:** the negative log of the concentration of H^+ expressed in moles per liter. pH expresses the acidity or alkalinity of a solution.

A. **pH scale:** a scale to measure the acidity or alkalinity of a solution on a scale from 0 - 14.

B. **Acidic solution:** a solution in which the pH is greater than 0 and less than 7. The lower the number the more acidic the solution, the higher the concentration of H^+ .

C. **Basic solution:** a solution in which the pH is greater than 7 and less than 14. The higher the number the more basic the solution is because the concentration of H^+ is lower.

D. **Neutral solution:** a solution in which the pH is equal to 7. In this solution the concentration of H^+ is equal to the concentration of OH^- , and is thus neutral.

E. **Buffers:** chemical substances that regulate the changes in pH and therefore in the body help maintain homeostasis. Buffers are weak acids or weak bases that are added to neutralize strong bases or strong acids.

X. **Organic Chemistry:** the study of organic compounds.

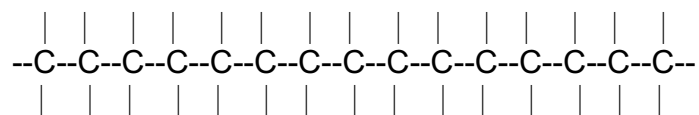
- A. **Organic compounds:** compounds that contain carbon and usually hydrogen.

Example: carbohydrates for example, $C_6H_{12}O_6$ (glucose), proteins, fats, vitamins, DNA, RNA

- B. **Inorganic compound:** compounds that do not contain carbon bonded to carbon or carbon bonded to hydrogen

Example: water, minerals, CO_2 , oxygen, nitrogen

- C. Carbon atoms are the most versatile building blocks. The atomic number of carbon is 6, therefore it has 4 valence electrons. In order to complete its outermost electron shell, it makes 4 covalent bonds. This ability to form 4 bonds makes large, complex molecules possible. Carbon can form bonds with many different elements. Many organic molecules are long chains of carbon atoms bonded to carbon atoms:



XI. **Nutrients**

- A. There are 6 categories of nutrients required by the body:

1. Carbohydrates
2. Proteins
3. Lipids
4. Vitamins
5. Minerals
6. Water

- B. Carbohydrates, proteins, lipids and vitamins are organic molecules. Minerals and water are inorganic molecules.

XII. **Carbohydrates:** composed of carbon, hydrogen and oxygen (carbon + water).

They provide the major source of energy for the body. There are 3 types or carbohydrates:

A. Monosaccharides

1. 'Simple sugars'
2. Contain 3 - 7 carbon atoms
3. Examples: glucose, fructose, galactose

B. Disaccharides

1. 'Double sugars'
2. Combination of 2 monosaccharides
3. Examples:
Sucrose (table sugar) is glucose + fructose
Maltose (malt sugar) is 2 glucose molecules
Lactose (milk sugar) is glucose + galactose

C. Polysaccharides

1. Combinations of more than 2 monosaccharides
2. Examples: starch, glycogen, cellulose

D. Carbohydrates are catabolized from polysaccharides -->disaccharides--> monosaccharides with the use of enzymes at each step.

XIII. **Lipids:** composed of carbon, hydrogen and oxygen, but in different ratios than carbohydrates.

A. Insoluble in water (hydrophobic).

B. May contain other elements, such as phosphorous and nitrogen.

C. Categories of lipids:

1. Triglycerides = neutral fats
 - a. Triglycerides are the most abundant form of lipids, both in the

diet and stored in the body.

b. Composed of:

(1) Glycerol, a 3 carbon molecule

(2) 3 fatty acids

(a) Saturated fatty acids:

i) have no carbon to carbon double bonds

ii) solid at room temperature

iii) found in animal fat

iv) Examples: lard, butter

(b) Unsaturated fatty acids:

i) have one or more carbon to carbon double bond

ii) liquid at room temperature

iii) Examples: vegetable oil, corn oil

2. Phospholipids

a. Phospholipids are the main components in cell membranes.

b. Composed of:

(1) Glycerol

(2) 2 fatty acids

(3) Phosphate group

3. Steroids

a. Composed of 4 fused carbon ring structures.

b. Examples: cholesterol, bile salts, testosterone, estrogen, progesterone and corticosteroid hormones

4. Eicosanoids

- a. Eicosanoids are chemical messengers between cells.
- b. Examples:
 - (1) prostaglandins, which cause contraction of smooth muscles
 - (2) leukotrienes which are involved in allergic and inflammatory responses

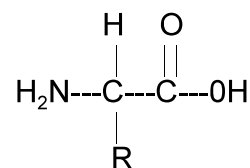
XIV. **Proteins:** composed of carbon, hydrogen, oxygen and always nitrogen, any may contain sulfur, phosphorous and iron.

A. Proteins are built from long chains of amino acids.

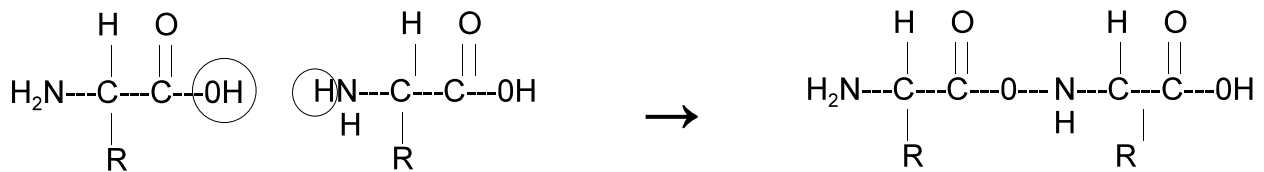
- 1. Dipeptide: a chain of 2 amino acids
- 2. Tripeptide: a chain of 3 amino acids
- 3. Polypeptide: a chain of between 15 and 100 amino acids
- 4. Protein: a chain of more than 100 amino acids
- 5. Production of proteins (protein synthesis) will be covered in the cell chapter.

B. Amino acids:

- 1. The basic structure of an amino acid includes a central carbon bonded to:
 - a. An amino group (NH_2)
 - b. A hydrogen
 - c. A carboxyl group (COOH)
 - d. A variable side chain represented by 'R'
- 2. There are 20 different 'R' groups, which means there are 20 different amino acids.
 - a. Essential amino acids:



- (1) Must be consumed in the diet, the body cannot manufacture these.
 - (2) There are 9 essential amino acids.
- b. Nonessential amino acids:
- (1) Can be manufactured in the body.
 - (2) There are 11 nonessential amino acids.
3. Amino acids join together with a special bond called a peptide bond. A dehydration reaction occurs, bonding the Carboxyl carbon of one amino acid to the nitrogen of the next amino acid.



C. Levels of protein structure

1. **Primary structure:** the list of the amino acids in a protein. Also called the sequence of the amino acids. This sequence is determined by the DNA in the nucleus of the cells. Alterations in this sequence may cause a change in the functioning of the protein.
2. **Secondary structure:** twisting or folding of the chain of amino acids. There are 2 types of secondary structures. Hydrogen bonding holds secondary structures together.
 - a. **Alpha helix** (α helix)
 - b. **Beta sheet** (β sheet)
3. **Tertiary structure:** folding and coiling of the protein chain due to

interactions between 'R' groups or between 'R' groups and water. May be held together by covalent bonds and/or ionic bonds.

4. **Quaternary structure:** interaction of two or more polypeptide chains to form the complete protein.
5. All levels of protein structure must be maintained for the protein to function properly. A protein's conformation (shape) is key to its function.
6. Denaturation: drastic changes in the conformation of a protein may render the protein useless for its original function. Proteins may be denatured by changes in:
 - a. Temperature, for example: cooking egg whites cause that protein to become a solid
 - b. pH

D. Examples of proteins:

1. Antibodies: protect against disease
2. Hemoglobin: transports oxygen in the blood
3. Enzymes
 - a. Speed up the rate of chemical reactions in the body.
 - b. Can be reused to catalyze the reaction again, enzymes are not changed in the reaction
 - c. Are very substrate specific.

XV. **Nucleic Acids:** organic compounds composed of nucleotides.

A. Nucleotides have 3 components

1. One or more phosphate groups
2. A 5-carbon sugar

- a. Ribose
- b. Deoxyribose
- 3. A nitrogenous base
 - a. Pyrimidines:
 - (1) cytosine (C)
 - (2) uracil (U)
 - (3) thymine (T)
 - b. Purines
 - (1) adenine (A)
 - (2) guanine (G)

B. DNA: deoxyribonucleic acid

- 1. DNA is the major components of chromosomes, the hereditary information contained in the nucleus of cells.
- 2. DNA controls the activity of cells by controlling protein synthesis.
- 3. DNA is a double stranded helix. The strands are held together by hydrogen bonds between the adjacent nitrogenous bases.
 - a. Adenine always bonds with thymine (A - T)
 - b. Cytosine always bonds with guanine (C -G)
- 4. The sequence of the nucleotides determines heredity. A change in the DNA sequence, called a mutation, may produce a hereditary change. Not all mutations change the final product, the protein.
- 5. DNA contains the sugar, deoxyribose.

C. RNA: Ribonucleic acid

- 1. RNA is a single stranded molecule involved in protein synthesis in cells.

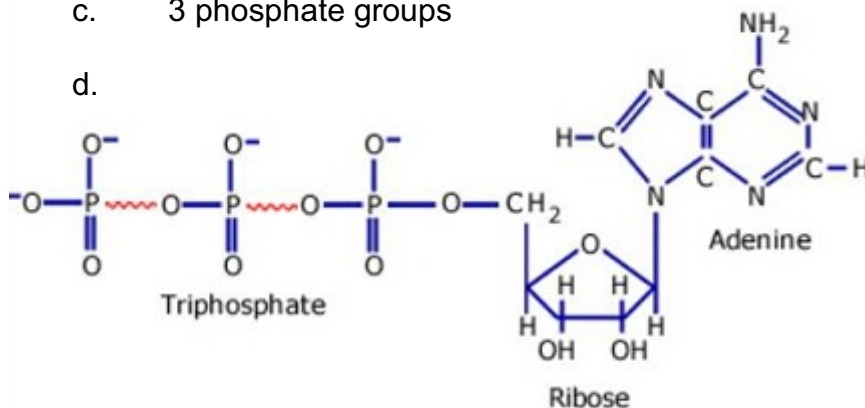
2. RNA contains uracil in place of thymine.
 - a. Adenine bonds with uracil (A - U)
 - b. Cytosine still bonds with guanine (C - G)
3. RNA contains the sugar ribose.
4. There are 4 main types of RNA. Their functions will be discussed with protein synthesis.
 - a. Messenger RNA (mRNA)
 - b. Transfer RNA (tRNA)
 - c. Ribosomal RNA (rRNA)
 - d. Nuclear RNA (nRNA)

D. ATP: Adenosine triphosphate

1. ATP is the energy molecule for cells. Cells store energy as ATP and use the energy in ATP as needed to perform cell functions.
2. When energy is needed, ATP is hydrolyzed (using enzymes) to form ADP (adenosine diphosphate) and an inorganic phosphate group (P_i):

- Enzymes
- $ATP + H_2O \xrightarrow{\hspace{1cm}} ADP + P_i + \text{energy (for work and/or heat)}$
3. ATP is composed of:

- a. Adenine
- b. Ribose (a 5 carbon sugar)
- c. 3 phosphate groups
- d.



4. Most ATP is synthesized in the mitochondria in a series of reactions called 'cellular respiration'. This process will be discussed in the metabolism chapter.

Chapter 3, Cells, Tissues, and Body Membranes

Textbook Chapter: _____

A. ULTRASTRUCTURE & FUNCTION OF THE CELL:

The cell is the structural and functional unit of all living organisms. **It is made of three major parts:**

THE CELL'S PARTS

1. The plasma membrane
2. The cytoplasm
3. The nucleus

1. THE PLASMA MEMBRANE:

The plasma membrane (also called **plasmalemma**) forms the outer boundary of the cell

a. Functions:

- 1.) It is a selective permeable gate that allows certain substances to get into and out of the cell.
- 2.) It maintains an electrochemical difference between the external and internal environment of the cell.
- 3.) It contains peripheral and integral proteins which play a fundamental role in the body's defense system on one hand, and serve as receptor sites for chemical communication between cells on the other hand.

b. Structure

According to the "Fluid Mosaic Model Theory" postulated by Singer & Nicolson, the plasma membrane is **composed mainly of phospholipids, proteins, and carbohydrates.**

- 1.) The Phospholipids form a fluid "sea" made of a central bimolecular layer; here the long hydrophobic hydrocarbon chains of fatty acids (tails) are attached to the hydrophilic globular portions of phosphate (head).

- 2.) **The Proteins** float like "icebergs". Depending on their position they can be classified as:
- a.) Peripheral proteins which associates to the globular portions of phospholipids. They act as transporters or receptors.
 - b.) Integral proteins which are attached to the hydrophobic portion. They act as cytoskeleton anchors or enzymes.
- 3.) **The Carbohydrates** consist of glycolipids and glycoproteins which form a filmy covering called the glycocalyx; it acts as
- a.) an adhesive between cells.
 - b.) site for immunological response
 - c.) cell identity markers.
- 4.) **Cholesterol**: attached to phospholipid chains; it determines the fluidity of the plasma membrane.

c. **Movement across the plasma membranes:**

Two basic types of molecular traffic take place in and out of cells: **passive movement** and **active movement**

1.) **PASSIVE MOVEMENT**

Molecules pass through the plasma membrane according to their concentration gradient (meaning from areas of high concentration to areas of low concentration without the use of energy (ATP)). Passive movement includes the following:

PASSIVE MOVEMENTS:

- a.) **Diffusion**
- b.) **Facilitated Diffusion**
- c.) **Osmosis**
- d.) **Filtration**
- e.) **Dialysis**

- a.) **Diffusion** - random movement of molecules from areas where they are highly concentrated to areas where they are less concentrated until a uniform distribution of molecules is achieved. (e.g.) inhaled O₂ → Lung → Bloodstream.

b.) **Facilitated Diffusion** - when carrier proteins in the plasma membrane combine temporarily to molecules and allow them to pass through membrane via protein channels; they move from an area of high concentration to an area of low concentration. (e.g.) - absorption of glucose or amino acids by the duodenum during digestion.

c.) **Osmosis** - when water molecules move through a selectively permeable membrane from an area of high concentration of water to an area of low concentration of water.

(1.) **Osmotic Pressure** is the force exerted by a highly concentrated solution "A" which prevents the net flow of water across the selectively permeable membrane coming from a lower concentrated solution "B".

(2.) Osmotic pressure concept has its application in chemistry, biology, and medicine, and allows one to distinguish **three types of solutions**.

(a.) **Hypotonic solution**: when the solute concentration is lower outside the cell than it is inside the cell. (e.g.) when pure water is exposed to red blood cells (RBC), **hemolysis** occurs due the swelling and bursting of RBCs.

(b.) **Isotonic solution**: when the water and solute concentration outside the cell is the same as inside the cell. (e.g.) - exposition of Red Blood Cells to a solution containing 0.85g of sodium chloride per 100 ml. water (physiological solution) does not result in the net movement of water into or out of the RBCs.

- (c.) **Hypertonic solution**: when the solute concentration is higher outside of the cell than it is inside. (e.g.) - Exposition of RBCs in a solution containing 100g sodium chloride per 100 ml; results in **crenation** due to the loss of water by RBC and the shrinkage.
- d.) **Filtration**: Process that forces small particles dissolved in a solution to cross the semipermeable membrane with the help of hydrostatic pressure. (e.g.) - Ultrafiltration of blood by the glomeruli of the kidneys.
- e.) **Dialysis**: Exchange of solutes between two solutions separated by a semipermeable membrane. (e.g.) - Use of the cellophane sheets in the artificial kidney machine is based upon this principle.

2.) **ACTIVE MOVEMENT**

When substances move across a selectively permeable membrane from areas of low concentration to areas of high concentration. Since active movement is against the concentration gradient, it requires energy in the form of ATP. **Active movement includes** the following:

ACTIVE MOVEMENTS:

- a.) **active transport**
- b.) **exocytosis**
- c.) **endocytosis**
- a.) **Active Transport** - uses energy from the breakdown of ATP to move substances across selectively permeable membrane against a concentration gradient. (e.g.) - continuous transport of sodium out of resting cells by the "sodium-pump" even though its concentration is much higher outside of the cell.
- b.) **Exocytosis** - is the fusion of secretory vesicles with the plasma membrane, followed by their expulsion from the cell

through the plasma membrane. (e.g. release of neurotransmitters by the neurons).

- c.) **Endocytosis** - process during which particles are engulfed by cytoplasmic extensions, thus forming membrane bound vesicles within the cytoplasm. There are **three types of endocytosis**:

TYPES OF ENDOCYTOSIS:

- (1.) **pinocytosis**
- (2.) **receptor-mediated endocytosis**
- (3.) **phagocytosis**

(1.) **Pinocytosis** (also called "**Cell Drinking**") - is the process during which the plasma membrane invaginates and encloses small amounts of fluid droplets, thus forming small pockets which are released into the cytoplasm. (e.g. Kidney cells take in tissue fluids to maintain fluid balance).

(2.) **Receptor-mediated endocytosis** - when extracellular large molecules bind with specific receptors on plasma membrane, causing the membrane to invaginate and draw them into the cytoplasm.

(3.) **Phagocytosis** (called "**Cell Eating**") - is the ability of the plasma membrane to engulf large particles (foreign bodies, bacteria), and digesting them by fusing the pocket into which they are contained with lysosomal enzyme. (e.g. neutrophils digest harmful bacteria).

2. **THE CYTOPLASM** - is the portion of the cell located between the plasma membrane and the nucleus. It consists of an **aqueous phase and an particulate phase**.

a. **Aqueous Phase** or "**Fluid Phase**" - consists of cytosol. The cytosol is composed of water (75% to 90%), proteins, carbohydrates, lipids, nucleic acids, and inorganic substances.

b. **Particulate Phase** consist of **organelles and inclusions**:

1.) Organelles:

a.) Endoplasmic Reticulum -"ER"- is a network of tubes and flattened sacs that channels the flow of substances around the cytoplasm. Two types of "ER" are distinguishable: **Smooth Endoplasmic Reticulum "SER"** and **Rough Endoplasmic Reticulum "RER"**.

(1.) Smooth Endoplasmic Reticulum -"SER"-

- (a.) is a delicate branching network of tubules free of ribosomes.
- (b.) is the site of steroids synthesis, especially steroid hormones (e.g. progesterone, estrogen, testosterone).
- (c.) is involved in the degradation of hormones and drugs in the liver cells.
- (d.) stores calcium in striated muscles.

(2.) Rough Endoplasmic Reticulum -"RER"-

- (a.) is a complex system of branching tubes and flattened sacs covered by ribosomes on their surface.
- (b.) assists in protein synthesis.

b.) Ribosomes

(1.) Are spherical nonmembranous-bound organelles made of two subunits:

- (a.) The small ribosomal subunit.
- (b.) The large ribosomal subunit.

