# Fall Final Study Guide

Honors Anatomy and Physiology Fall Final
Chapters 1-4, 6, 7, 15, 16

## Cheat Sheet

- You may have one 3x5 card – both sides
- Hand-written only (no printed figures, no computer generated anything)

For each chapter, you need to know the bold terms.

## Chapter 1: An Introduction to Anatomy and Physiology

- What are the five basic functions performed by all living things?
  - Be sure to be able to define each of these functions
  - Give an example of each
- Know the differences and the overlap between anatomy and physiology
- What are the sub-categories of anatomy?
  - Gross and Microscopic
  - What is the difference?
- Know the sub-divisions of physiology
  - Be sure to know the definition of each sub division
- What are the levels of organization?
  - Know the order of the levels of organization
  - Know what each level includes
  - Know the sub-divisions of each level
- What is homeostasis and why is it important?
- Know each of the 11 organ systems,
  - What is the system's primary function and which organs are involved?
- How does feedback work?
  - What is the difference between positive and negative feedback?
- Know the terms and figures associated with anatomical descriptions
  - Directional references (Fig 1-8, 1-10 and Table 1-1, 1-2)

## Chapter 2: The Chemical Level of Organization

- What is chemistry?
- What are atoms?
  - What are subatomic particles?
  - What is the structure of an atom?
  - What is an electron shell?
- What are isotopes?
- What are the three types of chemical bonds?
  - How do these bonds form?
- What are the pieces of a chemical reaction?
- What are the two types of energy? Give an example of each
- What are enzymes and why are they important?
- What are organic and inorganic compounds?

- What is pH and what does it measure?
- What are the four macromolecules?
    - For each macromolecule, know:
        - The pieces that make up the larger molecule.
        - The name of the reaction that puts the molecules together and breaks the molecules down.
- What is ATP?
    - Why is it so important?
    - It is recyclable – how?

**Chapter 3: Cell Structure and Function**

- What is the cell theory and what does it say?
- Plasma membrane
- Know each of the following in terms of their primary function:
    - Plasma membrane
    - Cilia
    - Flagella
    - Ribosomes
    - Endoplasmic Reticulum
    - Golgi
    - Lysosomes
    - Mitochondria
    - Nucleus
- Know the different types of movement in a cell:
    - Diffusion
    - Active and passive transport
    - Osmosis
        - Hypertonic, isotonic, hypotonic solutions
    - Carrier-mediated transport
        - Facilitated diffusion
        - Active transport
        - Vesicular transport
            - Endo and exocytosis
- How are proteins made from DNA?
    - What is transcription?
    - What is translation?
- Know the cell cycle
    - What happens in each step?
- What does cell division have to do with cancer?

**Chapter 4: The Tissue Level of Organization**

- What are the four types of tissue?
    - What are the sub-categories of each type of tissue?
    - What does each tissue do, in general?
- What are the four functions of epithelia?
    - What are endocrine and exocrine glands?
    - What do each secrete?
- Name the define the three types of cell junctions

- Know how to classify cell layers.
- What is connective tissue and what does it do?
    - What are the sub categories of connective tissue?
- What is connective tissue proper and what are the major cell types?
- Know each type of loose and dense connective tissue
    - Know what each type of tissue does
    - Know where each tissue is found
- Know each type of cartilage
    - What does each type of cartilage do and where can it be found?
    - What does each membrane do?
- What are the three types of muscle tissue?
    - Where are each of these tissue found in the body?
    - How do the three types of tissues differ?
- What is the role of neural tissue?
    - What are the parts of the neuron?

**Chapter 6 - The Skeletal System**

1. Know the five functions of this system
    a. What are the scientific terms for:
        i. Bone
        ii. Bone building cells
        iii. Bone breaking down cells
        iv. Bone cells, in general
2. What is the microscopic composition and structure of bone?
3. What is the difference between compact and spongy bone?
4. What are the three types of cells found in bones?
    a. What does each do?
5. What is ossification?
    a. What are the two major forms of ossification?
    b. What is the difference between these two forms?

**Chapter 7 - The Muscular System**

1. Know and describe the five functions of muscle.
2. What is the smallest functional unit of skeletal muscle fiber
    a. Know how this unit functions in detail.
    b. Know the anatomy and terminology associated with this structure in detail.
3. What is a motor unit?
    a. How does it work?
    b. What determines fine or gross movements?
4. How does a muscle cell get the energy needed to contract? Know the role/process of:
    a. ATP/ADP
5. Know details about cardiac muscle tissue:
    a. Where it is located
    b. How it works
    c. How it looks
    d. How communication occurs
    e. The importance of pacemaker cells
    f. The role of contractile cells

**Chapter 16 - The Digestive System**

1. Name and describe the six functions of the digestive system.
2. Movement of digestive materials
3. The Pharynx
    a. Where is this and what are the three divisions of this region?
4. The Esophagus
    a. What and where is this?
5. The Stomach
    a. Know the regions of the stomach
6. Nutrient Processing
    a. How are carbs broken down?
    b. How are carbs used by our body?
    c. How are lipids broken down?
    d. How are proteins broken down?
    e. How is water absorbed?
    f. How are vitamins absorbed (both fat soluble and water soluble)?
7. The Large Intestine
    a. Where is this organ located?
    b. Give the functions of this organ
8. The Gallbladder
    a. Where is this organ?
9. The Liver
    a. Know the anatomy of the liver

**Chapter 15 – The Respiratory System (sections 15.1-15.5 and Vaping)**

1. What are the functions of the respiratory system?
2. Know the structures of the respiratory tract.
3. What are the functional zones of the respiratory tract?
4. Know how air travels through the nose and the anatomy of the nose.
5. What is the pharynx and what are the three subdivisions?
6. Where is the larynx?
    a. What is the epiglottis and what does it do?
    b. What is the adam's apple?
    c. What is cricoid cartilage and where is it found?
7. Know the anatomy of vocal cords.
    a. How are sounds produced?
8. Where is the trachea?
9. What supports the tracea?
10. Know the anatomy of bronchi and all of the branches.
    a. What is the bronchial tree?
    b. How many times does it branch?
11. What are terminal bronchioles?
    a. What do they do?
12. What are alveolar ducts?
13. What are alveoli?
    a. What do they do?
    b. Know the anatomy.
        i. Know the cells found in the alveoli.

    c. What is surfactant? How is it produced?
14. What is cystic fibrosis?
15. What is the respiratory membrane and what is its function?
16. What are the three layers of respiratory membrane?
17. What is a pulmonary embolism?
18. Know the anatomy of the lungs.
19. What are the pleural cavities?
20. What is external respiration?
    a. What are the three processes involved in gas exchange?
21. What is hypoxia?
22. What is anoxia?
23. What is internal respiration?
24. What is pulmonary ventilation?
    a. What is a respiratory cycle?
    b. What is the respiratory rate?
25. How does air move into and out of the lungs? Know the details regarding the pressure gradient.
26. What is the role of the diaphragm in breathing?
27. What is compliance?
28. What are the different modes of breathing?
29. Know the terms associated with lung volume and capacity:
    a. Tidal volume
    b. Expiratory Reserve Volume
    c. Inspiratory Reserve Volume
    d. Vital Capacity
    e. Residual Volume
    f. Minimal Volume
30. What are the levels of use related to addiction?
31. Generally, what is the survival/reward circuit of the brain?
32. Related to survival, learning, and emotions, which goes into working memory the fastest?
33. What is drug-seeking behavior?
34. What happens to our neurons when we learn?
35. What does nicotine impersonate in our body?
36. What is tolerance/dependence/withdrawal?
37. Name four ways that vaping can physiologically damage lung tissue.

**Lab Practical**

1. Know what each of the parts of the respiratory lab showed.

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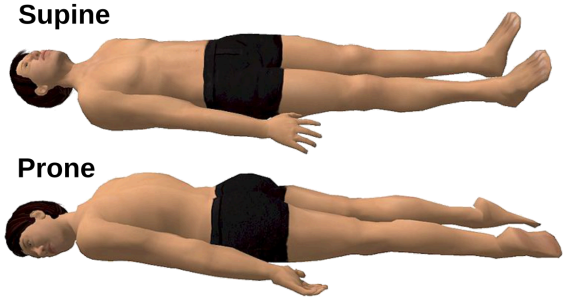
# Unit 1: An Introduction to Anatomy and Physiology Study Guide

1. Biology, the study of life, characterizes life by 5 factors:
    a. Responsiveness (i.e., an octopus camouflaging in response to the environment's color)
    b. Growth and Development (i.e., egg → hatch → juvenile → adult)
    c. Reproduction
    d. Movement
    e. Metabolism (def. chemical reactions (i.e., synthesizing macromolecules, breaking down nutrients, etc…) needed to maintain life)
2. Anatomy is the study of internal and external structures and the physical relationship between body parts, while physiology is how living organisms perform their vital functions
3. Anatomy subdivisions:
    a. Gross (macroscopic) ⇒ surface → regional (i.e., trunk) → systemic (systems, i.e., digestive system)
    b. Microscopic ⇒ cytology (cells) and histology (tissue)
4. The 5 Categories of Physiology are:
    a. Human: looking at the human body as a whole unit
    b. Cell: cellular function and structure (i.e., morphology, cell-specific functions)
    c. Special: specific organs, i.e., Bladder Physiology
    d. Systemic: how organ systems function
        i. The 11 Organ Systems are:
            1. Integumentary System
                a. Function and Organs: Protects, regulates temperature, senses, skin, hair, nails, glands.
            2. Skeletal System
                a. Function and Organs: Supports, protects, moves, stores, bones, cartilage, ligaments.
            3. Muscular System
                a. Function and Organs: Moves, stabilizes, generates heat (thermoregulation), muscles, tendons.
            4. Nervous System
                a. Function and Organs: Controls, communicates, senses, brain, spinal cord, nerves.
            5. Endocrine System
                a. Function and Organs: Regulates, signals, hormones, glands, pituitary, thyroid, adrenals.
            6. Cardiovascular System
                a. Function and Organs: Transports, circulates, heart, blood, vessels, arteries, veins.
            7. Lymphatic System

        a. Function and Organs: Drains, defends, lymph, nodes, spleen, thymus, vessels.
    8. Respiratory System
        a. Function and Organs: Breathes, exchanges gases, lungs, trachea, diaphragm, bronchi.
    9. Digestive System
        a. Function and Organs: Breaks down, absorbs, stomach, intestines, liver, pancreas.
    10. Urinary System
        a. Function and Organs: Filters, excretes, kidneys, bladder, ureters, urethra.
    11. Reproductive System
        a. Function and Organs: Reproduces, produces hormones, testes, ovaries, uterus, penis.
e. Pathological: disease-oriented physiology

5. Homeostasis is the process of maintaining a stable internal environment, yet there are three components of homeostatic regulation:
    a. Receptor (receives a stimulus) (aka the thermometer)
        i. *Thermoreceptors in the skin detect a drop in external temperature.*
    b. Control Center (processes and integrates information) (aka the thermostat)
        i. *The hypothalamus in the brain processes the signal and initiates a response.*
    c. Effector (causes a response) (aka the heater/AC)
        i. *Muscles (shivering) contract to generate heat, raising body temperature.*
6. Negative Feedback Loop: opposes the stimulus - Example: Regulation of blood glucose levels.
    a. Stimulus: Blood glucose rises after a meal
    b. Receptor: Pancreatic beta cells detect high glucose
    c. Control Center: Pancreas processes the signal and releases insulin
    d. Effector: Liver and muscles take up glucose, lowering blood levels
    e. Result: The response opposes the stimulus, stabilizing glucose levels
7. Positive Feedback Loop: enforces the stimulus - Example: Childbirth during labor.
    a. Stimulus: Uterine contractions begin, pushing the baby
    b. Receptor: Stretch receptors in the cervix detect pressure
    c. Control Center: Hypothalamus triggers oxytocin release
    d. Effector: Uterus contracts more intensely, increasing pressure
    e. Result: The response amplifies the stimulus, progressing labor until delivery
8. Supine and Prone Anatomical Positions:
    a. 

b. You can remember the prone position is face down because you are more prone to getting hurt by an evil sasquatch if your face is down and can't see what is behind you.