(2.) Are usually grouped in clusters in the cytoplasm and are then called **polysomes**.

(3.) Are sites of protein synthesis.

c.) Golgi Apparatus or Golgi Complex

- series of five to seven flattened sacs, involved in processing, storing, and packaging of secretory proteins.

d.) Lysosomes

- membrane-bound organelles that contain digestive enzymes (acid hydrolase); act as

the digestive system of the cell; also known as "suicide bags".

e.) Peroxisomes

- (1.) membrane-bound organelles found mostly in the liver, in the kidney and the macrophages...
- (2.) contain enzymes (peroxidase) which are involved in the formation of hydrogen peroxide as they oxidize various substances.

* **NOTE:** they destroy hydrogen peroxide after completion of the chemical reaction to avoid its toxic effect.

f.) Mitochondrion (plural "Mitochondria**")**

- (1.) Double layered membrane organelle with its inner layer thrown into folds called "**cristae**" projecting into the inner cavity filled with amorphous substance called "**matrix**" where different enzymes are found.
- (2.) Mitochondria are abundant in different types of cells such as myofibers, neurons, spermatozoa,...
- (3.) Is the site of the final steps in cellular respiration, which result in the production of ATP used in the cell metabolic activities.
- (4.) Mitochondria are the "**powerhouses**" of the cell because of ATP production.

(5.) ATP

_____ (a.) ATP means **ADENOSINE TRIPHOSPHATE**.

_____ (b.) ATP is the main ENERGY SUPPLIER for most BIOLOGICAL ACTIVITIES in the CELL. The phosphate bond (the P of ATP) is where most of the energy exists.

_____ (c.) Most of it is created in the

cell's mitochondria.

g.) Cytoskeleton

(1.) Formed by:

(a.) Microtubules

(b.) Microfilaments

(c.) Intermediate filaments

(2.) Function - forms a supportive framework, assists in organelles movement, and provides a transport system within the cell.

h.) Centrioles

(1.) A pair of cylindrical cytoplasmic organelles located in a space near the nucleus called centrosome.

(2.) Assist in cell division by forming Mitotic Spindle System * Note that mitotic spindle is involved with chromosome movement during mitosis.

i.) Cilia

- Minute cytoplasmic extensions from the cell which are involved in the transport of materials along the cell surface (e.g. mucus movement in the trachea; movement of the ova in the fallopian tube.)

j.) Flagellum

Cellular appendage which protrudes from the cell and allows its propulsion. (e.g. Spermatozoa tail is made of flagellum)

k.) Secretory Vesicles

Membrane bound cytoplasmic chambers containing products of secretion such as protein.

l.) Cytoplasmic Inclusions

There is a variety of cellular inclusions. Examples are:

(1.) Lipid droplets → storage for energy

- (2.) **Glycogen** → principal storage form of carbohydrates
- (3.) **Zymogen granules** → secretory products rich in inactive enzyme
- (4.) **Melanin pigment** → most abundant skin pigment
- (5.) **Hemosiderin** → yellowish brown pigment resulting from degradation of hemoglobin

3. **THE NUCLEUS**

- a. Site where the genetic material is stored
- b. It consists of three components.

NUCLEAR COMPONENTS

- 1.) **Nuclear Membrane**
- 2.) **Chromatin**
- 3.) **Nucleolus**

- 1.) **Nuclear Membrane** or **Nuclear Envelope**
Separates the nucleus from the cytoplasm. Contains opening called nucleopores which are potential passageway for exchange of substances (e.g.) Messenger Ribonucleic Acid (mRNA)
- 2.) **Chromatin**
Complex substance made up fibrous strands containing DNA and proteins. DNA controls:
 - a.) Cell's Heredity
 - b.) Protein Structure
 - c.) Other nonmetabolic activity
- 3.) **Nucleolus**
Dense nonmembranous mass where RNA is synthesized; location for the components found in ribosomes.

* **Note:** Red Blood Cells (RBC) in circulation don't have a nucleus; therefore, they are unable to divide and they die after 4 months in circulation.

B. **THE CELL CYCLE**

1. It is the period between the beginning of one cell division and the beginning of the next cell division.

2. There are two types of cell division: **somatic and reproductive**.

a. Somatic Cell Division (Body Cell Division)

It involves three major process: **interphase, mitosis, and cytokinesis**.

1.) Interphase

Is a very active period of cell activity during which DNA in the nucleus doubles. The phenomenon is called "Replication", meaning that DNA makes the copy of itself.

2.) Cytokinesis

division of the cytoplasm into two distinct daughter cells.

3.) Mitosis

a.) Is the process during which two diploid (2n) daughter cells result from the division of a diploid (2n) parent cell.

b.) In human daughter cells, $n = 23$ chromosomes from each parent.

c.) **It is divided into four sequential stages:** prophase, metaphase, anaphase, telophase.

(1.) Prophase: the first stage of mitosis; it is the longest mitotic phase.

(a.) **Early Prophase:**

((1.)) Chromatin condenses and shortens into chromosomes.

((2.)) Each prophase chromosome has a pair of identical, double-stranded DNAs called **CHROMATIDS**.

(b.) **Late Prophase:**

((1.)) Disappearance of the NUCLEOLI.

((2.)) Breakdown of the NUCLEAR MEMBRANE.

((3.)) Movement of the two

CENTRIOLES toward
opposite directions.

((4.)) Appearance of MITOTIC
APPARATUS.

(2.) **Metaphase**: the second mitotic stage;
the CHROMATID pairs line up at the
center of mitotic apparatus.

(3.) **Anaphase**: the third stage.

(a.) Shortest mitotic phase

(b.) Movement of the two sister
chromatids of each
chromosomes toward opposite
pole of the cell.

(4.) **Telophase**: the fourth mitotic stage

(a.) Chromosomes uncoil and
become chromatin.

(b.) Formation of nuclear membrane
around each set of chromatin.

(c.) Appearance of nucleoli.

(d.) Mitotic apparatus disappears.

(e.) Formation of two daughter cells
with 46 chromosomes each.

b. **Reproductive cell division or Meiosis**

1.) **Occurs only in the gonads (testes & ovaries)**
and results in the formation of mature **gametes**
(**spermatozoa** in the male and **ova** in the female)

2.) Starts at the onset of puberty and continues
during the entire lifetime in the male; stops
during menopause in the female.

3.) Unlike the somatic cell division, meiosis is
characterized by the formation of **haploid (n
chromosome)** daughter cells resulting from the
division of the **diploid (2n chromosome)** parent
cell. Thus, each daughter cell contains only
23 chromosomes.

4.) **Meiosis consists of two steps**: first meiotic

division (reduction) and second meiotic division (equatorial).

a.) **First Meiotic Division** is composed of four sequential phases:

- (1.) **Prophase I** Appearance of double stranded chromosomes. Pairing of homologous chromosomes lie side by side.
- (2.) **Metaphase I** Pairs of homologous chromosomes line up at the center of mitotic apparatus.
- (3.) **Anaphase I** One chromosome of each homologous pair migrates to opposite poles.
- (4.) **Telophase I** Two haploid (n chromosome) daughter cells result from the division of a diploid ($2n$ chromosome) parent cell.

b.) **Second Meiotic Division** is the continuation of the first meiotic division and is also subdivided into four phases.

- (1.) **Prophase I**: Each chromosome of the haploid daughter cell resulting from the first meiotic division has two chromatids.
- (2.) **Metaphase**: Single chromosome lines up at the center of the mitotic apparatus.
- (3.) **Anaphase**: Migration of the chromatid of each chromosome to opposite poles.
- (4.) **Telophase**: Production of two haploid cells from each haploid cell of the telophase I.

TISSUES

A. Introduction

1. With a few exceptions, even the most complex animal starts out as a single cell, (the fertilized egg), which divides almost endlessly.
2. A division of labor exists, with certain groups of cells becoming specialized to perform functions that benefit the organism as a whole.
3. Definition - a group or cluster of cells with a common function, similar origin, and having similar shapes.
4. Histology - the study of tissues.

B. Classification of Tissues

1. Epithelial Tissue (or Epithelium)

- a. Covers external body surface (as the epidermis).
- b. Lines internal body's cavities and tubules.
- c. Composes the secreting parts of various endocrine glands (hormone producing) and exocrine glands of the body.

 - 1.) exocrine glands - secrete into their ducts.
 - 2.) endocrine glands - secrete hormones into the bloodstream; do not have ducts.
- d. involved in the beginning formation of the gametes.
- e. Functions of epithelial tissue:
 - 1.) Protection
 - 2.) Absorption
 - 3.) Filtration
 - 4.) Secretion
 - 5.) help control/regulate temperature
- f. Characteristics
 - 1.) Not a very strong tissue.
 - 2.) Cells fit closely together to form membranes, or sheets of cells, and are bound together by specialized points of contact known as cell junctions.

- 3.) Membranes always have one free surface, called the apical surface.
- 4.) Cells attached to an adhesive **basement membrane**.
- 5.) Have **no** direct blood supply of their own (are avascular) but depend on their blood supply from the underlying connective tissue.
- 6.) Can easily regenerate if well nourished (can go through mitosis).
- 7.) Contains a **basement membrane**, and it is this membrane that is used to determine if epithelium is **simple or stratified epithelium**.
 - a.) **simple epithelium** - one layer of cells attached to the basement membrane.
 - b.) **stratified epithelium** - more than one layer of cells with the bottom layer attached to the basement membrane.

8.) **Epithelial Cells Shapes (4):**

-
- a.) **squamous** - flat-like
 - b.) **cuboidal** - cube-shaped; often look oval
 - c.) **columnar** - tall; looklike columns
 - d.) **transitional** - somewhat round-like with one end more swollen than the other; sometimes thought of as resembling hot-air balloons.

g. **Types:**

1.) **simple epithelium:**

- a.) Simple squamous epithelium -
- b.) Simple cuboidal epithelium -
- c.) Simple columnar epithelium -
- d.) Pseudostratified ciliated columnar

epithelium -

2.) **stratified epithelium:**

- a.) Stratified squamous epithelium -
- b.) Stratified cuboidal epithelium -

c.) Stratified columnar epithelium -

d.) Transitional epithelium - lines the urinary bladder; it is the only epithelial tissue that can stretch significantly and not be damaged by the stretching.

2. Connective Tissue:

a. Found in all parts of the body, (as discrete structures or as part of various body organs).

b. Most abundant and widely distributed of the tissue types.

c. Functions:

1.) Some types protect.

2.) Some types support.

3.) Some types bind together other tissues of the body.

4.) Some types make blood products.

5.) Some types make most of the immune system.

6.) During periods of less eating (ex.- fasting), some types can be converted to energy for the body.

d. Characteristics

1.) With a few exceptions (cartilage, tendons, and ligaments), they are well vascularized.

2.) Composed of many types of cells.

3.) Connective tissue generally has a great deal of noncellular nonliving material (matrix) between the cells. It has two components:

a.) Ground substance - consists largely of glycoproteins and polysaccharides.

b.) Fibers - includes collagenic (white), elastic (yellow) and reticular (fine collagenic) fibers.

e. Some Major Types:

1.) Embryonic (mesenchyme)

2.) Areolar connective

3.) Adipose - fat, lipid

4.) Dense regular - tendons & ligaments

5.) Dense irregular

- 6.) Elastic irregular
- 7.) Hyaline cartilage - fetal skeleton, nose
- 8.) Fibrocartilage - disc of vertebrae
- 9.) Elastic cartilage - ear, parts, of respiratory system
- 10.) Bone (osseous)
- 11.) Blood
- 12.) Reticular tissue - forms the framework of organs (ex. - liver and spleen)

f. TENDON -

g. LIGAMENT -

3. Muscle Tissue

- a. Highly specialized to contract (shorten) in order to produce movement of some body parts.
- b. Quite elongated, providing a long axis for contraction.

_____ c. (3) Types:

1.) Skeletal muscle

- a.) The "meat" or the "flesh" of the body; is attached to the skeleton.
- b.) Consciously controlled (voluntary).
- c.) Its contractions move the limbs and other external body parts.
- d.) The cells are long, cylindrical, and multinucleated.
- e.) They have striations (stripes).

2.) Cardiac muscle

- a.) Found only in the heart.

- b.) As it contracts, the heart acts as a pump, propelling blood through the blood vessels.
- c.) Cardiac muscle has striations.
- d.) Cardiac cells branch at tight junctions called intercalated discs.
- e.) Cardiac muscle is involuntarily controlled.
- f.) Uninucleated

3.) Smooth muscle (or visceral muscle)

- a.) Smallest muscle cell.
- b.) It is found in the walls of hollow organs and blood vessels.
- c.) Typically, there are two layers that run at right angles to each other, thus propelling substances along predetermined pathways.
- d.) Quite different in appearance from those of skeletal or cardiac muscle, because it is spindle shaped.
- e.) No striations are visible.
- f.) It has uninucleated cells.
- g.) Involuntary

4. Nervous Tissue - Composed of two major cell populations.

- a. Neuroglia - special supporting cells that protect, support, and insulate the more delicate neurons.
- b. Neurons - highly specialized to receive stimuli (irritability) and to conduct waves of excitation, or impulses, to all parts of the body (conductivity). They are the cells most often associated with nervous system functioning.

BODY MEMBRANES

A. **Introduction** - the body membranes, which cover surfaces, line body cavities, (and form protective (and often lubricating) sheets around organs), fall into two major categories: Epithelial and Synovial

B. **Catagories explained:**

1. **EPITHELIAL MEMBRANES**

- a. **Cutaneous** - is the skin; a dry membrane with a keratinized epidermis.
- b. **Mucous** - are composed of epithelial cells resting on a layer of loose connective tissue called the lamina propria; locations are in systems that are exposed to the outside environment (respiratory, digestive, urinary, reproductive systems); contain many WBCs.
- c. **Serous** - composed of a layer of simple squamous epithelium on a scant amount of loose connective tissue; locations are in systems closed to the outside environment (outer lung lining, outer lining of the G-I tract, outer lining of the heart); very few WBCs.

2. **SYNOVIAL MEMBRANE**

- a. It is **composed entirely of connective tissue**.
- b. It contains **no epithelial cells**.
- c. This membrane **lines the cavities surrounding the joints**, where they provide a smooth surface and secrete a lubricating fluid.
- d. This membrane lines smaller sacs of connective tissue (**bursae**) and tendon sheaths, both of which cushion structures moving against each other, as during muscle activity.

Chapter 4, The Integumentary System

Textbook Chapter: _____

Introduction

1. Often considered an organ system because of its extent and complexity.
2. The pliability of it enables it to withstand constant insult from outside agents.

B. Functions

1. It insulates and cushions the underlying body tissues.
2. It protects the entire body from lots of mechanical damage, chemical damage, thermal damage, and bacterial invasion.
3. It acts as a miniexcretory system (urea, salts, and water leave through the skin pores).
4. It is the site for the assemblage of vitamin D in the body.
5. It is a large and diffuse sensory organ (because the cutaneous sense organs are located in the dermis).

C. Basic Structure of The Skin: composed of 2 major layers

1. **EPIDERMIS** - epithelial tissue; composed of several sublayers:
 - a. **Stratum corneum** - many rows of dead cells
 - 1.) Composed of dead cells.
 - 2.) It your main skin barrier (thick).
 - 3.) Its the uppermost horny layer because of its tough flattened keratinized cells.
 - b. **Stratum lucidum** - clear, thin layer which appears as a pale band, contains fully keratinized cells. This layer is present only when the stratum corneum is thick (sole of the foot and palm of the hand); cells are dead.
 - c. **Stratum granulosum** - granular layer above the stratum spinosum; is the area in which the cells begin to die owing to their accumulation of keratohyalin granules and their increasing distance from the dermal blood supply.
 - d. **Stratum spinosum** - its cells have spines that

cause them to stick together; a lot of the race color is stored here. Its cells are alive.

e. **Stratum germinativum or stratum basale:**

- 1.) It is adjacent to the basement membrane (which is in turn adjacent to the dermis).
- 2.) The more inferior basal layers are constantly undergoing cell division; millions of new cells are produced daily.
- 3.) Its cells are moved into the stratum spinosum.
- 4.) Its cells are alive.
- 5.) The color of your race starts here.

2. **DERMIS** - connective tissue; two principal regions

- a. **Papillary layer** - more superficial dermal region. It is very uneven and has finger-like projections called the dermal papillae, from its superior surface which attach it to the epidermis above. These projections are reflected in fingerprints.

The pain and touch receptors (**Meissner's corpuscles**) are also found here.

- b. **Reticular layer** - is the deepest skin layer. It contains many arteries and veins, sweat and sebaceous glands, and pressure receptors. Both the papillary and reticular layers are heavily invested with collagenic and elastic fibers. The dermis has an abundant blood supply, which allows it to play a role in the regulation of body temperature. The dermis also contains the deep pressure receptor called a **Pacinian receptor**.

D. **Skin Color**

1. **Results from:**

- a. The relative amount of the **pigments** (melanin and carotene)
- b. The **degree of oxygenation of the blood**. People who produce large amounts of melanin have brown-toned skin. In light skinned people, who have less melanin, the dermal blood supply flushes through the latter transparent cell layers above, giving the skin a rosy glow.

2. Skin color may be an important diagnostic tool. For

example, flushed skin may indicate hypertension, fever, or embarrassment, whereas pale skin is common in anemic individuals. When blood is inadequately oxygenated, as during asphyxiation and serious lung disease, the skin takes on a bluish or cyanotic appearance. Another color is jaundice, in which the tissue become yellowed. It is almost always diagnostic for liver disease, whereas a bronzing of the skin hints that a person's adrenal cortex is hypoactive (Addison's disease).

E. Appendages of the skin

The hair, nails, and cutaneous glands - are all derivatives of the epidermis, but they reside almost entirely in the dermis. They originate from the stratum germinativum and grow downward into the deeper skin regions.

BODY TEMPERATURE

- A.** The skin plays a major role in thermoregulation; that is, the homeostasis of body temperature. As warm-blooded animals, we are able to maintain our body temperature at a remarkably constant 37°C (98.6°F) even though environmental temperature varies greatly. Negative feedback systems ensure that body temperature (a controlled condition) fluctuates very little.

MECHANISM:

1. some stimulus (stress) disrupts homeostasis by causing an increase in
↓
2. (controlled condition) body temperature
↓
3. thermoreceptors (temperature-sensitive receptors) in skin and brain input nerve impulses
↓
4. (control center) brain output nerve impulses
↓
5. effectors increased sweating from sudoriferous (sweat) glands causes increased heat loss by evaporation
↓
6. (response) decrease in body temperature
↓
7. return to homeostasis when response brings body temperature (controlled condition) back to normal.

B. Note that temperature regulation by the skin involves a **negative feedback system** because the response (cooling) is opposite to the stimulus (heating) that started the cycle. Also, the thermoreceptors continually monitor body temperature and feed back information to keep the brain informed. The brain, in turn, continues to send impulses to the sweat glands and blood vessels until the temperature returns to 37°C (98.6°F).

C. **Note:** a human is a **homeotherm** (warm blooded); uses internal mechanisms to control one's temperature within a very narrow range.

D. **Mechanisms used by a homeotherm to lose temperature:**

1. **conduction** - carries heat away via "touch".
2. **convection** - carries heat away via "circulation". (ex.

fan)

3. radiation - carries heat away via "waves".
 4. evaporation - carries heat away via "vapor" (sweat and breathing).
-

E. Ways Humans Gain Heat:

1. They can shiver or exercise.
2. They can increase certain metabolic factors, especially via hormones.
3. Absorb it from the environment.
4. During the digestive process.
5. When inactive, brain and liver play a role in controlling the body's temperature.

F. Hypothalamus - the brain part that is considered the "thermostat" of the body.

Chapter 5: The Skeletal System

Textbook Chapter: _____

A. **INTRODUCTION**

The skeleton is constructed of two of the most supportive tissues found in the human body - cartilage and bone.

B. **FUNCTIONS:**

1. A LEVER SYSTEM - (for movement)
2. PROTECTION
3. SUPPORT
4. STORAGE OF LIPIDS AND MINERALS.
5. HEMATOPOIESIS - (in bone marrow)

C. **COMPOSITION AND HISTOLOGY:**

1. Water
2. Proteins

3. **Mineral Salts:**

- a. calcium - over 90% is stored in the bones.
- b. phosphorus
- c. magnesium
- d. boron and manganese - (limited quantities).
- e. hydroxyapatite - makes bone matrix hard.

4. **Vitamins:**

- a. Vitamin A₁
- b. Vitamin B₁₂
- c. Vitamin C
- d. Vitamin D

5. **Hormones Associated with the Skeletal System and Their Effects:**

- a. **thyroid hormone, sex hormones, and somatotropin (growth) hormone** - stimulate bone formation
- b. **parathyroid hormone (parathormone)** - stimulates osteoclasts to reabsorb bone, thus increasing blood

calcium concentration (will result in thinner bones if not balanced).

- c. **calcitonin** (from the thyroid) - inhibits osteoclasts; lowers blood calcium level.

6. **Blood Supply**

10% of total blood circulation is required by the bones.

7. Bone growth and development is dependent upon **active functional cells**. These are named:

- a. **osteoprogenitor** - embryonic osteogenic precursor.
- b. **osteoblasts** - associated with bone formation and development.
- c. **osteocytes** - mature bone cells; maintain bones.
- d. **osteoclasts** - bone - destroying cells that creates the bone marrow cavity.

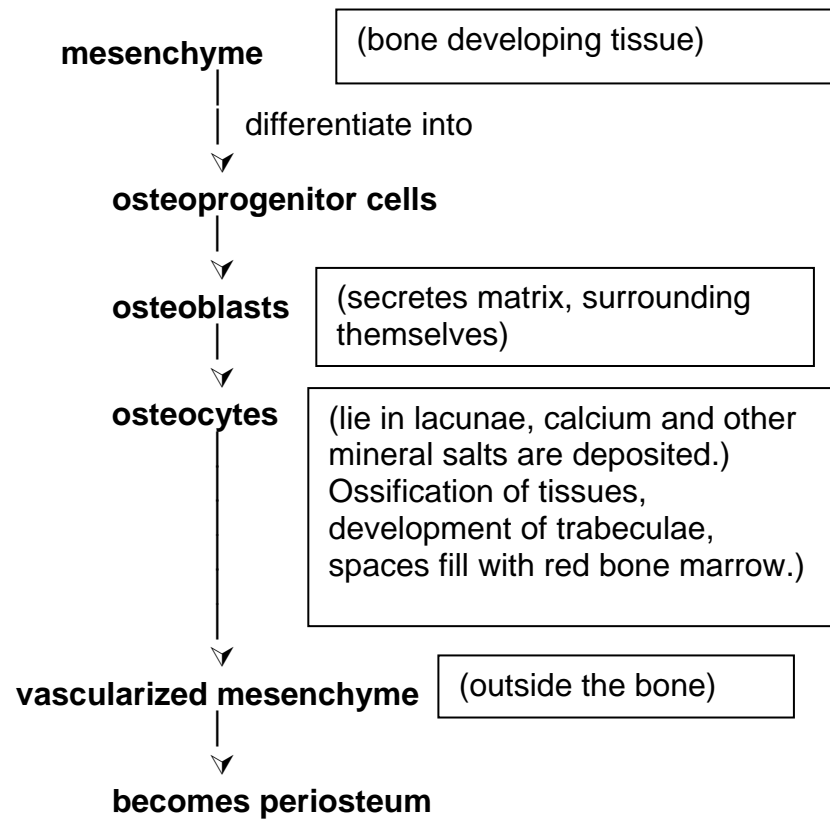
D. **SPONGY BONE TISSUE**

- 1. Site of red bone marrow in adults.
- 2. **Haversian systems (osteons)** are absent.
- 3. **Sites**: pelvic bones, ribs, sternum, vertebrae, some skull bones, and ends of some long bones.

E. **MODES (METHODS) OF EMBRYONIC DEVELOPMENT:**

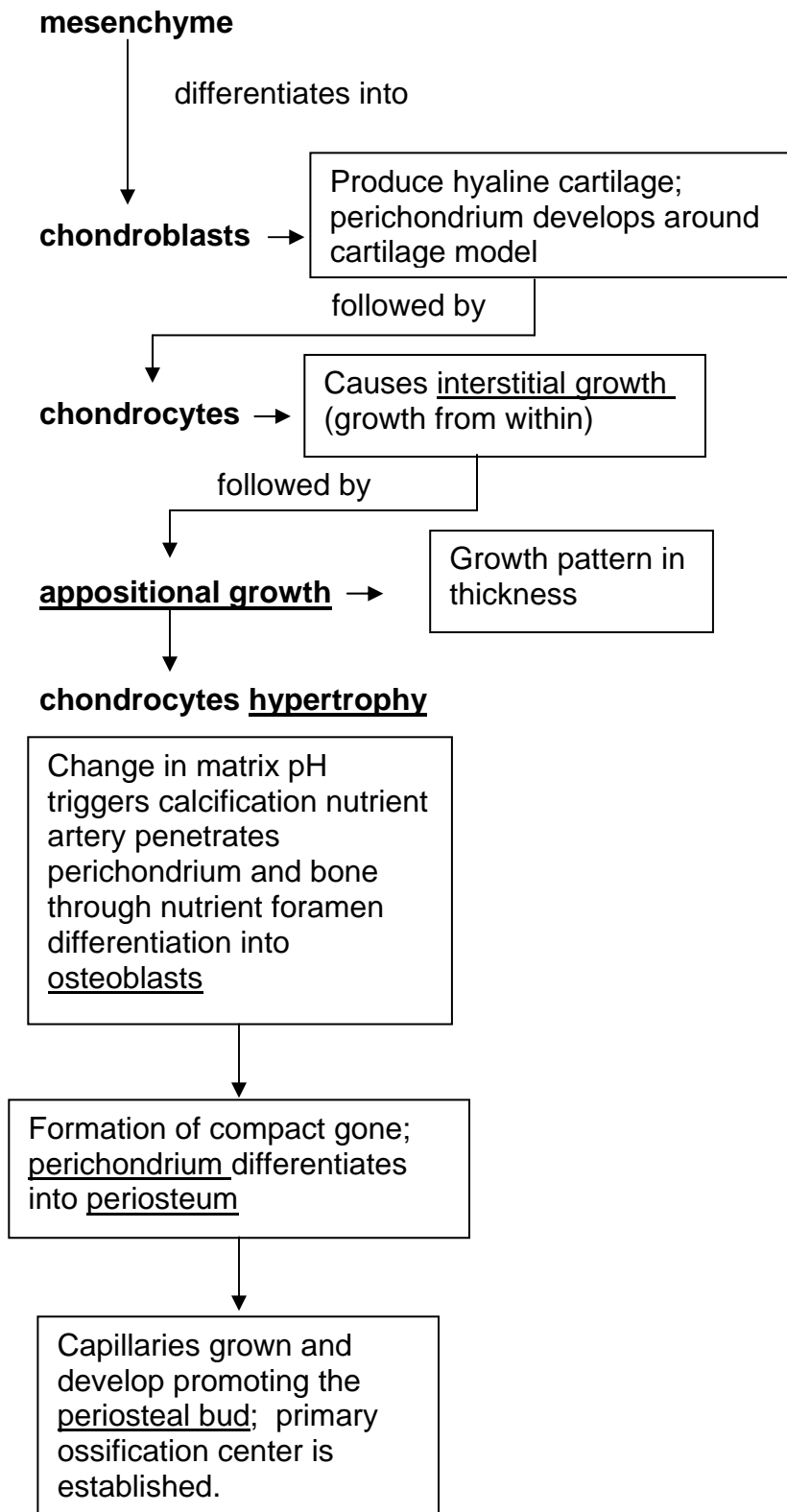
- 1. **Intramembranous** - development occurs directly on or within fibrous connective tissue membranes.
 - a. **Examples**: skull's flat bones, mandible, and the clavicles.

b. **Mechanism explained:**



2. **Cartilaginous (endochondral)** - formation of bone in hyaline cartilage.
Most bones are developed by this method.

a. **Mechanism explained:**



F. ANATOMICAL STRUCTURE:

1. **Diaphysis** - shaft
2. **Periosteum** - fibrous membrane covering
3. **Sharpey's fibers** - penetrating fibers from periosteum into bone
4. **Epiphysis** - end of the long bone
5. **Articular cartilage** - covers the epiphyseal surface
6. **Epiphyseal plate** - growth plate (youth)
7. **Epiphyseal lines** - remnants of epiphyseal plate (in the adult)
8. **Marrow cavity** - interior of the diaphysis
9. **Endosteum** - lining the shaft
10. **Metaphysis** - between epiphysis and diaphysis; during growth, this is the location for the epiphyseal plate.

G. MICROSCOPIC STRUCTURE OF COMPACT BONE

(NOTE): Look up and define each of the following words.

1. **Haversian Canal** -
2. **Osteocytes** -
3. **Lacunae** -
4. **Lamellae** -
5. **Canaliculi** -
6. **Volkman's Canal** -
7. **Osteon (or Haversian System)** -

H. CLASSIFICATION OF BONES IN THE AXIAL SKELETON and THE APPENDICULAR SKELETON

NOTE: Bones are classified several different ways. One of the most common ways is:

1. **Long bones** - know the following points about these bones:
 - a. determine the length of the extremities.
 - b. contains 2 epiphyses and 1 diaphysis.
 - c. more length than width.
 - d. ex. femur, humerus, radius, phalanges.
2. **Short bones** - know the following points about these bones:
 - a. width and length are almost the same in proportion.
 - b. ex. - tarsals & carpals
3. **Flat bones** - know the following points about these bones:
 - a. flexible and thin
 - b. ex. - most cranial bones (ex. parietal), sternum, ribs
4. **Sesamoid bones** - know the following points about these bones:
 - a. generally, roundish in appearance.
 - b. purpose - to reduce friction.
 - c. ex. - patella
5. **Irregular bones** - know the following points about these bones:
 - a. varied shapes that prevent them from being in the other categories.
 - b. ex. - vertebrae, some skull bones (ex. temporal), jaw bones.
6. **Other:**

Sometimes **sutural bones** are used as another category. These are bones which develop in the cranial sutures.

I. **The 2 Divisions of the Skeletal System** - (206 bones total).

1. **AXIAL SKELETON** (80 bones):

- a. **Skull** - 28 bones
 - 1.) cranium (8 bones)
 - 2.) facial bones (14)
 - 3.) 3 paired auditory ossicles (6)
- b. **Hyoid** - 1
- c. **Vertebral Column** - 26 or 33; depends on the classification method.
- d. **Ribs** - 24
- e. **Sternum** - 1

2. **Appendicular Skeleton** (126 bones).

- a. **Upper extremities (30 x 2 = 60) and their pectoral girdles (2 x 2 = 4).**
 - * Therefore, one upper extremity and its pectoral girdle = **32 bones**.
- b. **Lower extremities (30 x 2 = 60) and their os coxa (2 x 1 = 2).**
 - * Therefore, one lower extremity and its pelvic bone (os coxa) = 31 bones.

J. **Discussion of the Axial Skeleton** (80 bones).

1. **Skull** (28 bones)

- a. **Cranial bones** (8 bones but 2 are paired; therefore only 6 names).
 - 1.) **Frontal bone** (1) - know the following points about this bone:
 - (a.) forms the majority of the forehead and

foundation of bone under the eyebrow.

- (b.) contains frontal sinuses
- (c.) supraorbital foramen

2.) **Occipital bone (1)** - know the following points about this bone:

- (a.) forms the majority of the base of the skull.
- (b.) **occipital condyles** - articulate with the Atlas (C₁).
- (c.) **foramen magnum**

3.) **Sphenoid bone (1)** - know the following points about this bone:

- (a.) looks like a bat
- (b.) **only cranial bone to touch all other cranial bones.**
- (c.) **greater wings** and **lesser wings.**
- (d.) **sella turcica** - houses the pituitary gland.
- (e.) optic foramen
- (f.) superior orbital fissure
- (g.) "temple" bone
- (h.) contains foramen ovale

4.) **Ethmoid bone (1)** - know the following points about this bone:

- (a.) in the center of the skull.
- (b.) **perpendicular plate** - part of nasal septum.
- (c.) **superior concha** (turbinates) - 2 total.
- (d.) **middle concha** (turbinates) - 2 total.
- (e.) **cribriform plate** - contains openings for olfaction.
- (f.) **crista galli**
- (g.) ethmoid sinus

5.) **Parietal bones (2)** - know the following points about this bone:

(a.) forms the majority of the "roof" of the cranium.

(b.) **4 sutures** are associated with the 2 parietal bones. (see **sutures** - next page)

6.) **Temporal bones (2)** - know the following points about this bone:

(a.) **zygomatic arch (process)**

(b.) **petrous part** - houses the hammer, anvil, stirrup

(c.) **mandibular fossa** - for mandibular condyle (part of the **temporomandibular joint or TMJ**)

(d.) **mastoid process** - contain mastoid air cells

(e.) **external auditory meatus (canal)**

(f.) **carotid canal**

(g.) **jugular foramen**

(h.) **internal acoustic meatus**

(i.) **styloid process**

7.) **6 of the 28 skull bones are called ossicles.**

Their names are: **hammer (malleus), anvil (incus), and stirrup (stapes)**. They are located in the **temporal bones: 3/temporal bone**.

8.) **Sutures** - joints between skull bones which are immovable after the skull bones fuse together.

a.) **sagittal suture** - between the _____ and _____ bones.

b.) **squamous suture** - between the _____ and _____ bones.

c.) **coronal suture** - between the _____ and _____ bones.

- d.) **lambdoidal suture** - between the _____
and _____ bones.

9.) **Fontanelles (soft-spots)**

- a.) **names and locations:**

- b.) **functions:** allow for rapid brain growth
and they facilitate birthing

b. **Facial bones** (14 bones total, but because 6 are
paired, there are only 8 names).

1.) **Zygomatic bones (2)** - know the following points about this
bone:

- a.) form the **cheek bones**
b.) articulates with the temporal bone's
zygomatic process.

2.) **Lacrimal bones (2)** - know the following points about this
bone:

- a. in orbital cavity
b. **smallest facial bone**

3.) **Nasal bones (2)** - know the following points about this bone:

- a.) form **nose's bridge**
b.) in contact with the frontal bone and the
2 maxillas.

4.) **Maxillae bones (2)** - know the following points about this
bone:

- a.) unite to form the **upper jaw** (failure to
fuse - contributes to **cleft palate**).
b.) do not articulate with mandible.
c.) **palatine process**
d.) **alveolar processes**

5.) **Palatine bones (2)** - know the following points about this
bone:

- a.) **compose hard palate (posterior part of it).**
b.) **compose** part of the floor of the nasal cavity.
c.) **compose** part of the floor of the orbit.

6.) **Inferior nasal conchae (turbinates) (2)** -
know the following points about there bones:

- a.) **not part of ethmoid bone**
- b.) below middle conchae, and or lateral wall of nasal cavity.

7.) **Mandible (1)** - know the following points about this bone:

- a.) **largest and strongest bone of the face.**
- b.) **lower jaw**
- c.) contains **alveolar processes.**
- d.) part of the **TMJ**

8.) **Vomer (1)** - this bone forms the inferior and posterior part of the nasal septum.

c. **Orbits: consist of the following (7) bones:**
frontal, zygomatic, maxillae, lacrimal, ethmoid, sphenoid, palatine,

d. **Nasal septum - consists of the following:**

- 1.) ethmoid's perpendicular plate
- 2.) palatine bone
- 3.) maxillae
- 4.) vomer
- 5.) sphenoid
- 6.) hyaline cartilage

e. **Skull Sinuses**

1.) **2 groups:**

a.) **mastoid sinuses (1 pair):** part of temporal bones.

b.) **paranasal sinuses (4 pairs):**

(1.) **facts:**

- (a.) maxillary sinuses and sphenoid sinuses are not fully formed until the teenage years.
- (b.) lined in mucous and communicate with nasal cavity.

(2.) **names:**

- (a.) maxilla
- (b.) frontal
- (c.) ethmoid
- (d.) sphenoid

2.) **functions:**

- a.) used in voice production (**paranasal sinuses only**).
- b.) lighten the weight of the skull (**paranasal and mastoid sinuses**).

2. **Hyoid bone (1)** - know the following points about this bone:

- a. only "true floating" bone in the body.
- b. inferior to tongue's root.
- c. superior to larynx.
- d. used in muscle attachment between the tongue and the throat.

3. **Vertebral column (33 bones or 26 bones)**.

a. **vertebral structures:**

- 1.) **vertebral foramen** - contains the spinal cord and its meninges; composed of vertebral arch and body.
- 2.) **centrum (body)** - bears weight; anterior to vertebral foramen.
- 3.) **transverse process** - lateral to vertebral foramen; muscle and ligament attachment.
- 4.) **spinous process** - most posterior part; muscle and ligament attachment.
- 5.) **vertebral arch** - posterior part that forms the vertebral foramen; composed of 2 pedicles and 2 laminae.
- 6.) **facets** - surfaces used for articulations.
- 7.) **laminae** - form posterior arch of vertebral foramen.