9.

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**Figure 1-6 Anatomical Landmarks.** Anatomical terms are shown in boldface type, common names are in plain type, and anatomical adjectives (referring to body regions) are in parentheses.

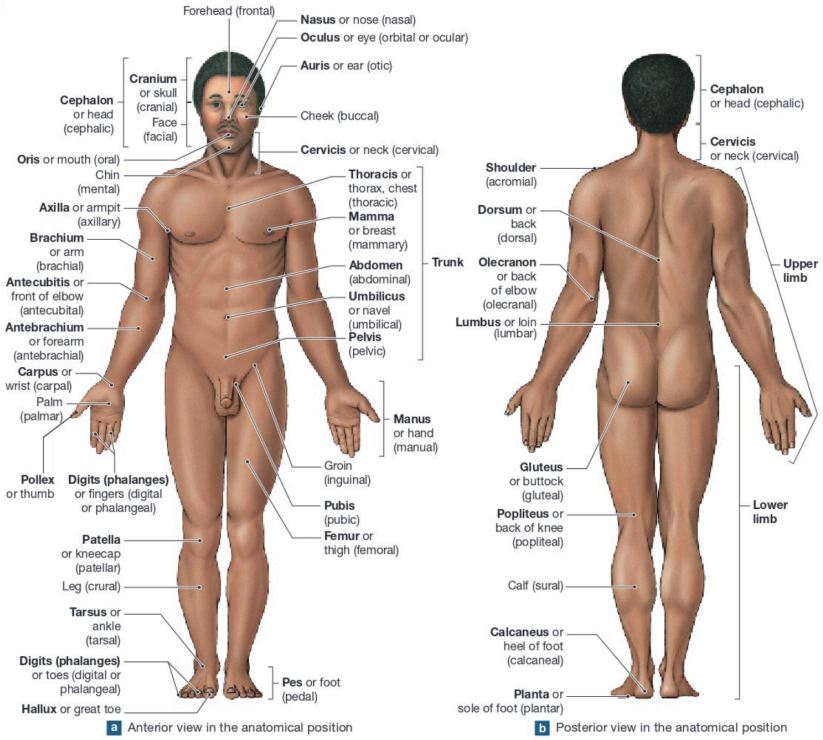


**Figure 1-7 Abdominopelvic Quadrants and Regions.**

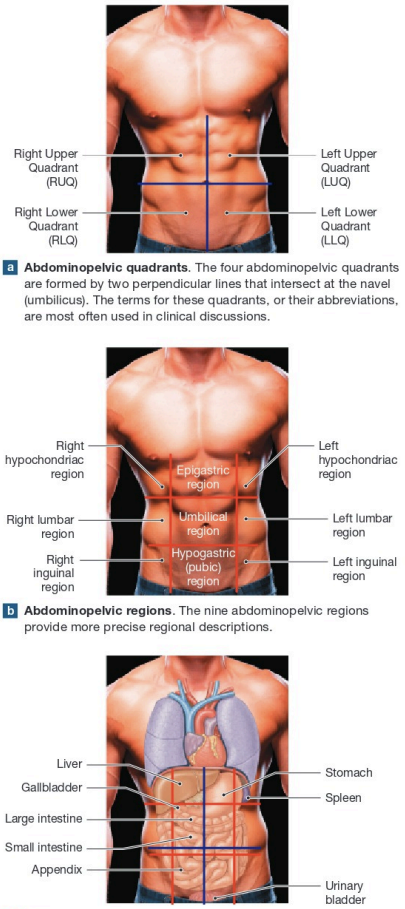


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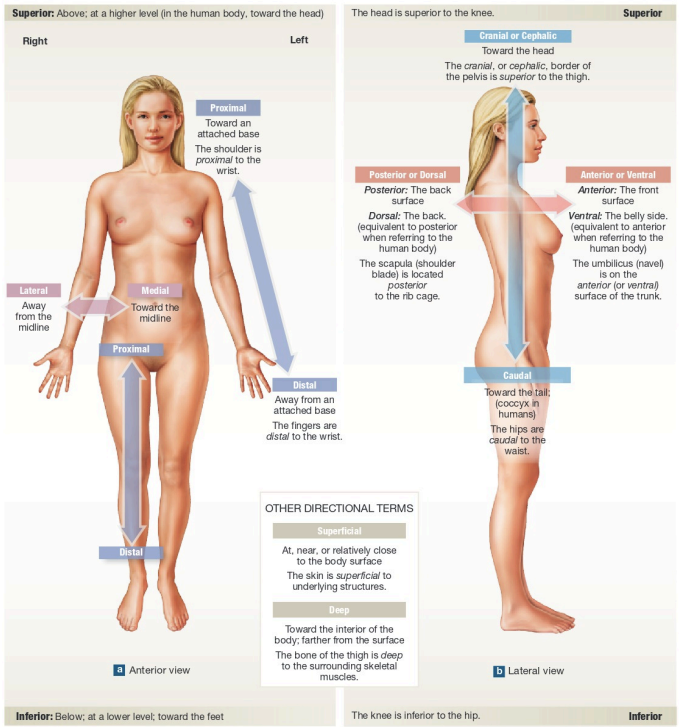
**Figure 1-8 Directional References.**



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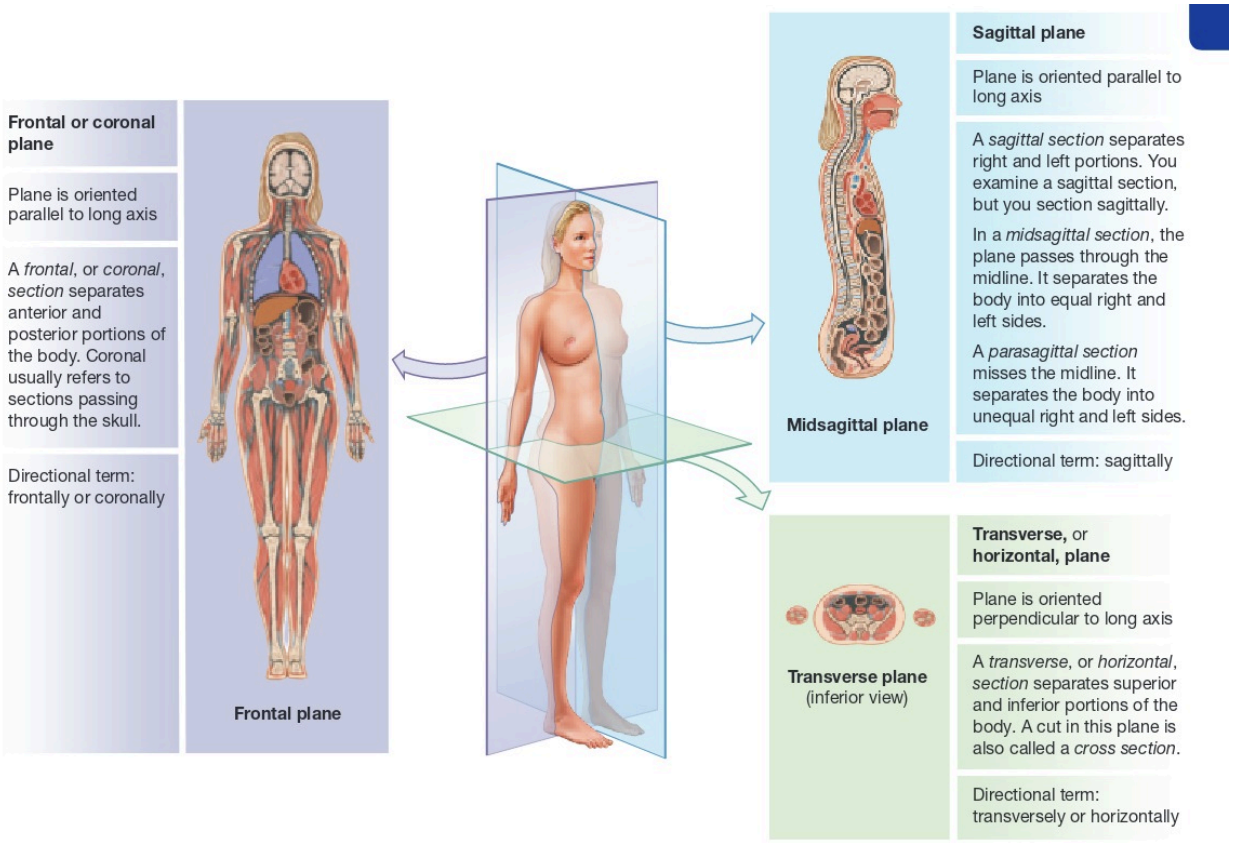
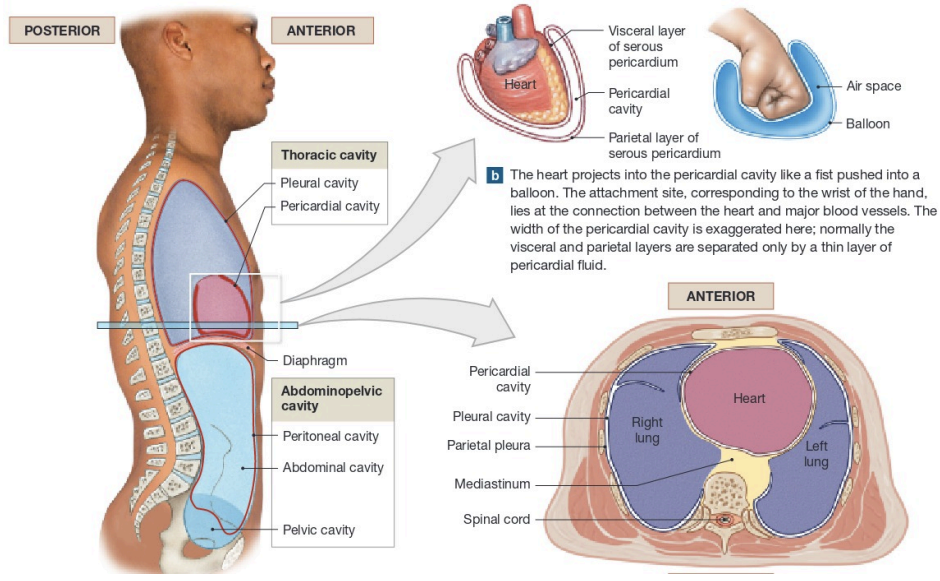



a. Coronal/Frontal, Transverse/Horizontal, Posterior/Dorsal, and Anterior/Ventral are interchangeable, so memorize all of them!

12. True Body Cavities:
    a. Closed, fluid-filled spaces
    b. Lined by a thin tissue layer called serous membranes
    c. Internal organs (also known as viscera) are suspended within these cavities

d.

**Figure 1-10** Relationships among the Subdivisions of the Body Cavities of the Trunk.



e. The diaphragm divides the superior thoracic and inferior abdominopelvic cavities. The thoracic cavity includes two pleural cavities with a central mass of tissue known as the mediastinum. Within the mediastinum is the pericardial cavity, which surrounds the heart. The abdominopelvic cavity consists of the abdominal cavity and the pelvic cavity. It contains the peritoneal cavity, a chamber lined by peritoneum, a serous membrane.
    i. Important radiological procedures (i.e., x-rays, CT and spiral CT scans, MRI, PET scans, and ultrasound) can provide insight into these structures and surrounding ones.