- 8.) **intervertebral foramen** - lateral vertebrae openings through which blood vessels and spinal nerves pass.

b. **Vertebrae named and grouped:**

1.) **7 cervical vertebrae (C₁ - C₇):**

- a.) **atlas (C₁)** - articulates with the occipital condyles.
- b.) **axis (C₂)** - articulates with the atlas and C₃; contains the **dens** (odontoid process).
- c.) **vertebra prominens (C₇)** - usually very visible; long spinous process
- d.) **transverse foramen** - only in cervical vertebrae; for blood vessels

2.) **12 thoracic vertebrae (T₁ - T₁₂):** rib attachment

3.) **5 lumbar vertebrae (L₁ - L₅):** equipped for bearing a lot of weight.

4.) **1 sacrum** - consists of 5 fused vertebrae (**S₁ - S₅**).

5.) **1 coccyx** - consists of 4 fused vertebrae (**Co₁ - Co₄**).

Which <u>vertebrae</u> is the <u>largest</u> , and which <u>single</u> is the <u>smallest</u>

- c. **intervertebral discs** - located between the bodies of the vertebrae.

d. **Curves Associated with the Vertebral Column.**

1.) **Standard curves:**

- a.) **cervical curve** - at birth, it is concave when viewed A/P; becomes convex so that infant can hold head up.
- b.) **thoracic curve** - concave when viewed A/P.
- c.) **lumbar curve** - at birth, it is concave when viewed A/P; becomes convex so that infant can stand.
- d.) **sacral curve** - concave when viewed A/P.
- e.) **coccygeal curve** - concave when viewed A/P.

2.) **Variations in the Curves of the Vertebral Column:**

- a.) **scoliosis** - abnormal lateral curvature of spinal column.
- b.) **kyphosis** - severely "hump-shouldered" and/or "hunch-back"; abnormal thoracic curvature.
- c.) **lordosis** - "sway-back"; abnormal lumbar curvature.

4. **Ribs (12 pairs or 24 total):**

- a. **true ribs** - 14 total (7 pair); each touches the sternum with its own piece of cartilage.
- b. **false ribs** - 10 total (5 pair); share cartilage to the sternum (pair #8, #9, #10,) or do not touch the sternum at all (pair #11 and #12).
- c. **floating ribs** - 4 total (2 pair); pair #11 and #12; do not touch the sternum.
- d. **intercostal spaces** - space between ribs; filled with muscles, some nerves, and some vessels.

5. **Sternum (1) - (breastbone);** consists of 3 parts:

- a. **manubrium** - articulates with rib pair #1 and with both clavicles.
- b. **sternal angle** - between manubrium and body; where rib pair #2 attaches to sternum.
- c. **body** - articulates with rib pairs #2 - #7.
- d. **xiphoid process** - inferior end; has no rib attachment.
- e. **sternal (jugular) notch**

6. **CLINICAL POINTS REGARDING THE AXIAL SKELETON**

K. **Discussion of the Appendicular Skeleton - (126 bones).**

- 1. **Upper Extremity** - 60 bones in the 2 extremities or 30 bones/extremity (numbers do not include the pectoral girdle).

a. **Shoulder (Pectoral) Girdle** - consists of the clavicle and scapula:

1.) **Clavicle** (2 total) - also called **collarbone**.

- a.) **NOTE**: most commonly broken bone.
- b.) **medially**, the clavicle articulates with the manubrium of the sternum
- c.) **laterally**, the clavicle articulates with the acromion process of the scapula.

2.) **Scapula** (2 total):

- a.) also called the **shoulder blade**.

- b.) **Parts** of the scapula you should know:

- (1.) **glenoid cavity (fossa)** - receives the head of the humerus.
- (2.) **spine** - laterally it becomes the acromion process.
- (3.) **acromion process** - most lateral projection.
- (4.) **supraspinous fossa** - above the scapular spine.
- (5.) **infraspinous fossa** - below the scapular spine.
- (6.) **subscapular fossa** - on anterior surface.
- (7.) **coracoid process** - on anterior surface.
- (8.) **vertebral border** - medial border.
- (9.) **axillary border** - lateral border.
- (10.) **scapular notch**
- (11.) **other**:

b. **Humerus** - arm bone

- 1.) **head** - fits into glenoid fossa.
- 2.) **capitulum** - distal end (**lat.**) - articulates with radius.
- 3.) **trochlea** - distal end (**med.**) - articulates with ulna.
- 4.) **olecranon fossa** - receives the **elbow** (olecranon process of ulna).
- 5.) **other points to know:**
 - a.) longest bone of upper extremity.
 - b.)

c. **Radius** - on lateral aspect of forearm.

- 1.) **head** - flat; articulates with **capitulum**.
- 2.) **styloid process** - lateral distal end.

d. **Ulna** - On the medial aspect of forearm

- 1.) **semilunar (trochlear) notch** - where trochlea fits.
- 2.) **olecranon process** - "elbow"; the proximal end of the ulna.
- 3.) **styloid process** - medial distal end.
- 4.) **Other points to know:**
 - a.) longer than the radius.
 - b.) **head** is at distal end.

e. **Carpals or wrist bones (8)** - there are 2 rows (of 4 bones per row)

f. **Metacarpals (5)**

- 1.) hand (palm) bones

- 2.) numbered #1 through #5 (starting with lat. being #1).
- 3.) their heads are commonly called **knuckles**.

g. **14 Phalanges (or finger bones)per hand**

- 1.) **pollex** - thumb
- 2.) **phalanges** - 3/finger; 2/thumb
- 3.) **other points to know**: proximal and distal

2. **Lower Extremity** - 60 bones total or 30 bones/extremity.
(This number does not include the pelvic girdle.)

a. **os coxa**: it has 3 joints associated with it ____, _
____, and _____.

- 1.) **pubic symphysis** - anterior joint where hipbones are united.
- 2.) **When we are born**, our os coxa is composed of 3 parts:
 - a.) **ischium** - lower part
 - b.) **ilium** - lateral part
 - c.) **pubis** - anterior part

* **acetabulum** - fossa where the 3 parts fuse; and it receives the head of the femur.

- 3.) **ilium** - contains the **iliac crest** and **2 iliac spines** (anterior superior and anterior inferior).
- 4.) **ischium** - contains the **ischial spine**, **2 sciatic notches** (greater and lesser), and the **ischial tuberosity**.
- 5.) **pubis** - contains the **superior and inferior pubic rami** (ramus is singular), and the **pubic symphysis**.
- 6.) **obturator foramen** -

7.) **pelvic girdle** - sacrum, coccyx, and the
2 hipbones (2 os coxa)

a.) **false (greater) pelvis** - the part above
the pelvic brim.

b.) **true (lesser) pelvis** - the part below
the pelvic brim.

c.) **Male pelvis compared to the female
pelvis**

(here are a few of the differences):

- (1.) symphysis pubis
- (2.) pelvic inlet
- (3.) ilium's angle

b. **femur** - (thighbone)

1.) **head** - fits into the acetabulum.

2.) **neck** - between head and trochanters; **if broken,
it is a broken hip.**

3.) **medial and lateral condyles** - distal and
posterior.

4.) **medial and lateral epicondyles** - distal and
lateral.

5.) **greater trochanter** - proximal and lateral.

6.) **lesser trochanter** - proximal, medial, and
posterior.

7.) **other facts:** longest and strongest bone in
body.

c. **patella** - (kneecap)

1.) **function** - muscles attachment; protection of
knee joint.

2.) **largest sesamoid bone** in the human skeleton.

d. **Tibia** - (shinbone) - bears most of the weight
between it and fibula.

- 1.) medial **leg** bone
- 2.) **lateral and medial condyles**
- 3.) **articulates with the following bones:** condyles of femur (proximally) and talus (distally).
- 4.) **Medial malleolus** - distal end which forms the medial ankle.

e. **fibula**

- 1.) lateral **leg** bone
- 2.) **lateral malleolus** - distal end which forms the lateral ankle.

f. **7 tarsal bones** - also called ankle bones

- 1.) **calcaneous** - heel bone
- 2.) **talus** - uppermost tarsal

g. **5 metatarsal bones** - form the sole of the foot and most of the longitudinal arch.

- 1.) **head** - distal; form "**ball of foot**".
- 2.) **base** - proximal end; next to tarsals
- 3.) numbered #1 through #5 (beginning with the medial).

h. **14 phalanges per foot:**

- 1.) **hallux** - big toe; contains 2 phalanges
- 2.) other toes have 3 phalanges
- 3.) **head** - distal end

i. **other facts about the foot:**

- 1.)
- 2.)

L. **ARTICULATIONS (JOINTS)**

1. Points of contact between bone and cartilage, bone and bone, or bone and teeth.

2. **Anatomical Classification:**

- a. Fibrous
- b. Cartilaginous
- c. Synovial

3. **Physiological Classification:**

a. **synarthrosis**

- 1.) **definition** - joints which do not move.
- 2.) **examples:**
 - a.) **suture** - units skull bones.
 - b.) **gomphosis** - bone to tooth (tooth socket)

b. **amphiarthrosis**

- 1.) **definition** - joints which have a little movement.
- 2.) **examples:**
 - a.) **symphysis** - symphysis pubis
 - b.) **syndesmosis** - distal articulation of fibula and tibia

c. **diarthrosis**

- 1.) **definition** - joints which freely move; **synovial joints**.
- 2.) **examples:**
 - a.) **gliding joint** - carpal to carpal movement
 - b.) **hinge joint** - knee movement, elbow movement
 - c.) **pivot** - radius & ulna movement at their proximal ends

- d.) **ellipsoidal** - carpals move (as a group) against the radius & the ulna
- e.) **saddle joint** - movement of the thumb's metacarpal to a carpal
- f.) **ball-and-socket** - movement of the femur in the acetabulum; movement of the humerus in the glenoid fossa

3.) **Bursae** -

M. **SPECIAL MOVEMENTS** - occurs at joints (via muscle actions on those joints):

1. **inversion** - to turn the sole of the foot medially
2. **eversion** - to turn the sole of the foot laterally
3. **dorsiflexion** - to raise the top of the foot superiorly
4. **planter flexion** - to lower the foot (toward the ground)
5. **protraction** - to protrude a part of the body anteriorly
6. **retraction** - to return a protruded part back to its original position
7. **supination** - to turn the palm (and anterior forearm) anteriorly
8. **pronation** - to turn the palm (and forearm) posteriorly
9. **elevation** - to raise a part of the body
10. **depression** - to lower a part of the body
11. **flexion** -

- 12. extension -
- 13. abduction -
- 14. adduction -
- 15. circumduction -
- 16. rotation -

Chapter 6 -- The Muscular System

Textbook Chapter: _____

A. MUSCLE ANATOMY

1. SKELETAL MUSCLE ANATOMY:

Muscle Structure	Associated Connective Tissue
entire muscle	surrounded by epimysium
fasciculi (a bundle of muscle cells)	surrounded by perimysium
muscle cell (muscle fiber)	surrounded by endomysium

a. ANATOMY OF THE SKELETAL MUSCLE CELL

- 1.) endomysium (previously discussed)
- 2.) contains several-to-many nuclei/cell
- 3.) sarcolemma - muscle cell membrane
- 4.) sarcoplasm - muscle cell cytoplasm
- 5.) T-tubules - tubes from sarcolemma to the sarcoplasm; carries the signal (stimulation) for contraction deep into the sarcoplasm
- 6.) myofibril - tubules or cylinders within the muscle cell that shorten (contract)
 - a.) enclosed by SR (sarcoplasmic reticulum)
 - b.) contain myofilaments (actin & myosin)
 - (1.) thin-filaments - composed of these proteins: **actin**, **tropomyosin**, and **troponin**.
 - (a.) actin - majority protein
 - (b.) tropomyosin - is able to prevent the myosin and actin from interacting.
 - (c.) troponin - binds calcium and holds the troponin-tropomyosin complex in position.

(2.) **thick filaments** - composed of **myosin** molecules (a protein).

(a.) contains a head, hinge, and tail.

(b.) **cross-bridges** - "myosin heads" interacting with thin filaments during contraction.

(c.) the hinge allows the head to pivot (pivoting is very important in muscle contraction).

7.) **sarcomere** - the organized, functional unit of myofilaments.

a.) sarcomeres link together to form the myofibril.

*b.) **the actual functioning unit of the muscle**; its components (thick and thin filaments) actually cause muscle contraction.

c.) **anatomy of the sarcomere**:

(1.) **A (anisotropic) band**

(a.) centrally located

(b.) its width is the length of myosin (thick filaments).

(c.) called **dark bands**

(2.) **I (isotropic) band**

(a.) from one A band to the next A band

(b.) called **light bands**

(c.) Z line is in the center of it

(3.) **Z lines** - boundary between 2 sarcomeres; separates 2 sarcomeres:

(a.) **Therefore, it can be said that a sarcomere's boundaries are from z line to z line.**

(b.) 2 transverse tubules circle each sarcomere in the region of overlap (for calcium release in muscle contraction).

(c.) the **striations (striping)** seen in skeletal and cardiac muscle can be generally said to be **due**

to the alignment of the A and I bands; specifically, it is said to be due to the z lines (where thin filaments, actins, inter-connect).

(4.) M line

- (a.) the center line in the A band.
- (b.) composed of protein.
- (c.) in the center of the sarcomere.

- b. **Sliding Filament Theory** - this theory is the explanation for the changes that occur during muscle contraction (see Muscle Contraction, B.₂).

2. **ANATOMY OF THE CARDIAC MUSCLE:**

- a. organized myofibrils
- b. striated
- c. one nucleus/cell
- d. T-tubules are located at the z line (remember, in skeletal muscle the T-tubules are located at the zone of overlap).
- e. **Sarcoplasmic reticulum:**
 - 1.) lack terminal cisternae
 - 2.) its tubules are in contact with T-tubules and the cell membrane
- f. Thrive on aerobic metabolism (consists of many mitochondria and myoglobin proteins).
- g. **intercalated discs** - location for cardiac muscle cell contact and interaction:
 - 1.) contain gap junctions and desmosomes.
 - 2.) where the electrical connection occurs between cardiac cells.
- h. **pacemaker cells** - specialized cardiac muscle cells that time the contraction of cardiac muscle tissue; therefore, cardiac muscle tissue

contracts without neural stimulation.

- i. Cardiac muscle tissue **cannot** have tetanic contractions.
- j. Contraction lasts **longer** in cardiac muscle than in skeletal muscle.

3. ANATOMY OF THE SMOOTH (VISCERAL) MUSCLE:

- a. one nucleus/cell
- b. shape: tapered on each end
- c. T-tubules are not present
- d. myofibrils are not arranged in an organized manner.
- e. no striations
- f. no sarcomeres
- g. Contains myosin and actin with the actins attached to dense bodies (anchors).
- h. Smooth muscle cells are attached to each other at their dense bodies.

4. Skeletal muscles are attached at two ends:

- a. origin - the end of the muscle that is anchored (less moveable end)
- b. insertion - the more moveable end

* <u>general pattern</u> - the insertion moves toward the origin (during contraction)

- c. belly - the bulk of the muscle that is located between the origin and the insertion.

B. MUSCLE PHYSIOLOGY

1. **FUNCTIONS OF THE 3 MUSCLE TYPES:**

a. **Some General Functions of Skeletal Muscle:**

- 1.) to move the skeletal system (thus, moving the body).
- 2.) to speak
- 3.) to contribute toward the beginning of the swallowing reflex.
- 4.) to physically move the eyes.
- 5.) to maintain the desired body position (posture).
- 6.) to open and close some body sphincters.
- 7.) to cover (and thus protect) some deeper tissues and organs.
- 8.) gives a major contribution to the body's overall shape

b. **Some General Functions of Smooth (Visceral) Muscle:**

- 1.) to move material along various systems: such as in the digestive, urinary, reproductive, respiratory, and circulatory systems.
- 2.) to contribute to the swallowing reflex.
- 3.) to focus the eye.
- 4.) to respond to the autonomic nervous system (ex. - arrector pili muscles, eye responses, systems (ex. - digestive responses).
- 5.) to open and close some body sphincters.
- 6.) to enable certain organs to functions.

c. **Function of Cardiac Muscle:**

to cause the heart to pump blood into the circulatory system

* **REMEMBER** - all muscle contraction (and its metabolism) produces heat for the body.

2. **Muscle Contraction:**

- a. CNS involvement in which a motor nerve's stimulation reaches its distal axon endings adjacent to the muscle cell's sarcolemma.
motor unit - all the muscle fibers (muscle cells which are stimulated ((innervated) by one motor neuron).
- b. This stimulation causes the distal motor neuron to secrete a neurotransmitter (the neurotransmitter is **acetylcholine** in skeletal muscle).
- c. An **action potential** results due to the neurotransmitter's presence on the sarcolemma; this action potential opens up channels in the sarcolemma and sodium ions enter the muscle cell in large amounts (**causes muscle depolarization**).
- d. Sodium's presence within the muscle cell results in the action potential traveling down the T-tubules (**see n. on outline**) causing the SR (sarcoplasmic reticulum (**see m. on outline**) to release calcium (which then binds to troponin).
- e. **Calcium initiates the movement between actin and myosin; that is, it initiates (muscle contraction).**
- f. **Troponin** then alters its position (which pulls tropomyosin away from the **active site on the actin**).
- g. The **myosin's heads** bind to the actin's active sites (**creating cross bridges**).
- h. Energy (from ATP) is now released; a new ATP binds to the head and helps to break the link-hook-up between the myosin's head and the actin's active sites (at the cross bridges).
- i. Myosin's heads are now free to bind another actin's active site. (thus pulling the thin filaments along).
- j. Actin then pulls on the thin filament (between myosin heads).
- k. The thin filament will eventually pull the Z line toward the ends of the

myosin (Z lines move toward each other) causing muscle contraction.

l. Strength of contraction increases proportionally with the number of cross bridges pulling on the thin filament's (actin's) active sites.

m. When a muscle contracts, only a fraction of the cross bridges are attached at a particular time.

n. **Sarcoplasmic Reticulum:**

1.) It is a type of endoplasmic reticulum (contains calcium).

2.) **Stimulation to release calcium for muscle contraction:**

neural stimulation → creates an action potential → travels across sarcolemma and down T-tubules → stimulates sarcoplasmic reticulum to release calcium → troponin → ... and eventually muscle contraction results.

o. **T-tubules:**

1.) extensions from the cell membrane that contain extracellular fluid.

2.) run at 90° to the myofibrils.

3.) transmission of the neural stimulation penetrates deep within the muscle via the T-tubules.

4.) **2 T-tubules/sarcomere (location: at the A band - I band junction).**

5.) adjacent to the sarcoplasmic reticulum.

3. **Muscle Relaxation:**

a. An enzyme (**acetylcholinesterase**) breaks down acetylcholine (the neurotransmitter).

* **BOTULISM** - blocks release of acetylcholine

* **TETANUS** - blocks acetylcholinesterase

b. **Therefore, for muscle contraction to continue, neural stimulation (with resulting action potentials) must continue and calcium concentration (from SR) must remain high in the sarcoplasm.**

c. Soon after it releases the calcium (and without further stimulation), the SR will begin to reabsorb the calcium in the sarcoplasm → calcium is released from troponin (which then returns to its former position) →

tropomyosin covers the active sites on the actins → **contraction ceases (muscle is now repolarized)**.

4. Definitions and Characteristics of Muscle Contraction.

- a. **REMEMBER!** a muscle cell is also called a muscle fiber.
- b. twitch - one stimulus produces one contraction, and then muscle relaxation follows; a brief involuntary muscle fiber contraction.
- c. summation - adding two or more twitches together to increase overall muscle contraction; frequent repetition of stimuli used to cause a response.
- d. tetanus - when the stimulation to the muscle arrives with such frequency that there is no relaxation between twitches; this produces a smooth and sustained contraction (thus, normal muscular contraction); also a disorder marked by intermittent muscle spasms.

* **NOTE** - the amount of muscle contraction and its strength are related to the amount of stimulation, the frequency of stimulation, the number of muscle fibers (cells) involved in the contraction, and the actual anatomy of the muscle fibers involved.

- e. tone:
 - 1.) muscle firmness (or muscle tension) when the muscle is relaxed (assuming no pathological or neurological problems).
 - 2.) due to some motor unit stimulation within the muscle at all times.
 - 3.) helps keep the body's posture and balance.
 - 4.) range: good (**hypertonic**) - to - poor (**hypotonic or flaccid**).
- f. treppe (staircase) after relaxation, when a muscle is stimulated to contract, each successive contraction causes the muscle tension to build and the contraction to become stronger (up to a point) (principal applied when athletes "warm up").
- g. isometric contraction - muscle tension increases but no movement occurs (ex. - in an extremity: synergist contracts as an antagonist contracts).
- h. isotonic contraction - actual muscle contraction; however, during the contraction the tension remains almost the same (ex. - weight lifting).
- i. hypertrophy - increase in muscle size (mass).
- j. atrophy - decrease in muscle size (mass).

- k. **rigor mortis**: - occurs after death.
 - 1.) all cross bridges (to actins) are attached.
 - 2.) there is no ATP to help break these attachments.
 - 3.) the enzyme released by lysosome destruction (after death) end rigor mortis as they breakdown muscle structure.
- l. **neuromuscular junction** - union of the neuron's axon and the sarcolemma.
- m. **motor end plate** - specific part of the sarcolemma that is in contact with the terminal part of the neuron's axon.

5. **Energy for Muscle Contraction:**

* Remember, <u>glycogen</u> is stored glucose.

- a. **Resting Muscle Metabolism:**
 - 1.) **mostly aerobic** - requires oxygen.
 - 2.) involves the metabolism of fatty acids for ATP (via mitochondria's Krebs cycle).
- b. **Contracting Muscle Metabolism:**
 - 1.) **both aerobic and anaerobic (via glycolysis).**
 - 2.) **glycolysis** - glucose breakdown to pyruvic acid to produce ATP.
 - 3.) also involves the breakdown of **glycogen** (human starch) to glucose, and then to pyruvic acid; (and with low O₂) pyruvic acid is converted to **lactic acid** with some ATP formation. (**see anaerobic formation below**).

4.) **that is:**

a.) **with enough O₂ (AEROBIC)** - muscle

contraction energy comes from: glycogen →
glucose → 2 pyruvic acids → Krebs's cycle
→ ...

* also, fatty acid metabolism is involved.

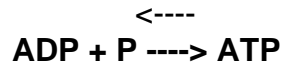
b.) **without enough O₂ (ANAEROBIC)**, energy for
muscle contraction comes from:

glycogen → glucose → 2 pyruvic acid — { → lactic acid
(in cytoplasm) { → 2 ATPs

* **this mainly occurs in the cytoplasm.**

* **NOTE**: after contraction, conditions which produced lactic acid are reversed and the muscle rests (**recovery period**); lactic acid is converted by the liver into glucose (**gluconeogenesis**) or into ATP via pyruvic acid entering the Krebs's cycle (TCA cycle).

c.) **creatine phosphate** - energy compound which
contributes a phosphate (energy) for ADP; ADP then is restored to ATP:



d.) **oxygen delivery proteins:**

(1.) **hemoglobin** - part of the RBC.

(2.) **myoglobin** - present in muscle tissue.

6. **General Categories of Skeletal Muscle Fibers (Cells).**

a. **Slow-Muscle Fiber (Cell) Category:**

- 1.) have a resistance to fatigue.
- 2.) have an extensive blood supply.
- 3.) many mitochondria (therefore, function aerobically).
- 4.) lots of myoglobin (muscle appears reddish).
- 5.) smaller than fast-muscle fibers.
- 6.) posture muscles

b. **Fast-Muscle Fiber (Cell) Category:**

- 1.) less blood and fewer mitochondria than slow muscle fiber.
- 2.) fewer myoglobin proteins (muscle appears whiter).
- 3.) function anaerobically
- 4.) larger than slow-muscle fibers.
- 5.) fatigues faster
- 6.) active muscles

* **NOTE:** most skeletal muscles have **both** fiber types in their anatomy.

7. **The Major Actions of Skeletal Muscles:**

- a. **prime mover (agonist)** - when it contracts it gives the person the action he/she desires (ex. – it causes flexion or extension at a joint).
- b. **synergist** - assists a prime mover (agonist) in producing the desired movement.
- c. **antagonist** - functions with an opposite contraction from the prime mover's (agonist's) desired contraction; therefore, when the prime mover is contracting, the antagonist muscle relaxes or offers little resistance.

* **NOTE**: a muscle can be a prime mover for one movement and an antagonist for another.

8. **Nerves associated with muscle:**

- a. **Somatic afferent nerves** - to the C.N.S. from skeletal muscle
- b. **Somatic efferent nerves** - to skeletal muscle from the C.N.S.
- c. **Visceral afferent nerves** - to the C.N.S. from smooth or cardiac muscles
- d. **Visceral efferent nerves** - to smooth or cardiac muscle from the C.N.S.

9. **Periods of muscle contraction:**

- a. **latent period** - period of relaxation before contraction polarization.
- b. **contraction period** - period of contraction/activation depolarization.
- c. **relaxation period** - period that follows activation repolarization.
- d. **refractory (recovery) period** - cardiac prolonged, smooth medium, skeletal short.

10. **Terms to know:**

- a. **tendon** -
- b. **ligament** -
- c. **aponeurosis** -
- d. **excitability** (irritability) -
- e. **extensibility** -
- f. **elasticity** -

g. fibrillation -

h. convulsion -

i. spasm -

j.

k.

l.

11. **Medical/Clinical Muscle Disorders/Diseases:** (look these up)

a. muscular dystrophy -

b. muscular sclerosis -

c. myasthenia gravis -

d. myalgia -

12. **Muscle actions** - Review m. under "**Skeletal Movements...**"

* Here are some examples. Review the list of these under **k. in the skeletal note section** and relate the muscles actions to bone movements.

a. **adductors** - muscles that move bones toward the body.

- b. **abductors** - muscles that move bones away from the body (generally in a lateral direction).
- c. **flexors** - muscles that decrease the angle (at a joint) between bones.
- d. **extensors** - muscles that increase the angle (at a joint) between bones.
- e. **levators** - muscles that raise a part of the body.
- f. **depressors** - muscles that lower a part of the body.
- g. etc....

13. **Naming Skeletal Muscles**

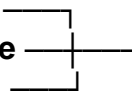
The skeletal muscles will be named and taught in laboratory. **As for the lecture exam, you should be able to:**

- a. **give the location** for any muscle you studied in laboratory example - which of the following is a muscle of the face? of the upper extremity? of the thorax? of the abdomen? etc..)
- b. know the muscles in the **quadriceps femoris** group.
- c. know the muscles in the **hamstring** group.
- d. various criteria for naming skeletal muscles

Chapter 7, The Nervous System

Textbook Chapter: _____

A. MAJOR FUNCTIONS:

1. **Control**
 2. **Coordinate**
 3. **Integrate**
- 
- Functions in all body activities.

B. Major Subdivisions and their structures.

1. **Central Nervous System (CNS)** - THE control center for the entire system. Consist of:
 - a. **Brain** - primary center for regulating and coordinating body activities. (THE COMPUTER)
 - b. **Spinal Cord** - center of reflex action containing the conducting paths to and from the brain. (THE TAIL OF THE BRAIN)
2. **Peripheral Nervous System (PNS)** - convey impulses to and from the brain (cranial nerves) or spinal cord (spinal nerves). Consist of:
 - a. **Afferent (Sensory) division** - sensory neurons conduct information toward the C.N.S.
 - b. **Efferent (Motor) division** - motor neurons conduct information away from the C.N.S.
 - 1.) **Somatic Nervous System (SNS)** - consists of efferent neurons that conduct impulses from the C.N.S. to skeletal muscles, and is under conscious control.
 - 2.) **Autonomic Nervous System (ANS)** - consists of efferent neurons that conduct impulses from the C.N.S. to smooth muscle, cardiac muscle, and glands. Usually not under conscious control. Subdivided into:
 - a.) **Sympathetic Nervous System**
 - b.) **Parasympathetic Nervous System**

C. Cells in the Nervous System:

1. **Neuroglial cells** - support and protect the nervous system Include:

- a. **Astrocytes** - most numerous, star shaped bodies, that play a major role in the transfer of materials to and from circulation (so-called **blood brain barrier**). Attaches neurons to their blood vessels.
 - b. **Oligodendrocytes** - functions in myelination of the C.N.S.
 - c. **Ependymal cells** - cellular layer of epithelial cells that line the ventricles of the C.N.S., modified to produce cerebrospinal fluid; therefore, are also cells of choroid plexus.
 - d. **Microglia** - small phagocytic cells derived from connective tissue. They play a role in the destruction of dead tissue and defense against microorganisms.
2. **Neurons** - structural and functional units of the nervous system. Neurons conduct action potentials. 3 major structures of a neuron:
- a. **Cell body** - central portion containing the nucleus, nucleolus, and other organelles.
 - 1.) **Nissl bodies** - condensations of rough endoplasmic reticulum (RER) which form dark staining bodies. They contain RNA and protein, and functions in protein synthesis.
 - 2.) **Neurofibrils** - slender rod-like structures composed of microtubules and fibrils; they play a role in cell support and release of neurotransmitters.
 - 3.) **Nucleus**
 - 4.) **Nucleolus**
 - b. **Dendrites** - highly branched, short cell processes which conduct action potentials toward the cell body, (they contain Nissl bodies).
 - c. **Axon** - one long cell process which conducts action potentials away from the cell body (they do not contain Nissl bodies).
 - 1.) **Myelin Sheath** - white, fatty covering of axons produced by Schwann Cells in the P.N.S.; insulates and protects the axons.
 - a.) **Schwann Cells** - produce myelin in the P.N.S.
 - b.) **Oligodendrocytes (neuroglia)** - produce myelin in the C.N.S.

- 2.) **Nodes of Ranvier** - unmyelinated segments of an axon where nerve impulses are produced.
- 3.) **Neurolemma** - outermost membrane, the cell membrane of a neuron's Schwann cell. It covers the myelin sheath.
- 4.) **Synapse** - where end fibers of the axon of one cell body meet the end fibers of the dendrite of another. Junction between two neurons.

j. **Classification of neurons (based on function and structure)**

- 1.) **Functional (Physiological) Classification** - according to the direction in which the impulse is traveling.
 - a.) **Motor (Efferent) Neurons** - transmit impulses from the C.N.S. to the effected site.
 - b.) **Sensory (Afferent) Neurons** - transmit impulses from the effected site to the C.N.S.
 - c.) **Interneurons - (Associate Neurons)** - found in the C.N.S. and connect sensory neurons to motor neurons.
- 2.) **Structural (Anatomical) Classification** - according to the number of processes extending from the cell body.
 - a.) **Multipolar Neurons** - most common type have several dendrites and one axon extending from the cell body (ex. - motor neurons).
 - b.) **Bipolar Neurons** - have two processes, one dendrite and one axon extending from the cell body; relay information concerning special senses.
 - c.) **Unipolar Neurons** - dendrite and axonal process are continuous and both come off the cell body.
* Sensory neurons are usually unipolar.

k. **Receptors** - may be the processes of specialized sensory neurons.
Classification of Receptors:

- 1.) **Exteroceptors** (outside) - located near surface, provide information about the external environment: touch, temperature, hearing, vision, smell, etc.
- 2.) **Interoceptors** (inside) - provide information about the internal environment, and located in the digestive, respiratory, cardiovascular, urinary, and reproductive systems; deep pressure and pain.
- 3.) **Proprioceptors** - provide information about the position and movement of skeletal muscles and joints.

D. Nerve Impulse - depends on polarization and depolarization of the neuronal membrane (as seen in muscle contraction).

1. **Membrane Potentials** - are indicated by the difference between the amount of ion concentration outside the plasma membrane.
 - a. **Polarization** - potassium (K^+) ions are highly concentrated inside cell, and sodium (Na^+) ions are highly concentrated outside cell. (resting state)
 - b. **Depolarization** (stimulation of nerve cell):
 - 1.) allows for transport of Na^+ across the cell membrane and into the cell, and K^+ outside of cell.
 - 2.) Transportation mechanism is called the "**sodium- potassium pump**."
 - c. **Repolarization** - return of ions to the polarized state.
2. **Action Potential** - is initiated after depolarization has taken place. It is the principle way in which neurons communicate.
3. **Refractory Period** - when a nerve receives a second stimulus at such a close interval that no response will occur. The nerve must have sufficient time to recover from the initial stimulus before receiving an additional one.
4. **All or none response** - If a stimulus is strong enough to initiate an action potential the impulse will travel along a neuron until its transmission is complete.
5. **Saltatory conduction** -

E. Segments of Nervous Tissue:

1. **White Matter** - group of myelinated nerve fibers and associated neuroglia.
2. **Gray Matter** - contain cell bodies and unmyelinated nerve fibers.
3. **Nerve** - a group of nerve cells (neurons) located outside the C.N.S.
4. **Tracts** (pathways) - A group of nerve cells (neurons) located inside the C.N.S.
 - a. **Ascending Tracts** - conduct sensory impulses up the spinal cord to the brain.
 - b. **Descending Tracts** - conduct motor impulses down the spinal cord.
5. **Ganglion** - a collection of neuron cell bodies located in the P.N.S. (that is, outside the C.N.S.).

6. **Nucleus** - a collection of neuron cell bodies located inside the C.N.S.
 7. **Horns** - areas of gray matter located in the spinal cord.
 - a. **Posterior (dorsal) gray horns** - contain sensory nuclei.
 - b. **Anterior (ventral) gray horns** - contain motor nuclei.
- F. **Spinal Cord** - an ovoid column of nervous tissue about 18 inches long. It extends from the medulla oblongata to the 2nd lumbar vertebra.
1. **Cervical Enlargement** (C₄ - T₁) - nerves arising from this region are associated with the upper extremities.
 2. **Lumbar Enlargement** (T₉ - L₁) - nerves arising from this region are associated with the lower extremities.
 3. **Cauda Equina** - after the terminal portion of the spinal cord; composed of the roots of the spinal nerves below the 1st lumbar nerve.
 4. **Conus Medullaris** -
 5. **Grey Horns** (previously discussed - see E.7.)
 6. **Columns of white matter**
 - a. **Dorsal Columns** -
 - b. **Lateral Columns** -
 - c. **Ventral Columns** -
 7. **Denticulate ligaments** - extensions of pia mater to dura mater; prevent lateral movement of cord.
 8. **Filum terminale** -
- G. **Protection of the C.N.S.**
1. Bony cranium (8 bones) and vertebral column.
 2. Meninges - 3 membranes.
 3. Cerebrospinal Fluid (C.S.F.).
- H. **Meninges** - are membranes surrounding the C.N.S. and function in protection. There are three meninges:
1. **Dura mater** (tough mother) - a tough outer layer which is fused with the periosteum of the cranial bones and vertebrae; ends at S₂.

- a. **Epidural space** - between skull or vertebra and the dura mater; contains a protective padding of adipose tissue.
- b. **Subdural space** - narrow space that separates the dura mater from the next meninges (arachnoid).
2. **Arachnoid** (spider layer) - the second or middle membrane. It is very delicate and sends webs down to the pia mater. It ends at S₂.
- NOTE: Subarachnoid space** - separates the arachnoid layer from the inner meninge (pia mater); this space is filled with C.S.F.
3. **Pia mater** (delicate or soft mother) - the innermost meningeal membrane. It is very thin and delicate, and is tightly attached to the surface of the brain and spinal cord. It ends at L_{1 1/2} (except for filum terminale).
4. **Meningitis** - inflammation of the meninges; generally due to bacteria or virus.
5. **Spinal Tap**

I. **Reflex arc** - a neural pathway between the point of stimulation (receptor), to the brain or spinal cord, and to the responding organ (effector). **The following are necessary components of a reflex arc:**

1. **Receptor** - receives the stimulation; the beginning of the dendrite of the sensory neuron (see "Receptors" on page ____).
2. **Sensory neuron** - carries impulse from the receptor to the C.N.S.
3. **Interneuron** - connects sensory neurons to motor neurons (in the spinal cord).
4. **Motor neuron** - carries impulse from the C.N.S. to the effected site.
5. **Effector** - site in the body that responds to the motor impulse (receives the motor neuron's stimulation).

J. **Reflexes** can be used to diagnose and identify certain injuries of the nervous system. Some types of reflexes:

1. **Patellar reflex (knee jerk)** - extension of lower leg in response to tapping on the knee. (contraction of quadriceps femoris). Damages to the 2nd, 3rd, or 4th lumbar regions could affect this reflex.
2. **Babinski reflex** - dorsiflexion of great toe upon stimulating the sole of the foot. Normal in children 1 1/2 years and younger. Nervous system has not completely developed. Abnormal if occurs after 1 1/2 years. problem in C.N.S.

K. Spinal nerves - nerves arising from the spinal cord. Each spinal nerve is attached to the spinal cord by two roots: a dorsal or posterior root and a ventral or anterior root.

1. There are **31 pairs of spinal nerves** and they are named and numbered according to the region and level of the spinal cord from which they arise:
 - a. **8** pairs of cervical nerves.
 - b. **12** pairs of thoracic nerves.
 - c. **5** pairs of lumbar nerves.
 - d. **5** pairs of sacral nerves.
 - e. **1** pair of coccygeal nerves.
2. **Spinal Nerve Coverings** - connective tissue coverings:
 - a. **Endoneurium** - connective tissue covering of an axon (individual nerve cell).

(NOTE): Fascicles - are bundles (groups) of axons with their endoneuriums.
 - b. **Perineurium** - connective tissue covering of fasciculus (fascicles).
 - c. **Epineurium** - connective tissue around the entire nerve.