# Chapter 2 Review – The Chemistry of Living Things

Complete this assignment in your notebook so you can use it on your open note quiz next class. Recalling the information you learned in Chemistry and using chapter 2 of the textbook to help you, answer the following questions. The concepts given here will be presented on the unit test so be sure to answer each question in detail and ask if you get stuck. In addition to the questions given below, be sure you know the definition of the bold terms given throughout the chapter.

1. What is the difference between mass and weight? Which one would change if you went to the moon?
    a. Mass is the amount of matter within an object
    b. Weight is the pull of gravity on an object
    c. Weight would change if you went to the moon
2. What is the term given to the smallest stable unit of matter and what are the names, charges, and locations of the particles that compose this unit?
    a. Atom
    b. Protons (+), neutrons (neutral charge), electrons (negative)
    c. Protons and neutrons are in the nucleus, electrons are in orbit in the electron cloud
3. What does the atomic number of an atom represent? (Where is this number on the periodic table?)
    a. Number of protons
    b. Upper right corner of the elemental symbol
4. What is the difference between the mass number and the atomic weight?
    a. Mass number is the total number of protons and neutrons in an element
    b. Atomic weight is the average mass of an element's atoms
5. What is an isotope? How is an isotope written?
    a. An isotope has the same number of protons as a particular element but a different number of neutrons.
    b. Example: Carbon-14 (6 Protons, 8 protons, 6 electrons)
6. What determines the chemical properties of an element?
    a. The number of electrons in the electron shells
7. How many electrons can be held in each of the first three electron shells? How can an electron be described if the outermost electron shell is not filled with electrons?
    a. 2, 8, 8
    b. If the outer shell is not filled with electrons, the element is said to be unstable and will be reactive
8. What is the difference between ionic, covalent, and hydrogen bonds?
    a. Ionic bonds are chemical bonds created by the electrical attraction between anions and cations
    b. Covalent bonds result when electrons are shared with other atoms
    c. Hydrogen bonds form when there is an attraction between a slight positive charge on the hydrogen atom of one polar covalent bond and a slight negative charge on an oxygen or nitrogen atom of another polar covalent bond.
    d. Note: be sure you understand how these bonds actually form
9. Describe the difference between a polar and a non-polar covalent bond.
    a. A polar covalent bond forms when electrons are shared unequally between two atoms

b. A non-polar covalent bond forms when electrons are shared equally between two atoms
c. Note: be sure you know how polar bonds form and how polarity is symbolized

10. Name and define the two types of energy.
    a. Potential – stored energy
    b. Kinetic – energy of motion
11. How do enzymes (biological catalysts) increase the rate of a reaction?
    a. By decreasing activation energy
12. Name at least three properties of water that are particularly important for the human body.
    a. Water is an excellent solvent
    b. Water is liquid a body temperature
    c. Water can absorb and hold heat energy
    d. Evaporation of water uses heat energy
    e. Water participates in essential chemical reactions
13. What is the relationship between pH, acids, bases, and buffers?
    a. pH measures the concentration of hydrogen ions in a solution
    b. An acid has more hydrogen ions than OH- ions when it breaks apart
    c. A base has more OH- ions than H+ ions when it breaks apart
    d. A buffer stabilizes pH
14. Name, define, and give an example of the four macromolecules (the four major classes of organic compounds).
    a. Carbohydrates
        i. Define: an organic molecule that contains carbon, hydrogen, and oxygen in a ration near 1:2:1
        ii. Examples: Monosaccharides (glucose), Disaccharides (sucrose), polysaccharides (Glycogen)
    b. Lipids
        i. Define: A molecule that contains carbon, hydrogen, and a little bit of oxygen. Most are insoluble in water.
        ii. Examples: Fatty acids, fats, steroids, phospholipids
            1. NOTE: Be sure you know the difference between these different types of fats.
    c. Proteins
        i. Define: All proteins contain carbon, hydrogen, oxygen, and nitrogen which form long chains of amino acids. All amino acids have an R-group, a central carbon atom, a hydrogen, and an amino group.
        ii. Examples: Structural proteins, Contractile proteins, transport proteins, hormones, enzymes
    d. Nucleic acids
        i. Define: Large organic molecules, DNA and RNA, that store and process information within a cell
        ii. Example: DNA and RNA
            1. NOTE: Know the difference in structure and function of each. Also know which nucleotide pairs with which.
15. How are macromolecules made and broken down?

a. Made – Dehydration reaction
b. Broken down - Hydrolysis

16. What is ATP and how does it release and store energy?
    a. ATP stands for Adenosine triphosphate.
    b. The molecule is composed of an adenosine and three phosphates bound together. When energy is needed, the third phosphate is broken off and energy is released. When energy is stored, it is stored in the bond sticking the third phosphate back onto the ATP molecule.

Chapter 3 Review
Structure and Function of Cells

Using your knowledge from other biology classes and the textbook, answer the following questions. Notice the questions 12-20 are not in your textbook but cover a major cellular concept. You will be tested on this material so, in addition to knowing the questions below, be sure you know the bold terms given in the chapter. Complete this assignment in your notebook as you will have an open noted quiz on this material next class using your notebook.

1. What are the three basic concepts of the cell theory/doctrine?
    a. All living things are composed of cells and cell products
    b. A single cell is the smallest unit that exhibits all the characteristics of life
    c. All cells come from pre-existing cells
2. Name the two most common forms of microscopy used for studying cells.
    a. Light and electron (SEMs and TEMs)
3. Give the composition of the plasma membrane.
    a. Phospholipids
4. What are the primary functions of the plasma membrane?
    a. Isolation
        i. a barrier that separates the inside of the cell from the outside
    b. Regulation
        i. controls the entry of ions and nutrients, the elimination of waste, the release of secretions
    c. Sensitivity
        i. The membrane is the first part of the cell affected by changes in the extracellular fluid
        ii. Has receptors
    d. Structural support
        i. Special connections between plasma membranes give tissue a stable structure
5. Give the structure/function of each of the following:
    a. Membrane lipids, proteins, carbs
        i. Lipids
            1. Phospholipids are a major component of the cell membrane. They have a polar head and a non-polar fatty acid tail
            2. Hydrophobic "tails" face each other
            3. Creates phospholipid bilayer
        ii. Proteins
            1. Major functions include:
                1. Receptors
                2. Channels
                3. Carriers
                4. Enzymes
                5. Anchors
                6. Identifiers
        iii. Carbohydrates
            1. Combine with lipids to form glycolipids
            2. Combine with proteins to form glycoproteins
            3. Function as lubricants and adhesives, receptors, and identifiers

b. Cytoplasm
    i. Found in the cell and contains the cytosol and organelles
c. Cytosol
    i. Another name for the intracellular fluid
    ii. Contains nutrients for the cell
d. Cytoskeleton and its sub-pieces
    i. Threadlike filaments and hollow tubules made of protein giving the cell strength and flexibility
    ii. Usually composed of microfilaments, intermediate filaments, microtubules
e. Centrioles
    i. Cylindrical in shape, move DNA strands in cell division
f. Cilia
    i. Use ATP to move substances across the surface of the cell
g. Flagella
    i. Look like long cilia but are used to move the cell through its environment
h. Ribosomes
    i. Make proteins.
    ii. Two categories: Free and fixed
        1. Free ribosomes are spread throughout the cytosol
        2. Fixed ribosomes are attached to the ER
i. Proteasomes
    i. Organelles containing protein-breaking proteolytic enzymes, or *proteases*
j. Endoplasmic Reticulum
    i. Two types: Smooth and Rough
        1. Smooth Endoplasmic Reticulum (SER)
            • Has no ribosomes
            • Is where lipids and carbohydrates are synthesized
        2. Rough Endoplasmic Reticulum (RER)
            • Has fixed ribosomes on the membrane
            • Is where proteins are synthesized
    ii. Main Functions:
        1. Synthesis of proteins, carbohydrates, and lipids
        2. Storage of materials, isolating them from the cytosol
        3. Transport of materials through the cell
        4. Detoxification of drugs or toxins
k. Golgi Apparatus
    i. Made of flattened membranous discs called *cisternae*
    ii. Major functions include:
        1. Modifies and packages secretions (through secretory vesicles)
        2. Renews or modifies plasma membrane
        3. Packages enzymes (through lysosomes)
l. Lysosomes
    i. Membrane bound structures that hold digestive enzymes
    ii. Function to help with cleanup and recycling of materials within a cell
m. Peroxisomes
    i. Contain enzymes that breakdown fatty acids
n. Mitochondria
    i. Formed of a double membrane. Inner membrane is folded and called the cristae

ii. Site of major ATP production through cellular respiration
o. Nucleus
i. Largest organelle in the cell
ii. Control center of the cell
iii. Dictates cell function and structure by controlling protein synthesis
iv. Nuclear envelope is a double membrane that surrounds the nucleus
1. Has pores that allow some movement of substances into and out of the nucleus

6. What is permeability and why is it important for a cell?
a. Permeability determines what substances can cross the membrane
i. Impermeable – nothing can cross
ii. Freely permeable – Anything can cross
iii. Selectively permeable – Some things can cross
7. What is the difference between passive and active transport? Give an example of each.
a. Passive does not need energy
i. Examples – Diffusion and Osmosis and filtration
b. Active requires ATP
i. Examples – carrier mediated transport, vesicles, endocytosis
8. What is diffusion?
a. When molecules move from an area of high concentration to an area of low concentration (down the concentration gradient)
9. What is osmosis? (Give the three characteristics of osmosis)
1. Diffusion of water molecules across a selectively permeable membrane
2. Occurs across a selectively permeable membrane that is freely permeable to water, but not freely permeable to solutes
3. Water flows from low solute concentration to high solute concentration
10. What is tonicity? Name and define the three solution types.
a. The effect of solute concentrations on the shape of the cell membrane
i. Three types:
1. Isotonic
a. A solution that has the same concentration as the intracellular fluid and the cell membrane stays intact.
2. Hypotonic
a. A solution that has a concentration of solutes that is lower than the ICF. Causes swelling and the cell my burst.
3. Hypertonic
a. A solution that has a concentration of solutes that is lower than the ICF. Causes water to move out of the cell and the cell shrinks.
11. What is the primary difference between endocytosis and exocytosis?
a. Both require ATP
b. Endocytosis moves material into the cell
c. Exocytosis moves material out of the cell
12. What is the difference between chromatin and chromosomes?
a. Chromosomes are found in the nucleus and are tightly coiled, X-shaped structures composed of DNA
b. Chromatin is loosely coiled DNA found in cells that are not dividing
13. How are proteins synthesized?
a. Transcription – DNA that encodes a particular protein is copied to mRNA in the nucleus. The mRNA is edited and leaves the nucleus. This is done in three steps:
1. RNA polymerase binds to promoter gene and "unzips" the DNA

2. New RNA codon triplets are formed, using uracil instead of thymine
3. At DNA "stop" signal, mRNA detaches and "unzipped" DNA reattaches

b. Translation – the mRNA is read by a ribosome and a protein is made. This is done in five steps:

1. "Start" codon of mRNA combines with small ribosomal subunit and first tRNA
   - Coding for methionine with the base sequence AUG
2. Small and large ribosomal subunits enclose the mRNA
3. 2nd tRNA brings another amino acid
   - Its anticodon binds to 2nd codon of mRNA
4. Ribosomal enzymes remove 1st amino acid and attach it to the 2nd with a peptide bond
   - Ribosome moves along the codons repeating these steps
5. Amino acids continue to be added until ribosome reaches the "stop" codon at end of mRNA
   - Ribosome detaches leaving the strand of mRNA and a newly completed polypeptide

14. Name the stages of the cell life cycle.
    a. Mitosis and Interphase.
15. Define the three phases of interphase.
    1. $G_1$ phase is when the cell duplicates organelles and adds cytosol
    2. S phase is when DNA is replicated in the nucleus
    3. $G_2$ phase is when centrioles are replicated
16. Define the four stages of mitosis.
    1. Prophase
       a. DNA has been replicated and is coiled
       b. Each chromatid is connected at the centromere
       c. Centrioles move to the opposite poles of the cell and spindle fibers appear
    2. Metaphase
       a. Chromatids line up on the metaphase plate
    3. Anaphase
       a. Centromere of each chromatid splits creating daughter chromosomes
       b. Daughter chromosomes are pulled apart and move toward the centrioles
    4. Telophase
       a. Nuclear membrane forms
17. What happens in cytokinesis?
    a. Usually begins in late anaphase and continues through telophase
    b. Cytoplasmic division results that forms two daughter cells.
18. Name and define the two types of tumors.
    a. Benign
       i. Usually contained in one area
    b. Malignant
       i. These cells spread – metastasized
19. What is cancer?
    a. Uncontrolled cell growth

20. What causes cell differentiation?
    a. When specific genes are turned off, leaving the cell with limited capabilities
        i. Gives cells a specific function.