(NOTE): Axon = nerve fiber = nerve cell
3. A spinal nerve splits right after it is formed into a **dorsal ramus** (goes to the posterior part of the body) and a **ventral ramus** (goes to the anterior part of the body)
 - a. The **anterior ramus** get together and form **plexuses**.
 - b. The **plexus** will yield **nerves** which represent their composition (or most of it) to the front and the side of the body. It is a grouping of anterior rami, and this group forms plexuses; and these plexuses yield more nerves.
4. **The ventral (anterior) rami of spinal nerves form a network of nerves called plexuses.** The principal plexuses are the:
 - a. **Cervical plexus** - (C₁ - C₄) - muscles and skin, of posterior scalp; **its major branch is the phrenic nerve (C₃-C₅)** to the diaphragm.

- b. **Brachial plexus** - (C₅ - T₁) - neck and shoulder muscles and upper extremities; **major branches are the axillary, musculocutaneous, medial, ulnar, and radial nerves.**
 - 1.) Axillary -
 - 2.) Musculocutaneous -
 - 3.) Medial -
 - 4.) Ulnar -
 - 5.) Radial -
- c. **Lumbar plexus** - (L₁ - L₄) - motor and sensory to the lower abdominal wall, external genitalia, and lower extremity; **major branches are the femoral and saphenous nerves.**
- d. **Sacral plexus** - (L₄ - S₃) - muscles and skin of buttocks, perineum and lower extremity; **major branches are the sciatic, tibial and fibular (common peroneal) nerves.**

L. **Cavities** in the central nervous system - (known as the **ventricular system of the brain and central canal of the spinal cord**). There are **4 ventricles** (cavities) in the brain (each contains (CSF):

- 1. **Lateral ventricles** - considered as ventricles I and II; located in the cerebral hemispheres.
- 2. **Third ventricle** - ventricle III is located in the diencephalon.
(NOTE): Foramen of Monroe (INTERVENTRICULAR FORAMEN) - communicating passage between the lateral and third ventricles.
- 3. **Fourth ventricle** - ventricle IV is located in the hindbrain region.
 - a. **Cerebral aqueduct (Aqueduct of Sylvius)** - communicating passage way between the 3rd and 4th ventricle.
 - b. **Foramen of Magendie (Median Aperture)** - communicating passage between the 4th ventricle and the subarachnoid space of the brain and spinal cord.

M. Cerebrospinal Fluid - (C.S.F.) a water cushion that protects the brain and spinal cord from shock. Each ventricle (cavity) of the brain contains a capillary complex known as a **choroid plexus**, which produces C.S.F.. The C.S.F. flows through the ventricles and into the subarachnoid space of the meninges. Within the subarachnoid space are capillary tufts known as **arachnoid villi**. They reabsorb the C.S.F. back into the blood stream. **FUNCTIONS OF THE C.S.F.:**

1. Absorbs shock, bathes and protects the brain and spinal cord.
2. Keeps brain and cord moist, (thus, less friction).
3. Carries away some metabolic waste.
4. Assists in maintaining a stable ionic concentration in the C.N.S. (Homeostasis)
5. Clear - golden fluid

NOTE: Hydrocephalus -

N. THE BRAIN Is one of the largest organs of the body. It is composed of 100 billion neurons, and weighs approximately 3 pounds. **It consists of a brain stem, cerebrum, and cerebellum.**

1. **Development of brain** - during the fourth week of embryonic development, **3 primary vesicles** are formed:
 - a. **Prosencephalon** (forebrain)
 - b. **Mesencephalon** (midbrain)
 - c. **Rhombencephalon** (hindbrain)
2. During the fifth week of embryonic development, additional vesicles are formed from the 3 primary vesicles.
 - a. **Telencephalon** - is derived from the **prosencephalon**.
 - b. **Diencephalon** - is derived from the **prosencephalon**.
 - c. **Mesencephalon** - does not change from primary vesicle.
 - d. **Metencephalon** - is derived from the **Rhombencephalon**.
 - e. **Myelencephalon** - is derived from the **Rhombencephalon**.

3. **Adult structures formed in (or from) these vesicles:**

- a. **Cerebral hemispheres and lateral ventricles** are derived from the **TELENCEPHALON**.
- b. **Thalamus, hypothalamus, and third ventricle** are derived from the **DIENCEPHALON**.
- c. **Midbrain, corpora quadrigemina, and the cerebral aqueduct** are derived from the **MESENCEPHALON**.
- d. **Pons, cerebellum, and part of the 4th ventricle** are derived from the **METENCEPHALON**.
- e. **Medulla oblongata and part of the 4th ventricle** are derived from the **MYELNCEPHALON**.

4. **TELENCEPHALON (FOREBRAIN)**

- a. **Cerebrum** (divided into 2 cerebral hemispheres by the longitudinal fissure).

(NOTE): Cerebral cortex - surface of the cerebrum.

- b. **Each hemisphere contains 4 lobes** that are named in association with the bones that cover them:
 - 1.) **Frontal lobe** - associated with memory, emotions, speaking, voluntary motor control of skeletal muscle, personality, and calculations. Motor cortex.
 - 2.) **Parietal lobe** - associated with understanding speech, interpreting, textures and shapes, light touch, pain, and pressure. Sensory cortex.
 - 3.) **Temporal lobe** - associated with auditory sensations, and stores memories of both auditory and visual events. Aids in understanding language.
 - 4.) **Occipital lobe** - associated with vision (association with eye movements by directing and focusing the eye). Thus, we are able to recognize what we see.

Limbic system - group of fiber tracts contained in the cerebral hemispheres that is involved in basic emotional responses such as fear, anger, joy, grief, sex and hunger. Often referred to as the "emotional brain".

c. **KNOW THE FISSURES YOU HAD ON THE LABORATORY MODELS.**

5. DIENCEPHALON (FOREBRAIN)

a. **Thalamus** - paired oval mass that forms the lateral walls of the 3rd ventricle.

- 1.) Relay station for sensory impulses to cerebral cortex from the spinal cord, brain stem, cerebellum, and other cerebral parts.
- 2.) Conscious recognition of crude touch, pain, temperature and pressure.

b. **Hypothalamus** - forms floor and part of lateral walls of third ventricle.

- 1.) **Controls and regulates autonomic nervous system (A.N.S.)**
- 2.) Regulates contraction of cardiac muscle, smooth muscle, and is the main regulator of visceral activities.
- 3.) Associated with rage and aggression.
- 4.) Regulates body temperature, food intake, thirst center, sexual functions, and sleep.

6. Mesencephalon (Midbrain):

a. Main connection for tracts between upper brain parts and lower brain parts and the spinal cord.

b. **Corpora quadrigemina** - superior portion of the midbrain; it contains 4 colliculi (2 superior and 2 inferior):

- 1.) **Superior colliculi** - reflex centers for eye, head, and neck movements in response to visual stimuli.
- 2.) **Inferior colliculi** - reflex centers for head and trunk movements in response auditory stimuli.

c. **Cerebral Peduncle** -

7. Metencephalon (Hindbrain)

a. **Pons** - bridge connecting the medulla oblongata and the cerebellum with upper portions of the brain.

- 1.) Contains nuclei for cranial nerves V, VI, VII, and VIII (vestibular division).

2.) **Contains two respiratory centers:**

- a.) **Pneumotaxic area** - inhibits the inspiratory center.
- b.) **Apneustic area** - stimulates the inspiratory center.

b. **Cerebellum** - second largest part of the brain

- 1.) Motor area of the brain.
- 2.) Plays important role in **coordination, posture, and balance (equilibrium).**

8. **Myelencephalon (Hindbrain):**

Medulla oblongata - a continuation of superior region of spinal cord.

a. **Contains all ascending and descending tracts that connect the spinal cord and brain.**

b. **Contains reflex centers for the following:**

- 1.) Cardiovascular center
- 2.) Respiratory center
- 3.) Swallowing center
- 4.) Vomiting center
- 5.) Coughing center
- 6.) Sneezing center
- 7.) Hiccuping center

c. Contains **nuclei** for **cranial nerves VIII, IX, X, XI, and XII.**

Reticular formation - small areas of grey matter in the midbrain, pons, and medulla. Helps maintain consciousness and awakening from sleep.

9. **Pineal Gland** -

O. **Brain waves** - electrical activity generated by neurons within the cerebral cortex.

- 1. **Electroencephalogram (EEG)** - a recording of the electrical activity of the brain by electrical activity of the brain by electrodes attached to certain regions of the scalp.

2. There are normally four kinds of brain waves:
- Beta waves** (14-20+) - produced during period of sensory input and mental activity, test taking, rational thoughts and tension.
 - Alpha waves** (8-13 or 8-14) - present in persons that are awake and relaxed, such as in daydreaming. These waves are absent when actually asleep.
 - Theta waves** (4-7 or 4-8) - are considered normal and present in children, but could indicate emotional stress if present in an adult.
 - Delta waves** (1-3 or 1-4) - present during sleep; normal in an awake infant; if present in an awake adult, they indicate brain disorder/damage.
3. **Sleep** - period of rest where physiological activities and consciousness are diminished and voluntary physical activity is absent. A person can be aroused by stimulation from this state. **Two types of sleep:**
- Non-Rapid Eye Movement (NREM)** - normally occurs during the first 30-45 minutes of the sleep cycle. **There are four stages to NREM:**
 - Stage 1** - Relaxing, eyes closed; **EEG** = Alpha waves, easy to awaken at this stage.
 - Stage 2** - True sleep; **EEG** = irregular patterns, harder to awaken at this stage.
 - Stage 3** - Deep sleep, very relaxed; **EEG** = theta and delta waves, occurs about 20 minutes after falling asleep.
 - Stage 4** - Deeper sleep; **EEG** = delta waves, if aroused at this stage, appear very disoriented, bedwetting and sleep walking at this stage.
 - Rapid Eye Movement (REM)**
 - Normally occurs 90 minutes after sleep begins,.
 - REM** = an awake sleep state; most dreams take place at this state.
 - One will generally remember most dreams from this state.

P. **Memory** - mental registration and recall of past experience, knowledge, ideas, sensations, and thoughts. **TWO STAGES OF MEMORY:**

1. **Short-term memory** - passing memory of events that last for seconds to a few hours.
2. **Long-term memory** - which can be obtained from repeating (rehearsing) events until transferred from short term memory to long term memory.

Q. **Peripheral Nervous System (PNS)** - includes all nervous tissue found outside of the brain and spinal cord. It consists of a **sensory (afferent)** and **motor (efferent)** division. **The PNS is classified as cranial nerves or spinal nerves**, depending if origin is from the brain or spinal cord.

1. **Spinal Nerves** (31 pairs; discussed previously with the spinal cord).
2. **Cranial Nerves** - **twelve pairs** of nerves that have their origin in the brain. The first two pairs originate from the forebrain; the others from the brain stem. **Cranial nerves serve** the head and neck structures, **except** for the vagus nerves which also goes into the body.
 - a. **Olfactory** (I) - (**Sensory**) - Smell
 - b. **Optic** (II) - (**Sensory**) - Vision
 - c. **Oculomotor** (III) - [**Mixed**: Motor and Parasympathetic]:
 - 1.) motor to 4 extrinsic eye muscles and upper eyelid muscle.
 - 2.) parasympathetic - to muscles associated with the pupil and lens.
 - d. **Trochlear** (IV) - (**Motor**) - to the superior oblique eye muscle
 - e. **Trigeminal** (V) - [**Mixed**: Sensory and Motor]:
 - 1.) 3 branches: ophthalmic, maxillary, mandibular
 - 2.) Sensory: from skin of face, teeth, oral and nasal mucous membrane
 - 3.) Motor: mastication (chewing) muscles and four other muscles associated with the head
 - f. **Abducens** (VI) - **Motor** - to the lateral rectus eye muscle.
 - g. **Facial** (VII) - [**mixed**: sensory, motor, and parasympathetic]:
 - 1.) motor - to facial muscles and four muscle associated with the head

- 2.) parasympathetic - to lacrimal gland (tears) and two salivary glands (sublingual and submandibular):
 - 3.) Sensory for taste and to the mucosal membrane of the palate.
- h. Vestibulocochlear (VIII) - (Sensory) - Equilibrium and Hearing.
- i. Glossopharyngeal (IX) - [**mixed**: sensory, motor, and parasympathetic]:
- 1.) sensory - to mucous membrane of oropharynx (throat), taste, carotid sinus, part of the ear's cavity.
 - 2.) motor - to stylopharyngeus muscle of the head.
 - 3.) parasympathetic - to parotid salivary gland.
- j. Vagus (X) - [**mixed**: sensory, motor, parasympathetic] – to the pharynx, larynx, thorax, and abdomen.
- 1.) sensory - to taste in part of the throat (around epiglottis), pharynx, larynx, respiratory system (bronchi and lungs), heart digestive system (esophagus stomach, most of intestines), and kidneys.
 - 2.) motor - to most muscles of the palate, pharynx, and to the larynx
 - 3.) parasympathetic - to viscera (similar to distribution of sensory).
- k. Spinal Accessory (XI) - (**Motor**) - to the trapezius and sternocleidomastoid.
- l. Hypoglossal (XII) - (**Motor**) - to the tongue and infrahyoid muscles.

R. Autonomic Nervous System (ANS) - is the efferent division of the Peripheral Nervous System (PNS). It **regulates the activities of smooth muscle, cardiac muscle, and glands**. It is also known as an Involuntary System. **Consists of two divisions: SYMPATHETIC and PARASYMPATHETIC**

1. SYMPATHETIC DIVISION - located in the thoraco-lumbar regions (off next to the spinal cord); regulates and allows the body to **respond to stress, danger, anger, and excitement**. These responses are collectively called **fight-or-flight response**. Expend energy. Some organs and their sympathetic responses:
 - a. **Eye** - dilates pupil of eye.
 - b. **Heart** - increases rate of heartbeat.
 - c. **Blood vessels** - constricts (decreases) peripheral blood vessels; blood is shifted away from smooth muscle, and is shifted to skeletal muscles and cardiac muscle.

- d. **Adrenal glands** - secrete epinephrine.
- e. **Sweat glands** - stimulates sweating.
- f. **Arrector pili muscles** - stimulates them to contract and yields goosebumps.
- g. **Lungs** - dilates bronchioles.
- h. burns calories (uses energy)
- i. ejaculation

2. **PARASYMPATHETIC DIVISION** - located in the cranio-sacral regions; **regulates and controls digestion and glandular functions**. Conserves energy. Some organs and their parasympathetic responses:

- a. **Eye** - constricts pupils of eyes.
- b. **Heart** - decreases rate of heart.
- c. **Blood vessels** - dilates some blood vessels; increases blood flow to smooth muscle and decreases (constricts) blood flow to the heart and skeletal muscles.
- d. **Lungs** - constricts bronchioles.
- e. Digestive system - stimulates this system
- f. Urinary system - stimulates this system
- g. sexual arousal state

(NOTE): These are a few of the sympathetic and parasympathetic effects on some various organs. (see lecture book for additional effects).

S. **Neurotransmitters** - are chemicals released by neurons. These transmitters may bind to specific receptors, and stimulate or inhibit their function. There are many neurotransmitters, but they all belong to one of these four chemical families:

- 1. **Acetylcholine (Ach)** - Released at the neuromuscular junctions in skeletal muscle. Can be excitatory or inhibitory. Ach is inactivated by an enzyme name Acetylcholinesterase.

2. **Amino Acids** - excitatory and inhibitory transmitters. Building blocks for proteins. Ex., Gamma Aminobutyric Acid (GABA), glutamate, aspartate, and glycine.
3. **Biogenic Amines** - modified amino acids. Ex. Norepinephrine, dopamine, serotonin, and histamine.
4. **Neuropeptides** - largest family of neurotransmitters. Consists of chains of amino acids. Ex. endorphins, enkephalins, and angiotensin II.

Chapter 8, The Special Senses

Textbook Chapter: _____

- A. In order to understand the senses, one must be familiar with sensory receptors and sensory stimulation. **Sensory receptors** can be thought of as antennas which "pick up" signals or information and transmit this information to our C.N.S.. Most physiologists agree that there are major categories and types of receptors.

1. General categories of sensory receptors are based on their location in our bodies:

- a. exteroceptors - located on or near the body's surface and detect signals from the external environment (ex. temperature).
- b. proprioceptors -
- c. interoceptors - located within the body and respond to internal signals (ex. hunger, thirst, gas).

2. Types of sensory receptors:

- a. thermoreceptors - detect temperature changes (ex. - warm, hot, cold).
 - 1.) organs of Ruffini - detect heat.
 - 2.) Krause bulbs - detect cold.
- b. nociceptors - detect pain; structurally, they are free nerve endings.
- c. chemoreceptors - detect chemical stimulation (ex. - taste, smell, blood gases):
 - 1.) olfactory receptors - detect smell.
 - 2.) taste (gustatory) receptors (taste-buds) - detect taste.
 - 3.) also in arteries to detect O₂ and CO₂.
- d. mechanoreceptors - detect mechanical changes (ex. - touch, pressure, joint position, blood pressure):
 - 1.) free nerve endings
 - 2.) Meissner corpuscles - detect light touch.
 - 3.) Pacinian corpuscles - detect deep pressure and tissue/organ vibration or movement.
 - 4.) root hair plexus - detect touch (movement)

across the body's surface via hair follicle movement.

5.) proprioceptors - detect muscle and joint movement/position.

6.) baroreceptors - detect pressure changes (in blood pressure as well as in some other systems such as digestive and urinary).

e. photoreceptors - detect light (ex. - in eye's retina):

1.) rods - (see explanation under eye)

2.) cones - (see explanation under eye)

f. organ of corti - for hearing

B. THE EYE

1. Protection:

a. bones - 7 bones form the orbit

b. eyebrows

c. eyelids (palpebrae)

d. eyelashes

e. secretions from glands: lacrimal and tarsal

f. conjunctiva

g. muscles

h. reflexes

2. Lacrimal mechanism:

lacrimal gland secretes tears (with lysozyme - a bactericidal enzyme) → lacrimal "blink" → 2 lacrimal puntas → lacrimal ducts → lacrimal canals (canaliculus) → lacrimal sac → nasolacrimal duct → inferior meatus (of nasal cavity)

3. Conjunctiva - epithelial membrane that lines the anterior surface of the eyeball and the interior surface of the eyelids; secretes mucus.

(NOTE): conjunctivitis (pink-eye) - irritation, damage, or infection of the conjunctiva.

4. 6 Extrinsic Eye Muscles - physically move the eyeball; their innervation is:

(LR₆SO₄)

6 - ABDUCENS

a. **4 recti muscles:**

4 recti muscles	actions	innervation
superior rectus	moves eyeball superiorly	oculomotor (III)
inferior rectus	moves eyeball inferiorly	oculomotor (III)
lateral rectus	moves eyeball laterally	abducens (VI)
medial rectus	moves eyeball medially	oculomotor (III)

b. **2 oblique muscles:**

2 oblique muscles	actions	innervation
superior oblique	moves eyeball inferior/ laterally	trochlear (IV)
inferior oblique	moves eyeball superiorly/ laterally	oculomotor (III)

5. **3 Eyeball Layers** (Tunics).

a. **fibrous tunic:**

- 1.) **sclera** - the white of the eye
- 2.) **cornea** - clear portion in the anterior eye

<p>* <u>limbus</u> - the junction line between the sclera and cornea.</p>
--

b. **vascular tunic:**

- 1.) **choroid** - separates fibrous tunic from the neural tunic (posterior to **ora serrata**) .

<p>* <u>ora serrata</u> - anterior edge of the inner (neural) tunic.</p>

2.) ciliary body:

a.) ciliary muscle

b.) ciliary processes (with suspensory ligaments going to the lens)

3.) Iris - color of the eye; protects the retina from light; the hole in its center is called the pupil.

c. inner (neural) tunic - contains the retina (with the photoreceptors: rods and cones)

1.) rods - sensitive to light; therefore, they enable humans to see in dim light; not color sensitive; contain rhodopsin (a pigment) which absorbs dim light.

2.) cones - color sensitive; **3 types of cones** (red, green, blue); contains retinene (a pigment).

(NOTE): color-blindness - due to lack of one or more types of cones.

6. Cavities Within the Eye

a. Anterior cavity - separated from the posterior cavity by the lens and the ciliary body (with its suspensory ligaments); **two chambers within it**:

1.) anterior chamber - from cornea to iris.

2.) posterior chamber - from iris to lens and ciliary body (with its suspensory ligaments).

3.) anterior cavity is filled with "aqueous humor":

a.) It is made by ciliary process cells.

b.) It helps eye retain its shape.

c.) It is recirculated by the venous (blood) system. Via the canal of Schlemm; its reproducible.

d.) If this fluid is hindered from entering the canal of Schlemm or if there is a drainage problem, then too much aqueous humor accumulates in the anterior cavity and produces glaucoma.

b. Posterior Cavity:

1.) It is posterior to the lens and ciliary body

(with its suspensory ligaments).

2.) It is filled with vitreous humor (vitreous body), which:

a.) helps maintain the eyeball's shape.

b.) supports the retina

c.) nonreproducible

7. Light Pathway Into the Eye

a. light enters cornea → anterior chamber → pupil → posterior chamber → retina

[illegible]

retina's cells (\rightarrow ganglion cells \rightarrow bipolar cells
(photoreceptor cells: rods & cones)).

b. Once it arrives at the photoreceptor cells, neural information goes in the opposite direction:

photoreceptor cells (rods & cones) → bipolar cells |

→ ganglion cells → optic nerve → optic chiasma →

- 2.) light focuses at a point anterior to the macula lutea (fovea centralis).

c. Presbyopia

- 1.) lens begins to lose its elasticity and ability to accommodate.
- 2.) usually an aging problem.
- 3.) a form of hyperopia.

10. Terms:

- a. emmetropia - normal vision
- b. scotomas - abnormal blind spot
- c. cataract - lens loses its transparency qualities
- d. night blindness - dim light fails to activate the rods.
- e. color blindness - one or more categories of cones does not function properly.

C. THE EAR

1. THE ANATOMICAL STRUCTURE OF THE EAR:

a. THE EXTERNAL EAR

- 1.) pinna (auricle) - extends from the skull; catches sounds; **its major parts are:**
 - a.) **helix**
 - b.) **antihelix**
 - c.) **lobe**
- 2.) external auditory meatus - channels sounds.
 - a.) contain ceruminous glands (secrete earwax).
 - b.) tympanic membrane - eardrum; separates external ear from middle ear.

<p>NOTE: Doctor uses an otoscope to examine the ear.</p>
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b. THE MIDDLE EAR

- 1.) It is separated from the external ear by the tympanic membrane.

- 2.) Eustachian tube (auditory tube) - connects middle ear to the nasopharynx (upper throat).

* function - equalizes pressure of the middle ear with the throat (outside air).

3.) contains auditory ossicles (3)

- a.) hammer (malleus) - connected to tympanic membrane
- b.) anvil (incus) - connects hammer to stirrup

- c.) stirrup (stapes) - connected to oval window

* function - to transmit sound (in the form of vibrations) to the inner ear (labyrinth) via the oval window.

4.) muscles associated with the middle ear:

- a.) tensor tympani - decreases the movement of the tympanic membrane.
- b.) stapedius - decreases the movement of the stapes (stirrup) into the oval window.

c. THE INNER EAR (LABYRINTH)

1.) BONY LABYRINTH - surrounds the membranous labyrinth.

a.) contains 3 parts:

- (1.) semicircular canals (3)
- (2.) vestibule
- (3.) cochlea

b.) contains 2 openings:

- (1.) oval window - Through it, the stapes vibrations are transmitted to the perilymph of the scala vestibuli.
- (2.) round window - It receives (and absorbs) perilymph waves from the scala tympani.

- c.) perilymph - It is the fluid between the bony labyrinth and the membranous labyrinth

2.) MEMBRANOUS LABYRINTH - inside the bony labyrinth.

a.) contains the following parts:

- (1.) semicircular ducts (inside the semicircular canals)

NOTE: fluid (endolymph) within these ducts stimulates receptors which inform one about head rotation.

- (2.) utricle and saccule (inside the vestibule).

NOTE: fluid (**endolymph**) within these sacs alerts receptors which allow one to be aware of the pull of gravity and acceleration (linear).

- (3.) cochlear duct or scala media (inside the cochlea).

NOTE: fluid (**endolymph**) within this duct signals receptors associated with hearing.

b.) COCHLEAR ANATOMY

- (1.) scala vestibuli - receives sound vibrations from the stapes (stirrup) through the oval window.

- (2.) scala media (cochlear duct)

- (3.) scala tympani

- (4.) vestibular membrane (Reissner's membrane) - separates the scala vestibuli from the scala media.

- (5.) basilar membrane - separates the scala tympani from the scala media.

(a.) high-frequency resonance occurs on the basilar membrane near the oval window (near entrance into cochlea).

(b.) low-frequency resonance occurs on the basilar membrane near the tip of the cochlea (cochlea's apex).

- (6.) organ of Corti:

(a.) It sits on basilar membrane.

(b.) It contains hair cells (receptors) that generate (originate) the electrical (nerve) wave (signal) for the sense of sound.

- (7.) Sound within the cochlea:

(a.) Stapes → oval window → perilymph waves (within the scala vestibuli & scala tympani) are distributed to the round window → these perilymph waves in the scala vestibuli also transmit

vibration through the vestibular membrane and basilar membrane to the scala tympani.

(b.) this movement of the basilar membrane stimulates the organ of Corti within the scala media (cochlear duct) via endolymph.

(c.) organ of Corti → cochlear nerve (a branch of VIII (vestibulocochlear nerve) → inferior colliculus → thalamus → cortex of temporal lobe .

2. VESTIBULAR MECHANISM (EQUILIBRIUM/BALANCE)

a. **Semicircular Ducts (3): anterior, posterior, lateral.**

1.) inside the semicircular canals

2.) filled with **endolymph**

3.) continuous with the utricle

4.) sensory receptors are hair cells in the **crista** (which are in the ampullas).

5.) these receptors respond to head rotation (what direction and the speed of turning).

b. **Utricle and Saccule**

1.) the sensory receptors are hair cells located in maculae.

2.) filled with **endolymph**

3.) these receptors respond to the position of the head in reference to gravity.

c. **Hair cells** from the sensory receptors in the utricle, saccule, and semicircular ducts congregate into sensory fibers which form the vestibular branch of VIII (vestibulocochlear nerve) → to cerebellum, superior colliculi, and to cortex.

D. TASTE

1. also called **gustation**.

2. **taste receptors** are located **in taste buds** (taste buds are located in/on papilla; some are on the palate and in the pharynx).

3. types of papilla (3 TYPES):

- a. fungiform - on flat/anterior surface
- b. foliate - on lateral tongue
- c. circumvallate - on posterior tongue

Note - some sources believe filiform should be used instead of foliate (and may locate them differently on the tongue).

4. 4 types of taste: sweet, sour, salty, bitter

5. Cranial nerves associated with taste:

- a. VII (facial) - anterior 2/3 of tongue
- b. IX (glossopharyngeal) - posterior 1/3 of tongue
- c. X (vagus) - upper pharynx (around epiglottis)

E. SMELL (OLFACTION)

1. sensory receptors - olfactory organs

2. nerve pathway:

olfactory organs → olfactory neurons (through cribriform plate) → olfactory bulbs → olfactory tract → cortex, hypothalamus, and limbic system.

Chapter 9, The Endocrine System

Textbook Chapter: _____

A. ENDOCRINE GLANDS OVERVIEW

1. **Endocrine glands** are glands of internal secretion because they secrete their products (hormones) into the blood or interstitial spaces (do not have ducts that open into cavities or onto surfaces).
2. **Exocrine glands** secrete their products into ducts.
3. **Hormone** is a chemical messenger released into the blood to be transported in a convenient way throughout the body.
4. **Endocrinology** is the science concerned with the endocrine glands and the treatment of disorders of the endocrine system.
5. **Endocrine glands include:**
 - a. **Endocrine glands:**
 - 1.) Pituitary (hypophysis)
 - 2.) Thyroid
 - 3.) Parathyroids
 - 4.) Adrenals (suprarenals)
 - 5.) Pineal (epiphysis cerebri)
 - 6.) Thymus
 - b. **Exocrine and Endocrine glands:**
 - 1.) Pancreas
 - 2.) Ovaries
 - 3.) Testes
 - 4.) Kidneys
 - 5.) Stomach
 - 6.) Liver
 - 7.) Small intestine
 - 8.) Skin
 - 9.) Heart
 - 10.) Placenta

B. NERVOUS AND ENDOCRINE SYSTEMS

1. **Nervous system** controls homeostasis through nerve impulses conducted along axons, either exciting or inhibiting muscle fibers or glands.
 - a. Nervous system causes muscles to contract and glands to secrete either more or less of their product.

- b. Nerve impulses produce their effects within a few milliseconds.
 - c. Effects of nervous system are brief.
- 2. **Endocrine system** releases hormones into the bloodstream that effect cells through the body.
 - a. Endocrine system alters metabolic activities, regulates growth and development, and guides reproductive processes.
 - b. Regulates the activities of smooth and cardiac muscle and some glands.
 - c. Hormones act within seconds and others take several hours.
 - d. Hormone effect is widespread and protracted.
- 3. **Neuroendocrine system** is represented by both nervous and endocrine systems.

C. HORMONES

- 1. About 50 hormones affect only a few types of cells.
- 2. Hormones Receptors
 - a. **Target cells** specific cells affected by hormones.
 - b. **Receptors** are the large protein or glycoprotein molecules to which hormones bind.
- 3. **Chemistry of Hormones**
 - a. **Four classes of hormones:**
 - 1.) Steroids
 - a.) Derived from cholesterol.
 - b.) The shape of each steroid hormone account for diversity of function.
 - c.) Endocrine tissues that secrete steroid hormones all are derived from the mesoderm.
 - 2.) Amines
 - a.) Several are synthesized by modifying the amino acid tyrosine (ie. thyroid hormones T₃ and T₄,) and

catecholamines (ie. epinephrine and norepinephrine from adrenal glands).

- b.) Histamine is synthesized from the amino acid histidine by mast cells and platelets.
- c.) Serotonin and melatonin derive from tryptophan.

3.) Peptides and Proteins

- a.) Glycoproteins like thyroid-stimulating hormone (TSH).
- b.) Chains of amino acids from 3 to 200.
- c.) Peptide and protein hormones are synthesized on rough endoplasmic reticulum.

4.) Eicosanoids

- a.) Mostly discovered group of mediators.
- b.) Two major types are **prostaglandins** and **leukotrienes**.
- c.) Derived from fatty acids called **arachidonic acid**.
- d.) Can be either local or circulating hormones.

4. Interaction of Hormones:

- a. **Permissive effect** occurs when the effect of one hormone on a target cell requires a previous or simultaneous exposure to another hormone. (ie. an increase in estrogens can bring about an increase in the number of progesterone receptors which gives a greater effect).
- b. **Synergistic effect** occurs when two or more hormones complement each other's actions and both are needed for full expression of the hormone effects. (ie. the production, secretion and ejection of milk by the mammary glands require the synergistic effects of estrogens, progesterone, prolactin, and oxytocin).
- c. **Antagonistic effect** is the effect of one hormone on a target cell is opposed by another hormone. (ie. insulin lowers blood sugar level and glucagon raises it).

D. HORMONAL SECRETION AND THE CONTROL.

- 1. In the absence of stimulation, endocrine gland secretions (burst) are minimal or

inhibited and blood level of hormone decreases.

2. Hormone secretion by endocrine glands is stimulated and inhibited by:
 - a. Signals from the nervous system.
 - b. Chemical changes in the blood.
 - c. Chemical changes in other hormones.
 - d. **Negative feedback** and sometimes positive feedback maintain homeostasis of hormonal secretions.

E. **HYPOTHALAMUS AND PITUITARY GLAND (HYPOPHYSIS).**

1. **Pituitary gland (hypophysis)** has been called the "master" endocrine gland because it secretes hormones that control other endocrine glands.
2. **Hypothalamus**
 - a. is the true "master" of the endocrine system and is the integrating link between the nervous and the endocrine system.
 - b. It receives input from several other regions of brain like limbic system, cerebral cortex, thalamus, and reticular activating system.
3. **Pituitary gland**
 - a. **Characteristics:**
 - 1.) Gland is pea-sized structure that lies in the sella turcica.
 - 2.) **Anterior pituitary gland** accounts for about 75% of weight; it contains many glandular epithelial cells.
 - 3.) **Posterior pituitary gland** derives from the neurohypophyseal bud.
 - 4.) **Pars intermedia (intermediate lobe)** atrophies during fetal development and may migrate into anterior pituitary.
 - b. **Anterior Pituitary Gland (Adenohypophysis).**
 - 1.) Anterior pituitary gland (anterior lobe) or adenohypophysis secretes hormones that regulate a wide range of bodily activities from growth to reproduction.

- 2.) **Releasing hormones** stimulate the release of anterior pituitary hormones.
- 3.) **Inhibiting hormones** suppress the release of anterior pituitary hormones.
- 4.) **Superior hypophyseal arteries** are branches of the internal carotid and posterior communicating arteries, and are responsible for connecting the hypothalamus to the anterior pituitary.
- 5.) **Five types of anterior pituitary cells:**
 - a.) **Somatotrophs** produce human growth hormone (hGH) which stimulates general body growth and regulates aspects of metabolism.
 - b.) **Lactotrophs** synthesize prolactin (PRL) which initiates milk production in suitably prepared mammary glands.
 - c.) **Corticotrophs** synthesize adrenocorticotrophic hormone (ACTH) which stimulates the adrenal cortex to secrete glucocorticoids. Also **melanocyte-stimulating hormone (MSH)** affects skin pigmentation.
 - d.) **Thyrotrophs** produce thyroid-stimulating hormone (TSH) which controls the thyroid gland secretions and other activities.
 - e.) **Gonadotrophs** produce two major hormones:
 - (1.) **follicle-stimulating hormone (FSH)** which stimulates maturation of ova and secretion of estrogen by the ovaries and production of sperm in the testes.
 - (2.) **Luteinizing hormone (LH)** stimulates other sexual and reproductive activities.
- 6.) **Tropins or tropic hormones** are hormones that influence another endocrine gland.

- 7.) **Gonadotropins** are hormones that regulate the functions of the gonads.
- 8.) **Thyrotropin and corticotropin** are alternate names for thyroid-stimulating hormone (TSH) and adrenocorticotrophic hormone (ACTH).
- 9.) **Hypophysiotropic hormones** or the hypothalamic releasing and inhibiting hormones and they act on hypophysis (pituitary).
- 10.) **Negative feedback systems** decrease the secretory activity of corticotrophs, thyrotrophs, and gonadotrophs when levels of their target gland hormones rise.

c. **Specific Hormones Secreted by the Anterior Pituitary Gland**

- 1.) **Human Growth Hormone (HGH) or Somatotropin**
 - a.) Causes body cells to grow.
 - b.) Stimulates protein synthesis and inhibits protein break-down. **HGH** stimulates protein anabolism and increases the growth of skeletal muscle and skeleton during childhood and teenage years. In adults the action is maintenance.
 - c.) Stimulates lipolysis, the breakdown of triglycerides into fatty acids and glycerol. **HGH** stimulates fat catabolism and metabolism switch from burning carbohydrates and proteins to fats.
 - d.) Retards use of glucose for ATP production. **HGH** decreases glucose utilization or an anti-insulin effect.
 - e.) **Diabetogenic effect of HGH:**
 - (1.) **Hyperglycemia** is high blood glucose concentration and may over work pancreatic beta cells.
 - (2.) **Diabetogenic effect** is the result of pancreatic burn-out (excessive hGH)

secretion) and may cause diabetes mellitus.

f.) **Growth hormone releasing hormone (GHRH) or somatocrinin.**

- (1.) Stimulated by low blood glucose level.
- (2.) GHRH stimulates somatotrophs to release hGH.
- (3.) hGH and somatomedins raise blood glucose level.
- (4.) Hyperglycemia inhibits hGH secretion.

g.) **Growth hormone inhibiting hormone (GHIH) or somatostatin.**

- (1.) Very high blood glucose level stimulates the hypothalamus to secrete GHIH.
- (2.) GHIH inhibits the release of hGH which cause blood glucose level to decrease.

h.) **Hypersecretion** is overproduction of hormone secretions.

- (1.) **Giantism (gigantism)** is hypersecretion of hGH during childhood causing an increase in length of long bone.
- (2.) **Acromegaly** is the hypersecretion of hGH during the adult years leading to abnormal growth.

i.) **Hyposecretion** is underproduction of hormone secretions.

- (1.) **Pituitary dwarfism** is the underproduction of growth hormone (HGH) during the growth years.

- (2). **HGH** can now be produced by bacteria using recombinant DNA techniques.

2.) **Thyroid-Stimulating Hormone (TSH) or Thyrotropin.**

- a.) Stimulates the secretion of **triiodothyronine** (T_3) and **thyroxine** (T_4).
- b.) **Thyrotropin releasing hormone** (TRH) controls the secretion of TSH.

3.) **Follicle-Stimulating Hormone (FSH)**

- a.) In females, it initiates the development of egg-containing follicles each month.
- b.) In females, FSH stimulates secretion of estrogens.
- c.) In males, FSH stimulates sperm production.
- d.) **Gonadotropin releasing hormone (GnRH)** comes from the hypothalamus and stimulates FSH release.
- e.) **Negative feedback** is the way estrogens and testosterone suppress GnRH and FSH.