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# Tissues
**Histology: the study of tissue**

## Epithelial
Covers exposed surfaces and produces grandular secretions (ex. liver lining, skin)

- **Transitional Epithelium** (permits expansion, recoiling, and stretching) (ex. bladder, uterus)
- **Simple Epithelium** (single-layered)
  - **Squamous** (reduces friction, controls vessel permeability, performs absorption and secretion)
  - **Cuboidal** (protection, secretion, absorption)
  - **Columnar** (ciliated (mainly found in intestines); involved in movement, secretion, and absorption)
- **Stratified Epithelium** (multi-layered)
  - **Squamous** (provides physical protection from abrasion, pathogens, and chemicals)
  - **Cuboidal** (protection, secretion, absorption)
  - **Columnar** (protection, movement of mucus with cilia)

## Connective
Fills internal spaces, provides structural support, and stores energy (ex. fat)

Connective tissue is found internally only, is highly vascular, and has specialized fibers and ground substance (matrix that surrounds and supports cells). Contains 1) specialized cells, 2) protein fibers, 3) ground substance

- **Supporting**
  - **Cartilage** (avascular, matrix of firm gel, held up by ECM-maintaining chondrocytes)
    - **Elastic** (ear, epiglottis, larynx), **Hyaline** (joints, ribs, nose, and trachea), **and Fibrocartilage** (intervertebral discs, pubic symphysis, knee menisci)
  - **Bone**
    - Osseous Tissue (osteon), little ground substance, made of hard calcium fibers
- **Fluid**
  - **Blood, Lymph, Plasma**
- **Connective Tissue Proper**

  **Made of 4 Different Cells:**
  1) Fibroblasts: make fibers, ground substance
  2) Macrophages: phagocytotic, migrated/fixed
  3) Fat Cells: stores energy
  4) Mast Cells: Histamine releasing

  **Made of 4 Fiber Types:**
  1) Collagen (unbranced)
  2) Elastic
  3) Reticular Fibers
  4) Ground Substance
  - **Dense** (tough and durable)
    - Tendons, Ligaments, Regular/Irregular Dense
  - **Loose** (packing material)
    - Areolar, Adipose, Reticular

## Muscle
Contracts to produce active movement

Three types: Cardiac (involuntary), Smooth (involuntary), Skeletal (voluntary)

## Neural
Conducts electrical impulses, carriers information (brain, spinal cord)

## Secretion Types
- **Exocrine** (glands and their secretions that are released via ducts to a body ***surface***)
  - **Merocrine** no cellular components are leaked (ex. sweats/eccrine glands)
  - **Apocrine** cytoplasm, lipids, and proteins leak (ex. mammary glands)
  - **Holocrine** whole cell burts, all cellular components are leaked out (ex. sebaceous glands)
- **Endocrine** (glands and organs that produce and release hormones into the ***bloodstream***)

## Tissue Membranes
Epithelium supported by connective tissue that acts as barriers

- **Mucous** coated with secretions – keeps things moist (i.e., digestive and respiratory tract
- **Serous** produce fluid, line internal cavities (i.e., pleura, peritoneum, and pericardium)
- **Cutaneous** thick and dry (i.e., skin)
- **Synovial** lubrication around joints (i.e., shoulder)

## Tissue Damage (Inflammation)
- **Redness** (increased blood flow certain area → blood is red → area becomes red)
- **Swelling** (blood flow is increased to certain area → that certain area increases in volume due to increase fluids)
- **Heat** (blood is warmer → when blood rushes to area → area gets warmer)
- **Pain** (increased blood flow to certain area → presses on surrounding nerves → causes pain

## Cell Adhesion Molecules (CAMs)
Large group of cell-surface proteins that allow cells to bind to one another

- **Large Transmembrane Proteoglycans**
- **Cell Junctions**
  - **Tight Junctions** Found in epithelial cells of the intestinal lining, creating a pathogen/ion/molecule leakage proof seal between adjacent cells
  - **Gap Junctions** Found between neurons of the brain, consist of connexons that form channels allowing direct transfer of ions and small molecules between adjacent neurons (signals and coordinates neural activity)
  - **Desmosomes** Intermediate filaments of neighboring cells fostering strong cell-to-cell adhesion. Especially important in areas of mechanical stress (i.e. cardiac muscle, bladder tissue, GI mucosa, epithelia)
    - **Spot and Hemidesmosomes**

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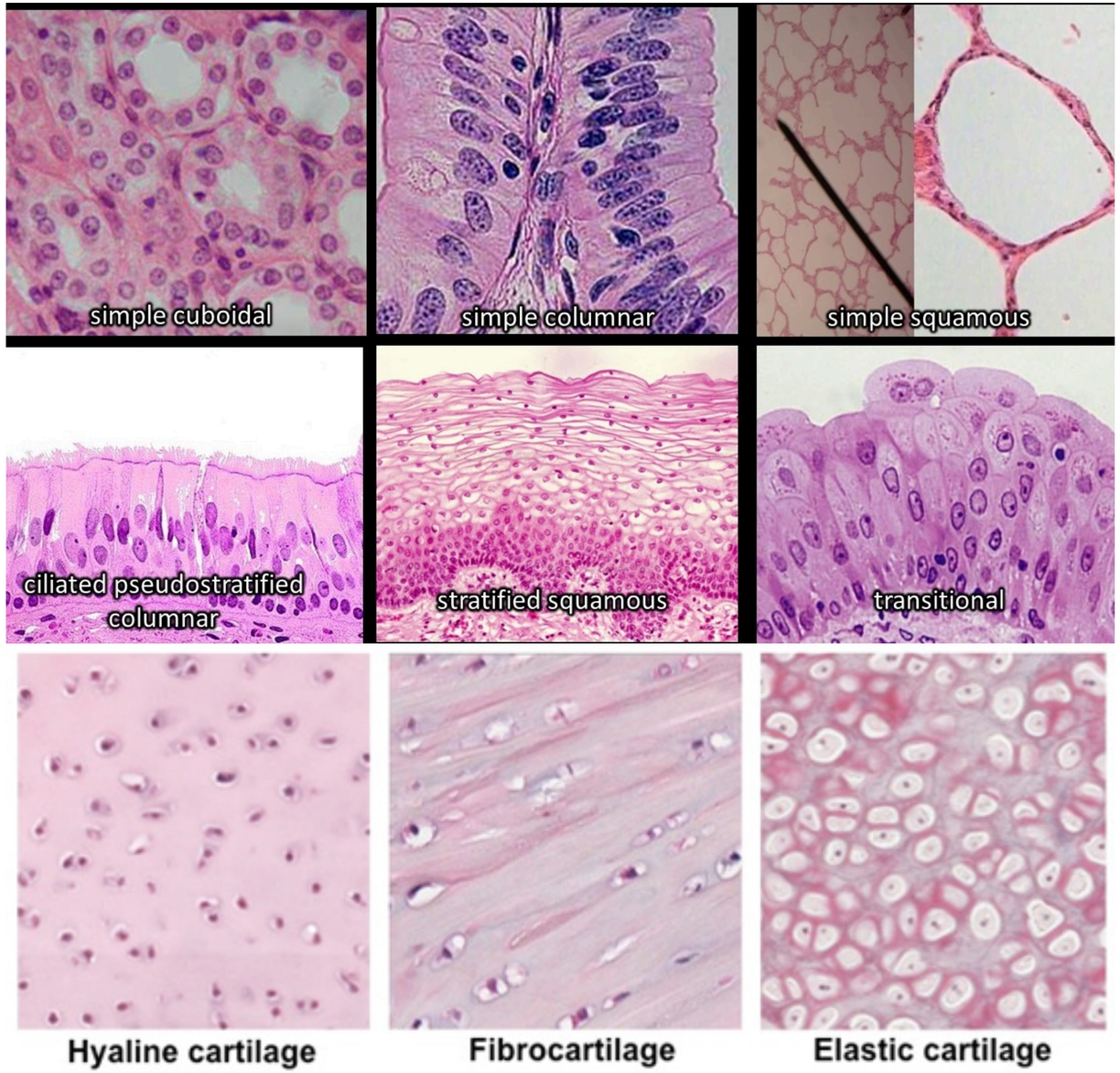


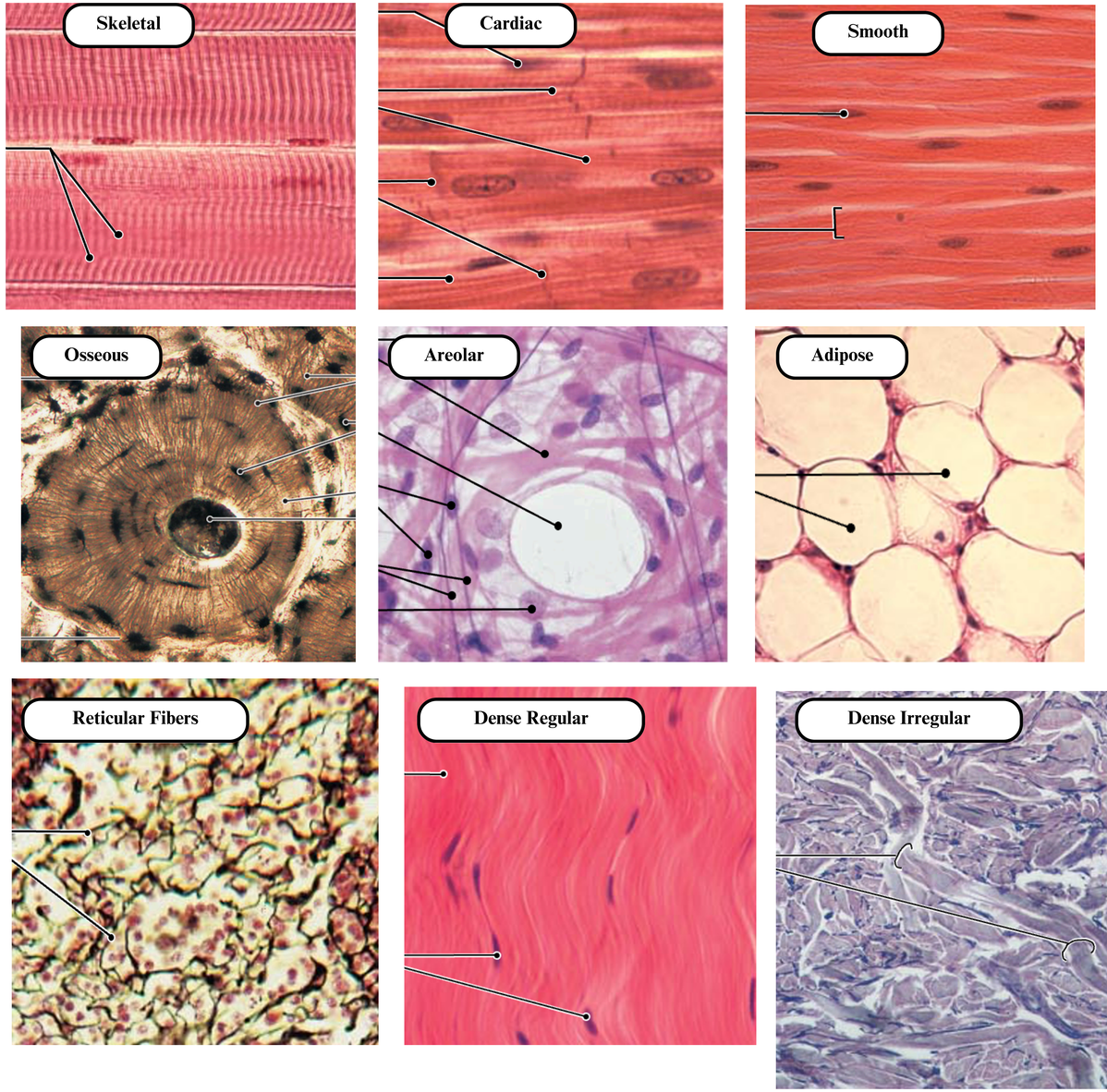

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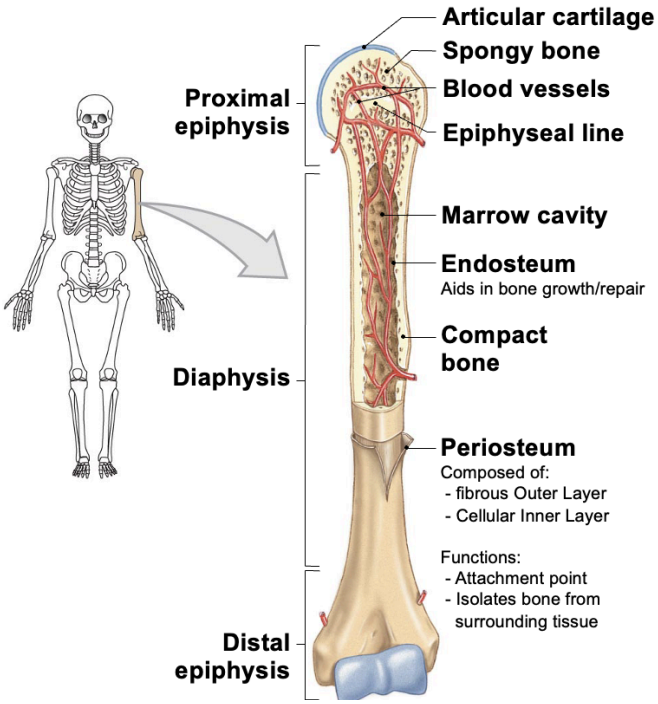
# Unit 3: The Skeletal System Study Guide

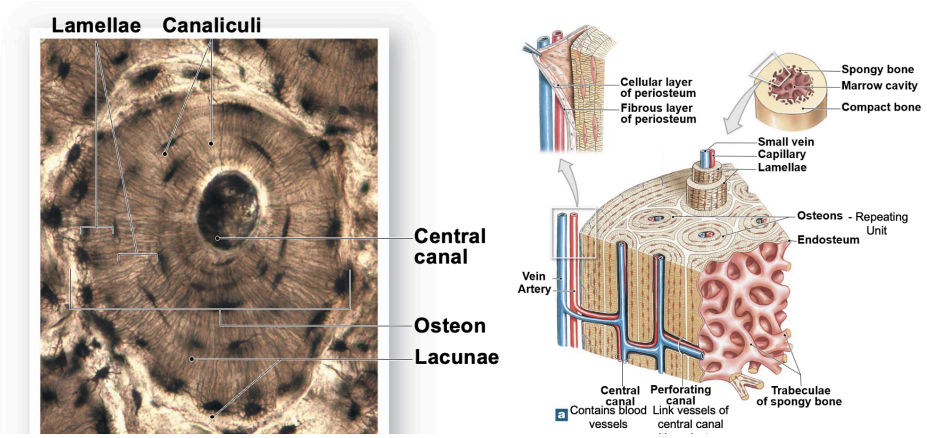
1. Functions of the skeletal system are:
    a. **Support** - rigid internal framework that resists the pull of gravity and gives the body its shape and posture
    b. **Storage** - calcium (bone matrix) and lipids (yellow bone marrow)
    c. **Blood Cell Production** - in red bone marrow
    **d. Protection**
    e. **Leverage** (act as levers in the body by acting as rigid bars, with joints serving as the pivot points (fulcrums) around which movement occurs)
2. Bone (Osseous) Tissue is a type of supporting connective tissue and is made of specialized cells and a matrix containing ground substance and extracellular protein
    a. 67% Calcium Phosphate
    b. 33% Collagen Fiber
3. Bones can be categorized into four types:
    a. Long Bones (i.e., Humerus): longer than wide
    b. Short Bones (i.e., Carpal Bones): equal in length and width
    c. Flat Bones (i.e., Parietal Bones): thin and broad
    d. Irregular Bones (i.e., Thoracic Vertebra): complex shapes
4. 

5. Bones are made of compact (dense) and sponge (cancellous) tissue types
    a. Compact (Dense)
        i. Covers all bone surfaces

ii. Has parallel arrangements of osteons within the bone
iii. Strong resistance against stress applied at the end of the bone but not the side

b. Spongy (Cancellous)
i. No osteons
ii. No central canal
iii. Contains red marrow
iv. Found in low stress locations
v. Found in locations with stress from many directions (i.e. epiphysis)

6. Microscopic Features of Osseous Tissue / Osteons

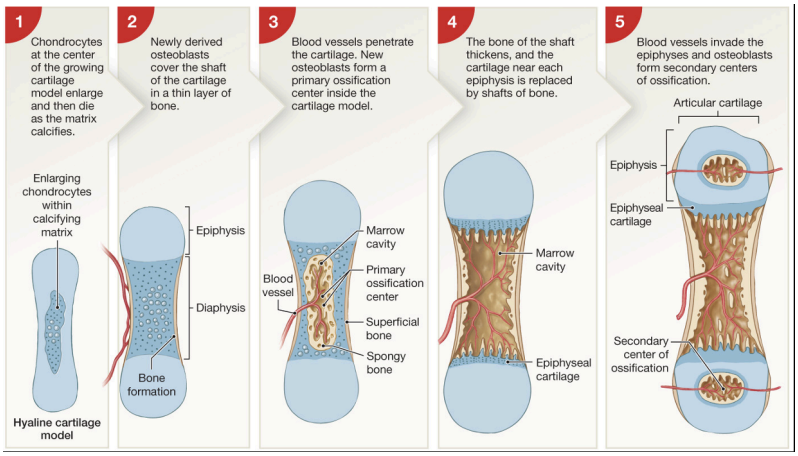
a. 


b. Central Canal: carriers blood vessels and nerves
c. Canaliculi: Connect lacunae, transport nutrients, waste
d. Lamellae: Strengthen bone with layered matrix
e. Osteon: Structural unit of compact bone
f. Lacunae: House osteocytes within bone matrix

7. Bone Cell Types
a. Osteocytes (Cytes hold the Site)
i. Maintain bone structure, most abundant
b. Osteoclasts (Clasts Blast the Bone)
i. Secrete acids/enzymes, breakdown bone
c. Osteoblasts (Blasts Build the Bone)
i. Ossification (calcification), some osteoblasts can develop into osteocytes

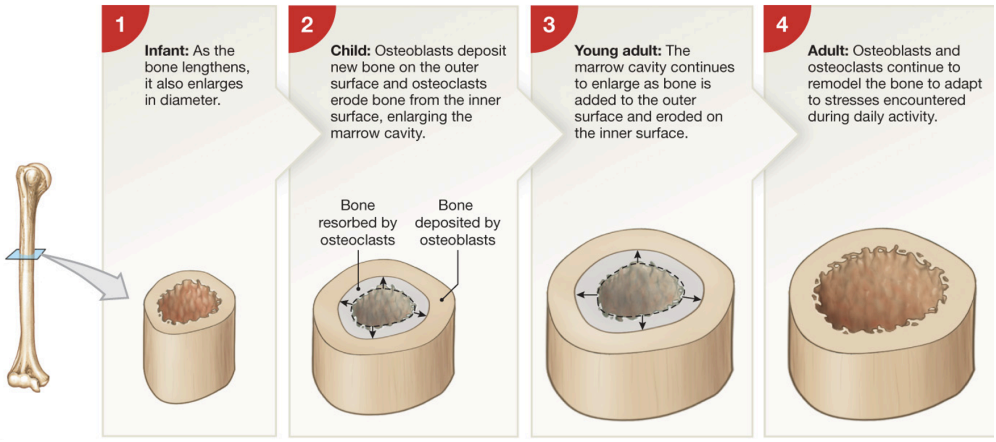
8. Bone Formation Differences in Babies and Adults
a. Babies = 300 bones, while Adults = 206 bones
b. Formation of bone as cartilage begins at week 6 in utero, and later ossifies and fuses post-delivery
c. Babies have more bones, that are yet to be fused, than adults since:
i. Brain growth increases head volume → skull bones need to expand to accommodate
ii. Skeletal system needs to accommodate potential stress during delivery through vaginal canal

9. Ossification is the process of replacing other tissue with bone during which calcification occurs
a. **Endochondral Ossification**: bones are formed through ossification of hyaline cartilage

i. 


b. **Intramembranous Ossification**: a process in which mesenchymal cells directly differentiate into osteoblasts, which then secrete osteoid (an unmineralized matrix) that calcifies to form bone, without an intermediate cartilage stage

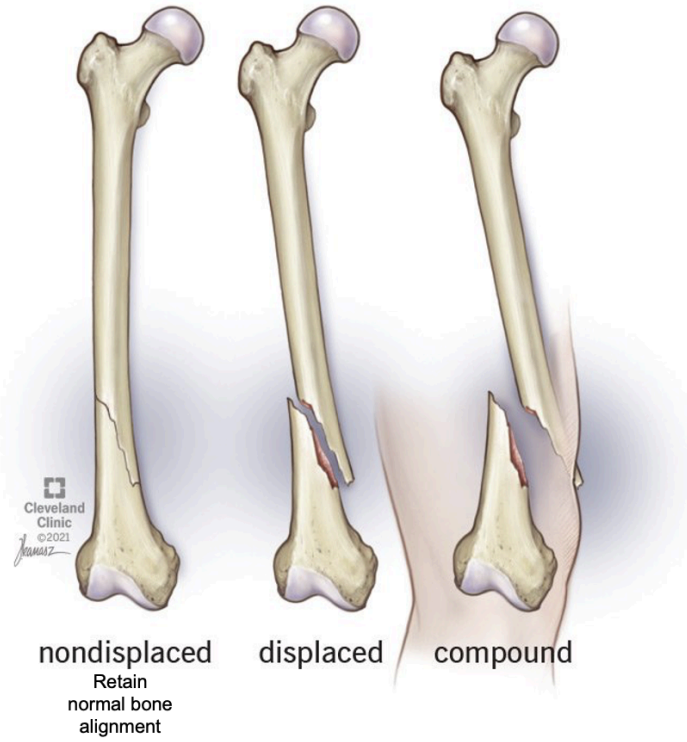
10. Puberty and Bone Development
    a. During puberty, more growth hormone is released, allowing for osteoblasts to produce bone faster than epiphyseal cartilage can expand
    b. Epiphyseal cartilage disappears and forms epiphyseal line (growth plate)
    c. Appositional Growth: growth in bone width by increasing bone matrix
        i. Osteoblasts increase outer surface of bone while osteoclasts erode inner surface
11. Requirements for Bone Growth
    a. Calcium (Ca)
    b. Vitamin D3 (aids in Ca metabolism, made by epidermal cells when exposed to sun, liver and kidney process D3 into calcitriol (a hormone that stimulates Ca and P absorption))
    c. Associated Pathologies: Rickets occurs from a vitamin D3 deficiency, Scurvy occurs from a vitamin C deficiency (decreases osteoblast activity)
12. Appositional Growth and Bone Remodeling (the continuous process that involves the breakdown and renewal of bone tissue)

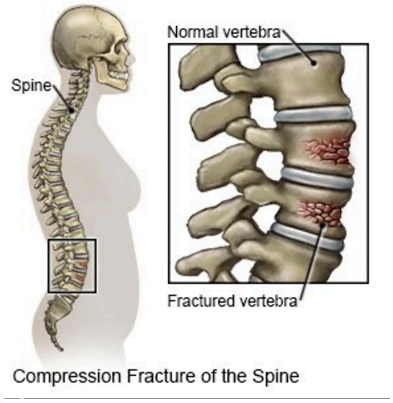
a. 