4.) **Luteinizing Hormone (LH)**

- a.) In females, together with FSH, LH stimulates **estrogen** secretion by ovaries and the release of the secondary oocyte (ovulation). It also stimulates the corpus luteum and the production of **progesterone**.
- b.) In males, LH stimulates the interstitial cells in the testes to develop and secrete large amounts of testosterone (**interstitial cell-stimulating hormone** [ICSH]).
- c.) Secretion of LH is controlled by GnRH.
- d.) **GnRH agonists** are compounds that mimic

GnRH are used to stimulate the gonads when they are functioning at too low a level.

5.) **Prolactin**

- a.) **Prolactin (PRL) or lactogenic hormone** helps to initiate and maintain milk secretion by the mammary glands.
- b.) Actual ejection of milk by the mammary glands depends on the hormone oxytocin.
- c.) **Lactation** is both milk secretion and ejection.
- d.) PRL requires help from estrogens, progesterone, glucocorticoids, human growth hormone (hGH), thyroxine, and insulin.
- e.) **Prolactin inhibiting hormone (PIH)** is dopamine and inhibits the release of PRL.
- f.) Breast tenderness just before menstruation may be caused by elevated PRL.
- g.) **Prolactin releasing hormone (PRH)** comes from the hypothalamus and stimulates prolactin during pregnancy.
- h.) **Hypersecretion of PRL** causes absence of menstrual cycles.

6.) **Melanocyte-Stimulating Hormone (MSH)**

- a.) It increases skin pigmentation by dispersion of melanin (not really understood).
- b.) **MSH releasing hormone (MRH)** promotes release of MSH.
- c.) **MSH inhibiting hormone (MIH)** suppresses MSH release.

7.) **Adrenocorticotrophic Hormone (ACTH)**

- a.) **Pro-opiomelanocortin or POMC** can give rise

to ACTH, MSH, beta-endorphin, and beta-lipotropin.

- b.) ACTH controls the production and secretion of glucocorticoids.
- c.) **Corticotropin releasing hormone (CRH)** stimulates secretion of ACTH by corticotrophs.
- d.) Glucocorticoids cause negative feedback inhibition of both CRH and ACTH release.

d. **Posterior Pituitary Gland (Neurohypophysis).**
It does not synthesize hormones but it does store and release **oxytocin (OT)** and **antidiuretic hormone (ADH)**.

1.) **Oxytocin**

- a.) During delivery, oxytocin enhances contraction of smooth muscle cells in the wall of the uterus.
- b.) After birth, oxytocin stimulates milk ejection "let-down" from the mammary glands in response to the mechanical stimulus provided by a suckling infant.
 - (1.) Ejection of milk starts slowly, about 30 seconds to 1 minute after nursing begins.
 - (2.) Stimuli other than suckling, such as hearing the baby's cry or touching the genitals, can trigger OT release.
 - (3.) Suckling stimulates OT release and inhibits PIH release which increases prolactin secretion.

2.) **Antidiuretic Hormone (ADH)**

- a.) ADH decreases urine production, thus urine output.

- b.) ADH causes kidneys to remove water from fluid that will become urine and return it to the blood.
- c.) The amount of ADH normally secreted varies with body's state of hydration or the elevated ratio of solutes to water increases osmotic pressure.
- d.) **Osmoreceptors** in hypothalamus detect osmotic pressure.
- e.) ADH decreases the rate of perspiration production.
- f.) **Vasopressin** are ADH's that raise blood pressure by causing constriction of arterioles.
- g.) **Factors that stimulate ADH:** Pain, stress, trauma, anxiety, acetylcholine, nicotine, morphine, tranquilizers, and some anesthetics.
- h.) **Factors that inhibit ADH:** Alcohol
- i.) **Diabetes insipidus** is caused by hyposecretion of ADH leading to secretion of large amounts of urine.

4. THYROID GLAND

- a. Located just below the larynx with right and left lobes on either side of the trachea.
- b. Under the influence of TSH, the thyroid follicular cells manufacture:
 - 1.) **Thyroxine (T₄)** has four atoms of iodine.
 - 2.) **Triiodothyronine (T₃)** has three atoms of iodine.
- c. Parafollicular cells or C (clear) cells produce calcitonin that influences calcium homeostasis.
- d. **Formation, Storage, and Release of Thyroid Hormones**

The Thyroid gland is the only endocrine gland that stores its secretory product in large quantity, about 100 day supply.

e. **Actions of Thyroid Hormones:**

- 1.) **Thyroid hormones regulate:** Oxygen use and basal metabolic rate, Cellular metabolism, and Growth and development.
- 2.) **Thyroid hormones** increase basal metabolic rate or BMR by stimulating cellular oxygen use to produce ATP.
- 3.) **Calorigenic effect** occurs when cells use more oxygen to produce ATP, more heat is given off, and body temperature rises.
- 4.) **Thyroid hormone:**
 - a.) Stimulates protein synthesis.
 - b.) Stimulates triglyceride breakdown.
 - c.) Enhances cholesterol excretion.
 - d.) Increases the use of glucose for ATP production.

f. **Control of Thyroid Hormone Secretion:**

- 1.) Thyroid gland is controlled by:
 - a.) the level of iodine in the thyroid gland.
 - b.) negative feedback systems involving both the hypothalamus and the anterior pituitary.
- 2.) **Cretinism** occurs when there is hyposecretion of thyroid hormones during fetal life or infancy and the child suffers dwarfism, jaundice and severe mental retardation.
- 3.) **Myxedema** occurs when there is hyposecretion of thyroid gland during the adult years leading to edema of facial tissues and generally lethargic

among other problems.

- 4.) **Graves' disease** occurs when there is hyperthyroidism and is an autoimmune disorder. A primary sign is an enlarged thyroid and possibly an exophthalmic goiter (bulging eyes).
- 5.) **Goiter** is an enlarged thyroid gland usually due to thyroid hormone (or iodine) deficiency.

g. **Calcitonin**

- 1.) Along with parathyroid hormone and calcitriol, calcitonin maintains homeostasis of calcium and phosphates in the blood.
- 2.) It lowers the amount of blood calcium and phosphates by inhibiting bone breakdown and accelerating uptake of calcium and phosphates by bones.

5. **PARATHYROID GLANDS**

- a. The 4 parathyroid glands are attached to the posterior surface of the thyroid gland.
- b. **Principal (chief) cells** are the major source of **parathyroid hormone (PTH) or parathormone**.
- c. **Parathyroid Hormone**
 - 1.) PTH increases the number and activity of osteoclasts.
 - 2.) PTH increases the rate at which the kidneys remove Ca^{2+} and magnesium (Mg^{2+}) from urine and returns it to blood.
 - 3.) PTH promotes formation of the hormone **calcitriol**, which is the active form of vitamin D. Calcitriol increases the rate of calcium, phosphate, and magnesium absorption from the gastrointestinal tract into the blood.
 - 4.) **Tetany** is caused by hypoparathyroidism and is characterized by nerve impulses and muscle

action potentials arising spontaneously.

6. **ADRENAL (SUPRARENAL) GLANDS**

- a. Paired adrenal (suprarenal) glands lie superior to each kidney.
- b. Adrenal cortex is the outer area that makes up the bulk of the gland.
- c. Adrenal medulla is the inner area and surrounded by the cortex.
- d. Adrenocortical secretions are necessary for life.
- e. **Adrenal Cortex:**
 - 1.) **Zona glomerulosa** is the outer zone of the cortex and secretes hormones called **mineralocorticoids**.
 - 2.) **Zona fasciculata** is the widest zone and secretes **glucocorticoids**.
 - 3.) **Zona reticularis** is the inner zone and secretes sex steroids called **gonadocorticoids**.
- f. **Mineralocorticoids:**
 - 1.) Help control water and electrolyte homeostasis.
 - 2.) 95% of mineralocorticoid activity is due to **aldosterone**.
 - a.) Aldosterone stimulates the retention of Na⁺.
 - b.) Aldosterone increases the excretion of K⁺.
 - 3.) **Renin-angiotensin pathway** is one mechanism that controls aldosterone secretion. It is:
 - a.) Low blood pressure stimulates **juxtaglomerular cells** to secrete **renin** into the blood.
 - b.) Renin converts **angiotensinogen**, a plasma protein produced by liver, into **angiotensin I**.
 - c.) As blood travels through lung capillaries, an enzyme, **angiotensin converting enzyme (ACE)** converts angiotensin I into **angiotensin II**.

- d.) Angiotensin II stimulates aldosterone secretion which increases Na^+ and water retention. Angiotensin is also a strong vasoconstrictor which increases blood pressure.
- 4.) An increase in K^+ will also stimulate aldosterone secretion leading to the active secretion of K^+ .
- 5.) Aldosteronism occurs with hypersecretion of aldosterone and is characterized by increased Na^+ and decreased K^+ levels in the blood.

g. Glucocorticoids

- 1.) Regulate metabolism and resistance to stress.
- 2.) Three glucocorticoids: Cortisol (hydrocortisone)- 95% of glucocorticoids, corticosterone, and cortisone.

3.) Glucocorticoid effects:

a.) Promote normal metabolism:

- (1.) Make ATP available.
- (2.) Increase the rate of protein catabolism.
- (3.) Stimulate gluconeogenesis.
- (4.) Stimulate lipolysis.

b.) Provide resistance to stress:

- (1.) More glucose for more ATP to fight stresses: fasting, fright, temperature extremes, high altitude, bleeding, infection, surgery, trauma, and most diseases.
- (2.) Make blood vessels more sensitive to vessel constricting chemicals.

c.) Glucocorticoids are anti-inflammatory compounds that inhibit cells.

- (1.) Reduce the number of mast cells and enzymes.
- (2.) Decrease blood capillary permeability.
- (3.) Depress phagocytosis.

- (4.) Retard connective tissue regeneration.
 - (5.) Depress immune responses (used in transplant surgery).
-
- 4.) Control of glucocorticoids secretion is done through negative feedback system. That is: Low blood levels of glucocorticoids stimulate the hypothalamus to release corticotropin releasing hormone (CRH).
 - 5.) **Addison's disease (primary adrenocortical insufficiency)** is hypersecretion of glucocorticoids and aldosterone leading to mental lethargy, anorexia, nausea, vomiting, weight loss, hypoglycemia and muscle weakness. There is also excessive skin pigmentation.
 - 6.) **Cushing's syndrome** is a hypersecretion of glucocorticoids and is characterized by redistribution of fat and catabolism of muscle protein. Also, hyperglycemia, osteoporosis, weakness, hypertension, increased susceptibility to infection, decreased resistance to stress and mood swings.

h. **Gonadocorticoids**

- 1.) Secrete both estrogens and androgens.
- 2.) Estrogens are several female sex hormones.
- 3.) Androgens are masculinizing in their effect.
- 4.) Important androgen, testosterone , is produced by testes.
- 5.) Males secrete insignificant amount of sex hormones from their adrenals.
- 6.) Female adrenal androgens contribute to sex drive and other sexual behavior.
- 7.) Androgens may be converted into estrogens (ie. during menopause).
- 8.) Androgens assist in the prepubertal growth such as axillary and pubic hair.

- 9.) **Gynecomastia** occurs when males have excessive growth of mammary glands (**feminizing adenoma**).

i. **Adrenal Medulla**

- 1.) Chromaffin cells are hormone producing cells.
- 2.) Sympathetic division of the ANS stimulates chromaffin cells.
 - a.) **Epinephrine (adrenaline)** constitutes 80% of total secretion of gland.
 - b.) **Epinephrine and norepinephrine** increase blood pressure by increasing heart rate and force of contraction and constricting blood vessels.

7. **PANCREAS**

- a. Pancreas is both endocrine and exocrine gland.
- b. **Islets of Langerhans** are clusters of endocrine tissue in the pancreas.
 - 1.) **Alpha cells** secrete the hormone **glucagon** which raises blood sugar level.
 - 2.) **Beta cells** secrete the hormone **insulin** which lowers blood sugar level.
 - 3.) **Delta cells** secrete growth hormone inhibiting hormone (GHIH) or somatostatin which inhibit secretion of insulin and glucagon.
 - 4.) **F-cells** secrete pancreatic polypeptide, which regulates release of pancreatic digestive enzymes.
- c. **Glucagon**
 - 1.) Increases blood glucose level when it falls below normal.
 - 2.) Main target tissue of glucagon is the liver.
 - 3.) **Glucagon:**
 - a.) Accelerates the conversion of glycogen into glucose (glycogenolysis).
 - b.) Promotes formation of glucose from lactic

acid (lactate) and certain amino acids (gluconeogenesis).

- c.) Enhances release of glucose into the blood.

d. **Insulin**

- 1.) Helps adjust blood glucose level by decreasing the level of it in the blood.

2.) **Insulin accelerates:**

- a.) The transport of glucose from the blood into cells, especially skeletal muscle fibers.
- b.) The conversion of glucose into glycogen (glycogenesis).
- c.) Entry of amino acids into cells and synthesis of proteins.
- d.) Conversion of glucose or other nutrients into fatty acids (lipogenesis).
- e.) Insulin decreases glycogenolysis.
- f.) Insulin slows gluconeogenesis.

- e. Islets of Langerhans functions are regulated by **negative feedback**.

- f. **Diabetes mellitus** is a group of disorders that all lead to an elevation of glucose in the blood (hyperglycemia) with the following results.

- 1.) polyuria - excessive urine production.
- 2.) polydipsia - excessive thirst.
- 3.) polyphagia - excessive eating.
- 4.) **Type I diabetes** (insulin-dependent diabetes mellitus [DDM]) is a deficiency of insulin.
- 5.) **Juvenile-onset diabetes** is an autoimmune disorder in people younger than 20 years of age but persists throughout life.
- 6.) **Type II diabetes (Maturity-onset diabetes)** is much more common than type I, representing 90%

of all cases. Occurs in people over 40 years and overweight.

7.) **Hyperinsulinism** occurs when a diabetic injects too much insulin.

8.) **Insulin shock** are events that result from hypoglycemia.

8. **OVARIES AND TESTES**

- a. Produce female sex hormones estrogens and progesterone which are responsible for the development and maintenance of female sexual characteristics.
- b. **Inhibin** is a hormone that inhibits secretion of FSH and LH.
- c. **Relaxin** is a hormone that relaxes the pubic symphysis and helps dilate the uterine cervix.
- d. **Testes** produce testosterone; it regulates the production of sperm and stimulates the development and maintenance of male sexual characteristics.
- e. **Testes** also produce inhibin which inhibits FSH.

9. **PINEAL GLAND (EPIPHYSIS CEREBRI)**

- a. Physiological role is still not clear.
- b. **Melatonin** is produced during darkness and may have an antigonadal influence.
- c. **Seasonal affective disorder (SAD)** is a type of depression that arises during the winter months when day-length is short and there is possible overproduction of melatonin.

10. **THYMUS GLAND**

- a. Hormones produced by the thymus gland, thymosin, thymic humoral factor (THF), thymic factor (TF), and thymopoietin, promote the proliferation and maturation of T cells, which destroy foreign microbes and substances.
- b. Thymic hormones may retard the aging process.

F. AGING AND THE ENDOCRINE SYSTEM

The endocrine system shows many changes and may hold the key to the aging process.

G. OTHER ENDOCRINE TISSUES:

1. **Hormones from the gastrointestinal tract (4).**
Gastrin, secretin, cholecystokinin (CCK), and gastric inhibitory peptide (GIP).
2. **Hormones from the placenta (5).**
Human chorionic gonadotropin (hCG), estrogens, progesterone, relaxin, and human chorionic somatomammotropin (hCS).
3. **Erythropoietin** is a hormone released by the kidneys and liver that can stimulate red blood cell production.
4. **Calcitriol** is the active hormone form of vitamin D.
5. **Atrial natriuretic peptide (ANP)** is produced by cardiac muscle fibers of the atria and when stimulated it increases sodium and water excretion in the urine and dilates blood vessels.

H. EICOSANOIDS

1. **Prostaglandins or PG's** alter smooth muscle contraction, secretion, blood flow, reproduction, platelet function, respiration, nerve impulse transmission, fat metabolism, and immune responses.
2. **Leukotrienes or LT's** stimulate chemotaxis of white blood cells and mediate inflammation.
3. **Arachidonic acid** is a precursor of PG's or LT's.
4. **Thromboxane (TX)** is a modified PG that constricts blood vessels and promotes platelet aggregation.
5. **Nonsteroidal anti-inflammatory drugs (NSAIDs)** like aspirin, ibuprofen and acetaminophen they inhibit a key enzyme in prostaglandin synthesis without affecting leukotrienes.

I. GROWTH FACTORS

These hormones stimulate cell growth: somatomedins, thymosin, insulin, thyroid hormones, human growth hormone, prolactin, and erythropoietin. Several more hormones called **growth factors** play important roles.

J. STRESS AND THE GENERAL ADAPTATION SYNDROME

1. If stress is extreme, unusual, or long-lasting, the normal homeostatic mechanism may not be sufficient.
2. **Stress response or general adaptation syndrome (GAS)** is a wide-ranging set of bodily changes.
3. **Stressors:**
 - a. Is any stimulus that produces a stress response.
 - b. They may be any disturbance such as heat, cold, environmental poisons, toxins, raging infection, heavy bleeding or strong emotional reaction.
4. **Alarm Reaction:**
 - a. The alarm reaction or fight-or-flight response is a complex of reactions initiated by hypothalamus stimulation of the sympathetic division of the ANS and the adrenal medulla.
 - b. The responses are immediate, mobilizing the body's resources for immediate physical activity (ie. response to attacking dog).
5. **Reactions Involving Resistance:**
 - a. **Resistance reaction** is the second stage in the stress response.
 - b. Resistance is initiated by hypothalamic hormones and is a long-term reaction.
 - c. Hormones are: CRH, GHRH, and TRH.
 - d. ie. CRH stimulates the anterior pituitary to increase secretion of ACTH, which stimulates the adrenal cortex to secrete more cortisol.
6. **"Exhaustion" What is it?**
 - a. Loss of potassium ions (K^+) is a major cause of exhaustion.
 - b. K^+ is partly responsible for controlling the water concentration of the cytosol and as cells lose more K^+ , they function less effectively.
 - c. **Stage of exhaustion** is the point where these cells start to die.
 - d. Unless this condition is rapidly reversed, vital organs cease and the person dies.
7. **Explanation of Stress and Disease**

- a.** Stress-related disorders include: gastritis, ulcerative colitis, irritable bowel syndrome, peptic ulcers, hypertension, asthma, rheumatoid arthritis, migraine headaches, anxiety, and depression.
- b.** Stress may increase susceptibility to infection by temporarily inhibiting certain components of the immune system.
- c.** System works by a negative feedback mechanism and remember that immunosuppressant drugs are effective with mechanism.