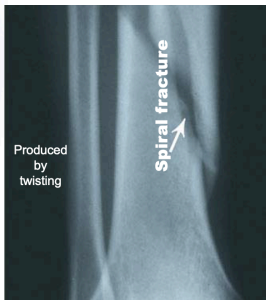

    b. Stressed bones grow thicker and stronger
    c. Inactive bones become brittle
    d. For young adults, 20% of their skeleton is remodeled per yr
13. The Importance of Calcium – especially for neural health and Calcium Regulation

a. Calcium (Ca) is vital for the body, with 99% stored in the skeleton, providing structural support. The remaining 1% in other tissues, like neurons, is crucial for their function. A 30% increase in calcium levels can lead to unresponsive neurons, impairing nerve signaling. A 35% decrease can cause convulsions due to disrupted nerve activity. A 50% decrease is life-threatening, potentially leading to death as it severely affects bodily functions, including the heart and brain.
b. Calcium Regulation
    i. Parathyroid Hormone (PTH) and Calcitriol Raises Ca
    ii. Calcitonin lowers Ca levels

14. Fractures (Crack in Bone) and Fracture Repair
    a. Two Categories: closed (internal only) and open/compound (internal and external)
    b.




    c. Immediately after fractures occur, extensive bleeding occurs. Over a period of several hours, a large blood clot (fracture hematoma) develops → then an internal callus forms as a network of spongy bone unites the inner edges, and an external callus of cartilage and bone stabilizes the outer edges → then the cartilage making up the external callus gets replaced by bone, and struts of spongy bone now unite the broken ends, fragments of dead bone and the areas of bone closest to the break have been removed/replaced
    d. Osteopenia (aka inadequate ossification) can lead to osteoporosis, which can increase the ease of fractures and heighten bone pain

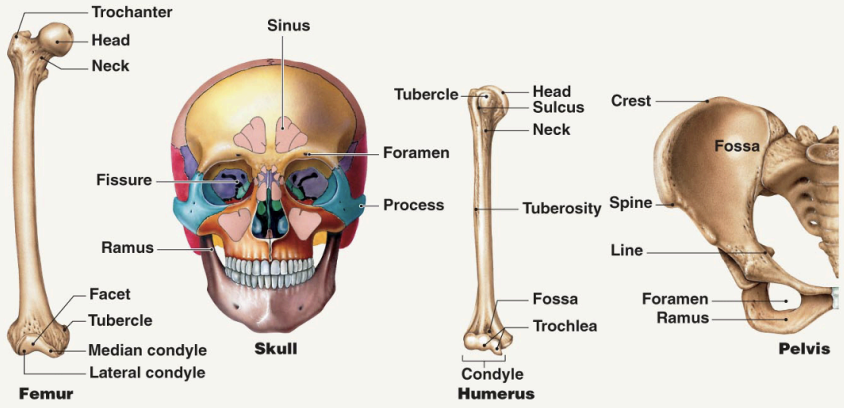
15. Bone Markings and Anatomy

a.

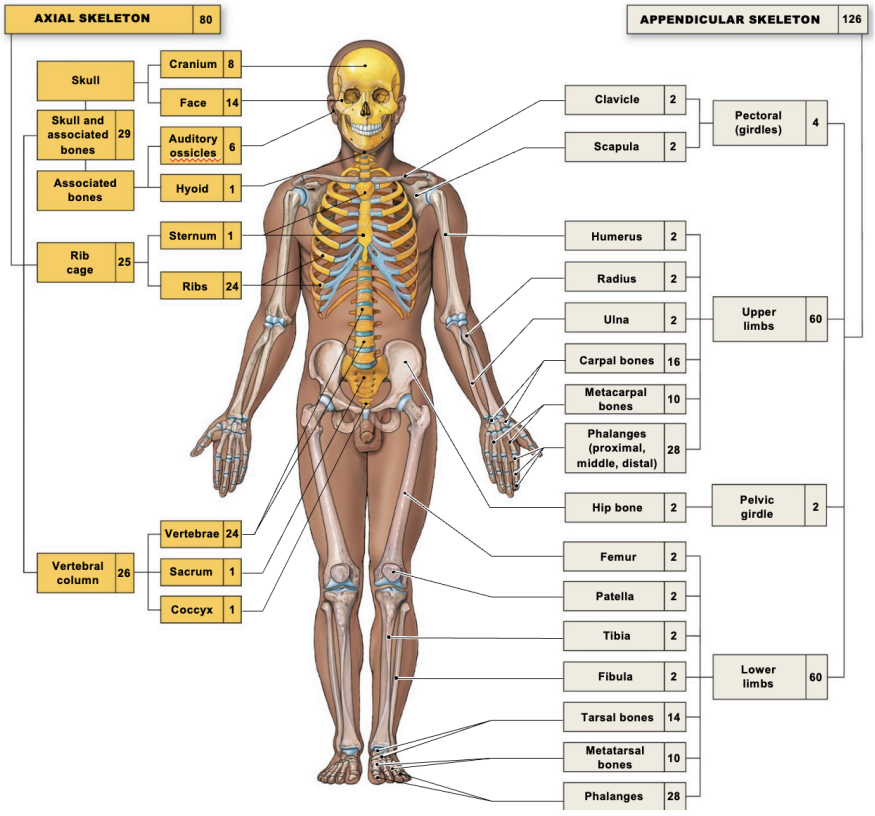
| General Description | Anatomical Term | Definition |
|---|---|---|
| Elevations and projections (general) | Process | Any projection or bump |
| | Ramus | An extension of a bone making an angle with the rest of the structure |
| Processes formed where tendons or ligaments attach | Trochanter | A large, rough projection |
| | Tuberosity | A smaller, rough projection |
| | Tubercle | A small, rounded projection |
| | Crest | A prominent ridge |
| | Line | A low ridge |
| | Spine | A pointed process |
| Processes formed for articulation with adjacent bones | Head | The expanded articular end of an epiphysis, separated from the shaft by a neck |
| | Neck | A narrow connection between the epiphysis and the diaphysis |
| | Condyle | A smooth, rounded articular process |
| | Trochlea | A smooth, grooved articular process shaped like a pulley |
| | Facet | A small, smooth articular surface |
| Depressions | Fossa | A shallow depression |
| | Sulcus | A narrow groove |

b.

| Openings | | |
|---|---|---|
| | Foramen | A rounded passageway for blood vessels or nerves |
| | Canal | A duct or channel |
| | Meatus | A passageway through a bone |
| | Fissure | An elongated cleft or slit |
| | Sinus | A chamber within a bone, normally filled with air |



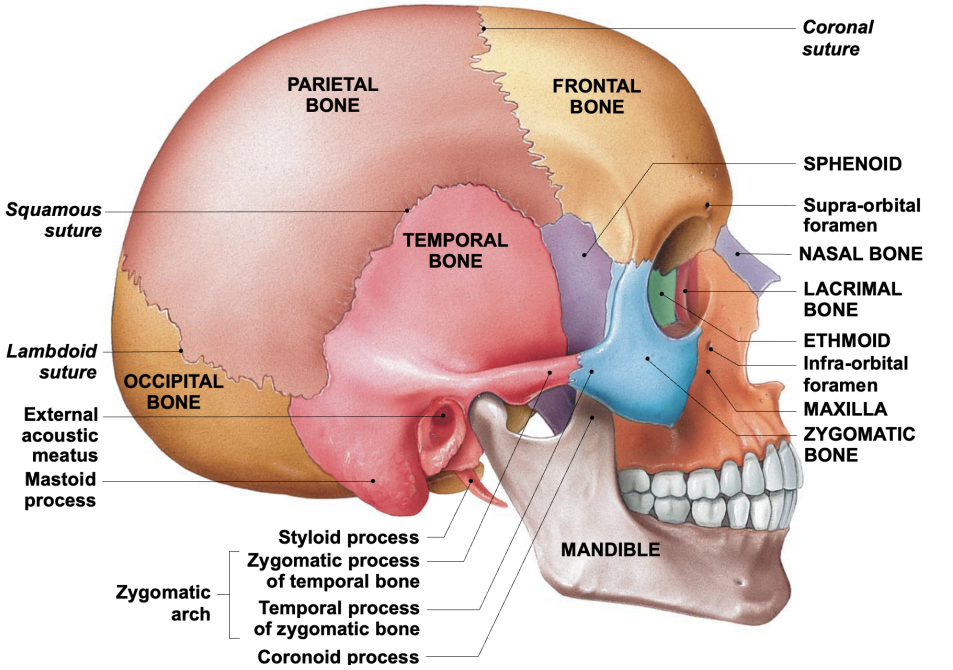

c.



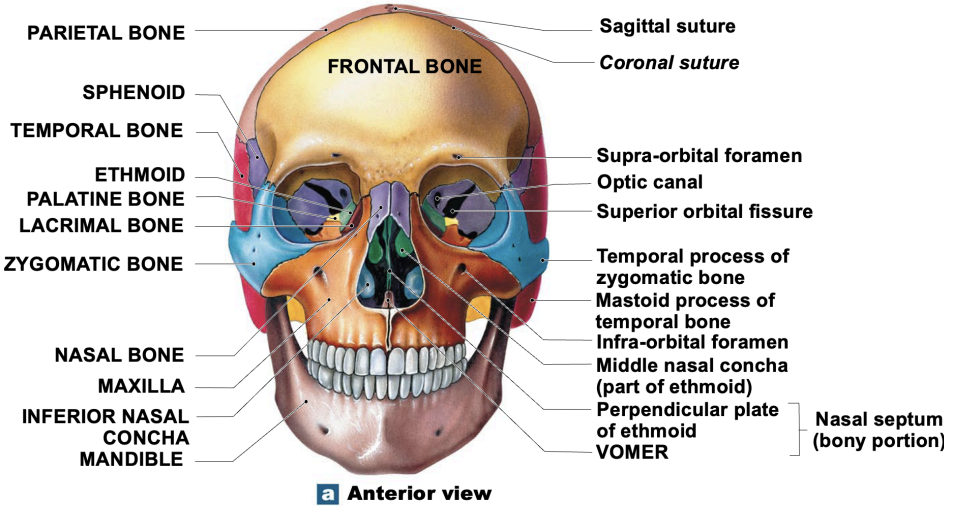
d. Two Skeleton Types: Axial and Appendicular
    i. Axial Skeleton
        1. Supports and Protects
        2. 80 bones
        3. Performs respiratory movement and aids in stability
    ii. Appendicular Skeleton
        1. Includes the bones of the upper and lower limbs (arms and legs), as well as the pectoral (shoulder) and pelvic (hip) girdles that connect them to the axial skeleton
        2. Facilitates mobility, locomotion, and interaction with the environment through movements like walking, running, grasping, and lifting

e. The Skull (22 bones total)

i.




ii.



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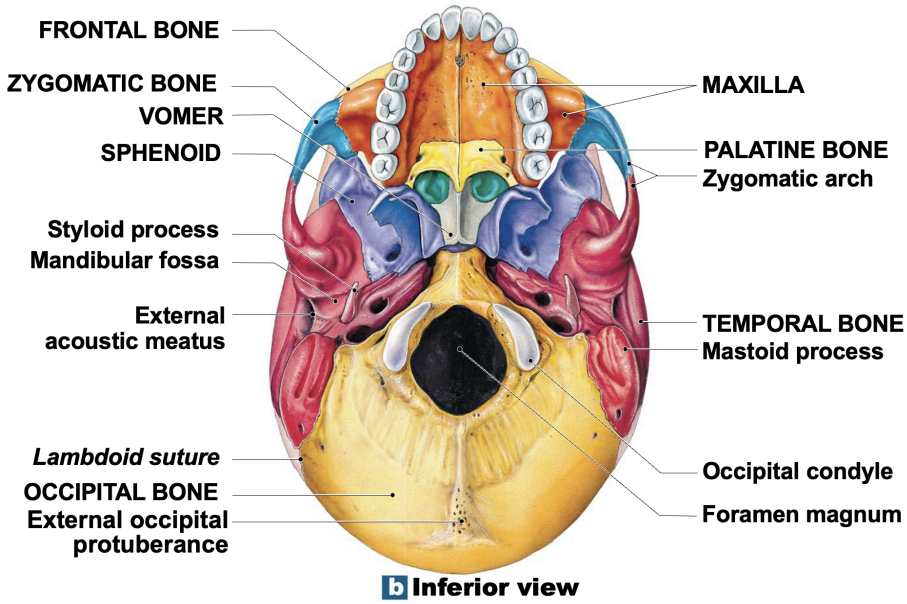
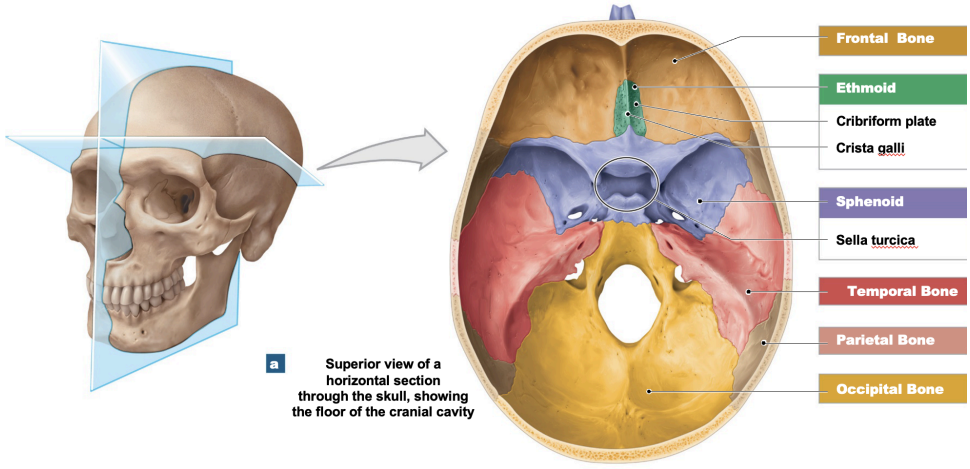
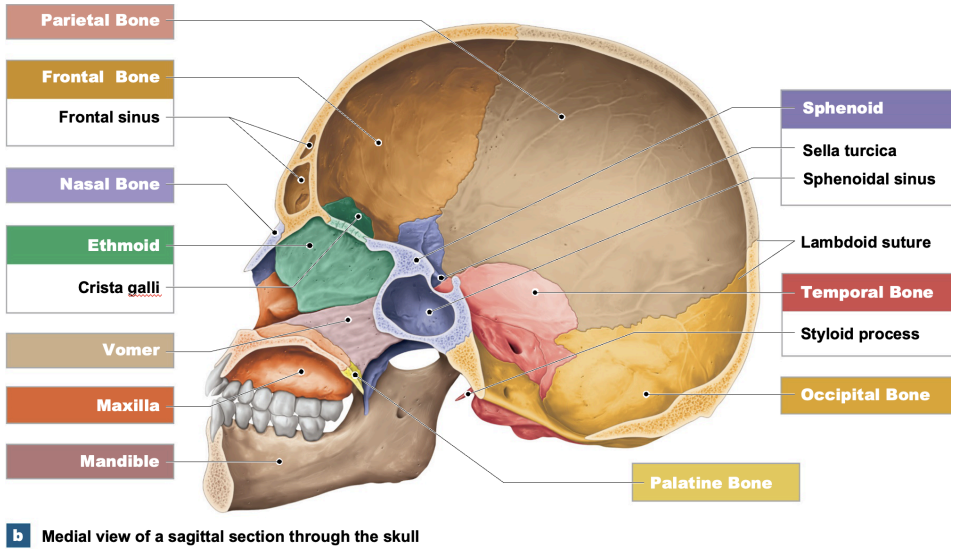



iv.

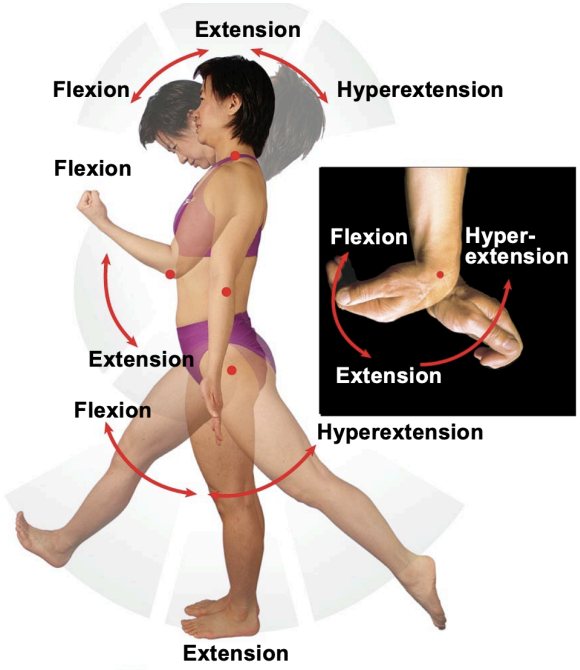



v.



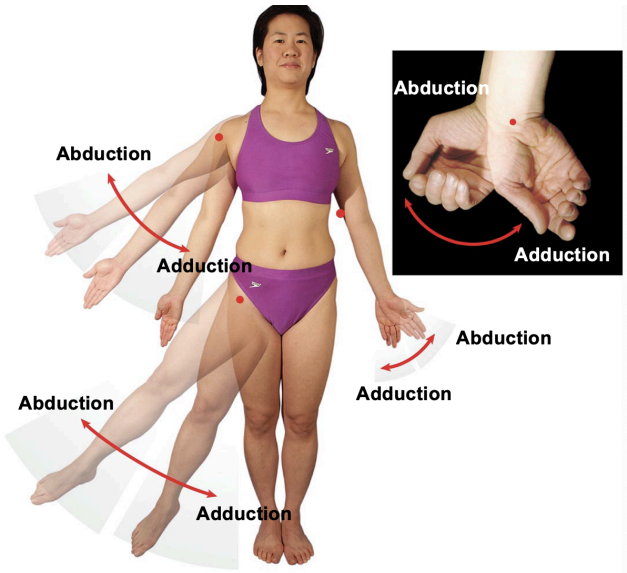

16. Angular Movements

a. Flexion: Decreases the angle between two bones. Example: Bending the knee.
b. Extension: Increases the angle between two bones. Example: Straightening the elbow.
c. Hyperextension: Extending beyond anatomical position. Example: Tilting the head backward.

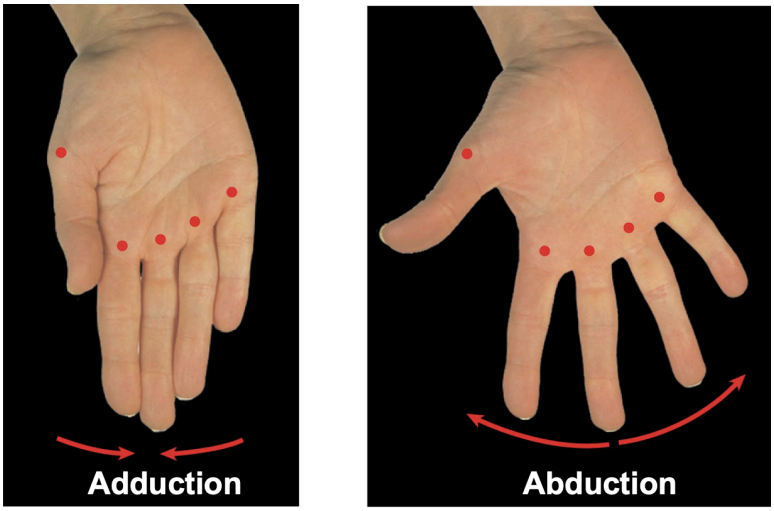



i. a Flexion/extension

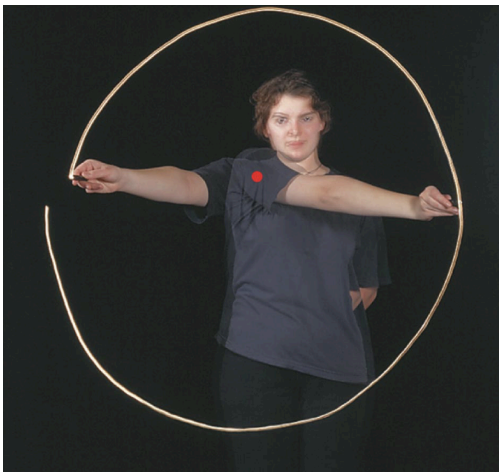
d. Abduction: Movement away from the body's midline. Example: Raising arm sideways.
e. Adduction: Movement toward the body's midline. Example: Lowering arm to side.



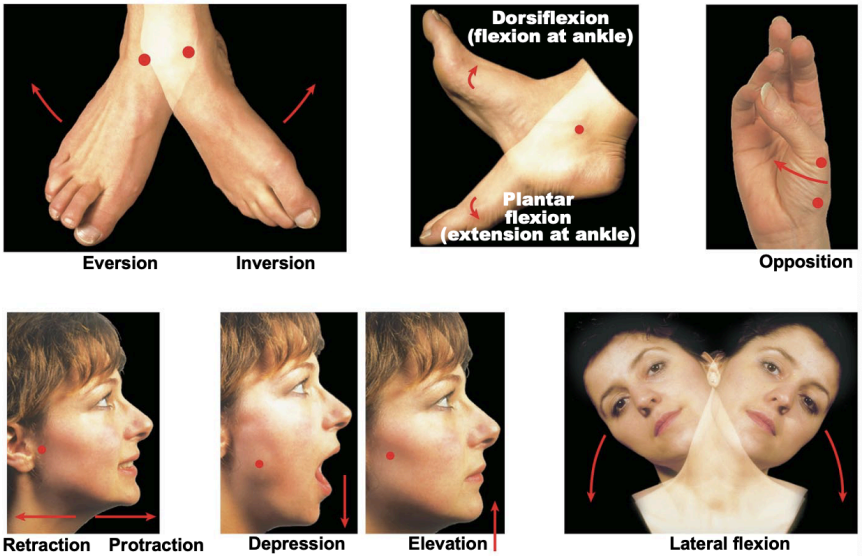

i. b Abduction/adduction

ii. 

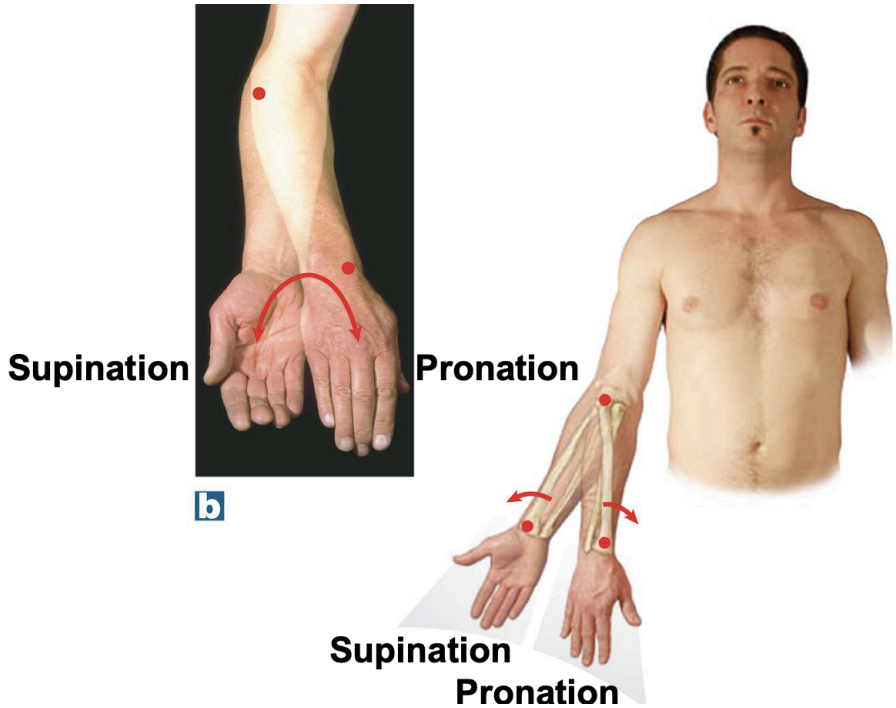

f. Circumduction: Circular movement of a limb. Example: Arm circles at the shoulder.

i. 

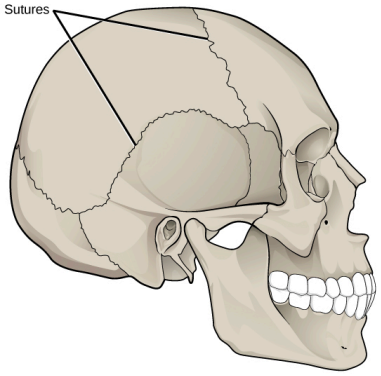
g. Opposition: Thumb movement touching other fingers. Example: Thumb to pinky tip.

h. 

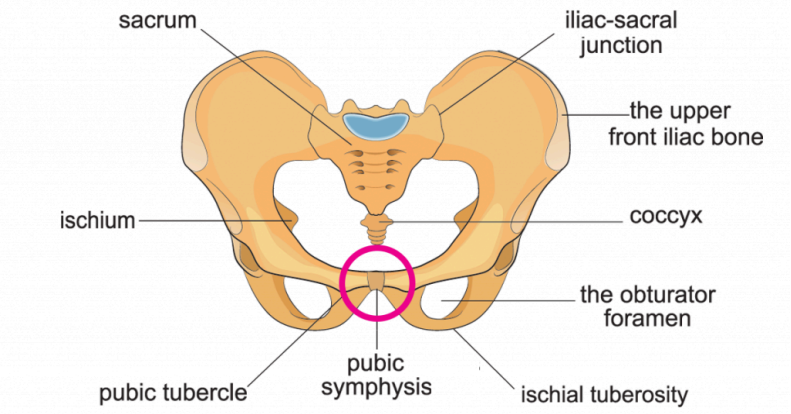
i.




17. Joint Types: A Functional and Structural Classification
    a. Synarthrosis (no movement): ex. suture joints between bones on your skull
    i.



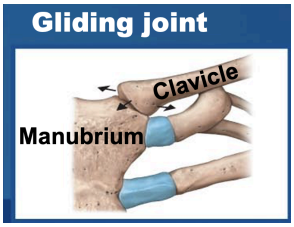
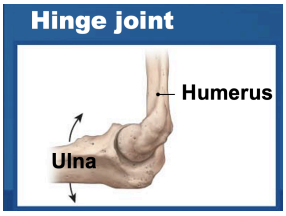
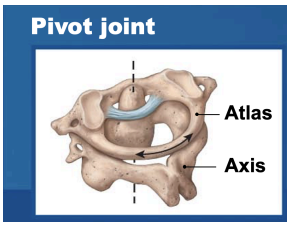
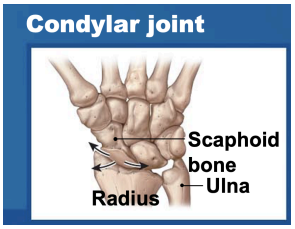
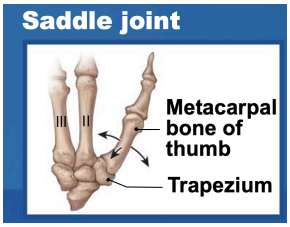

    b. Amphiarthrosis (little movement): ex. pubic symphysis
    i.

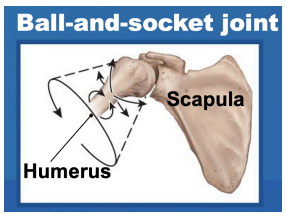



    c. Diarthrosis (free movement): knee and elbow joints
    d. Classifications by Structure

i. Fibrous: Bones joined by dense connective tissue, no joint cavity. Example: Skull sutures.
ii. Cartilaginous: Bones united by cartilage, limited movement. Example: Pubic symphysis.
iii. Synovial: Bones separated by fluid-filled cavity, freely movable. Example: Shoulder joint.

18. The 6 Synovial Joint Types
    a.

| IMAGE | DEFINITION / EX. |
|---|---|
|  | Flat surfaces slide past each other. Example: Clavicle–manubrium joint. |
|  | Allows flexion and extension. Example: Elbow (humerus–ulna). |
|  | Rotation around a single axis. Example: Atlas–axis (neck). |
|  | Oval surface fits depression, permits biaxial movement. Example: Wrist (radius–scaphoid). |
|  | Both bones concave/convex, biaxial. Example: Thumb (trapezium–metacarpal). |

| | |
|---|---|
|  | Multiaxial, spherical head in round socket. Example: Shoulder (humerus–scapula). |

19. Rheumatoid Arthritis: where your immune system attacks the tissue lining the joints on both sides of your body

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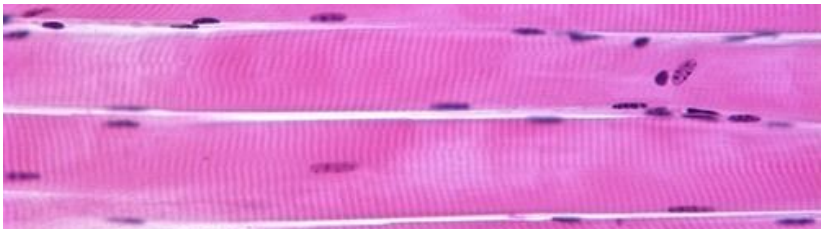
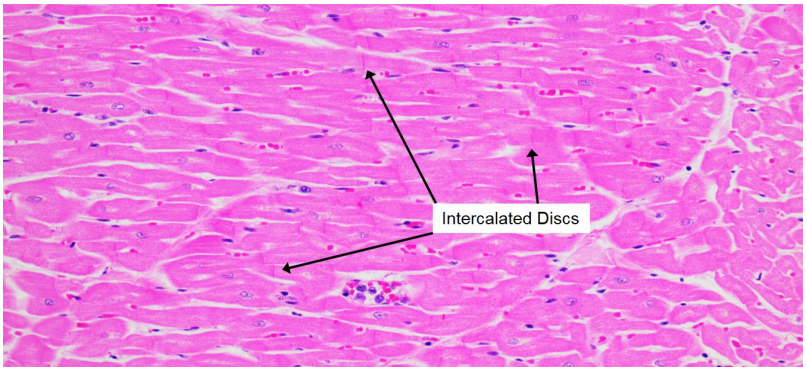
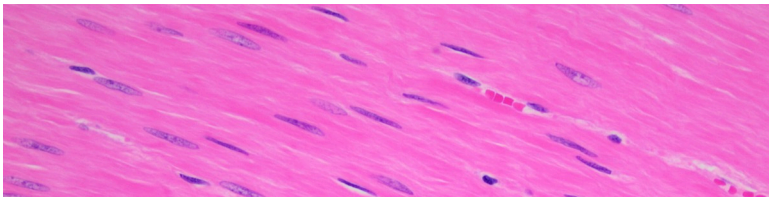
Anatomy and Physiology Honors - 2B

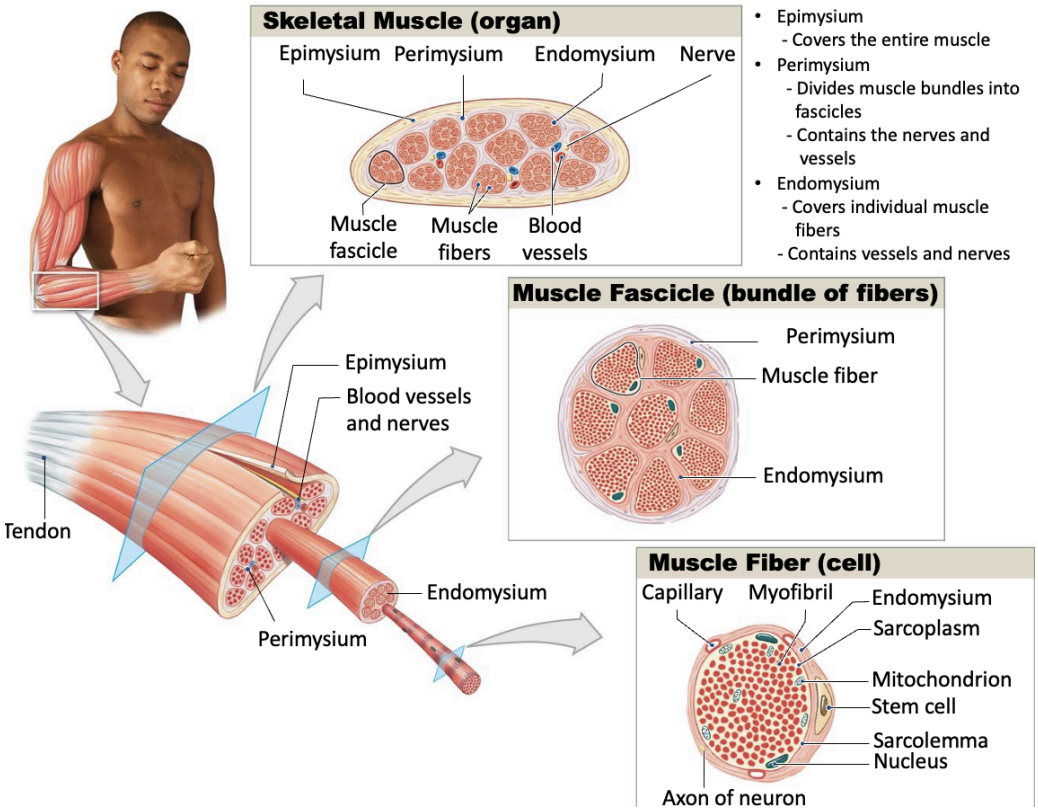
# Unit 4: The Muscular System Study Guide

1. Muscle Tissue: elongated muscle cells specialized for contraction
    - **a. Skeletal Muscle**
        - i. Mainly found in: Muscles attached to bones (e.g., biceps, quadriceps).
        - ii. Histopathological characteristics: Long, cylindrical, multinucleated cells; **striated** (visible bands due to sarcomere organization)
            1. 
        - iii. Voluntary
            1. Skeletal muscle is voluntary because axons push through to the endomysium for control of individual muscle fibers
    - **b. Cardiac Muscle**
        - i. Mainly found in: Heart (myocardium).
        - ii. Histopathological characteristics: Branched, striated cells with single or dual nuclei; **intercalated discs** (specialized junctions)
            1. 

        - iii. Involuntary
    - **c. Smooth Muscle**
        - i. Mainly found in: Walls of internal organs (e.g., intestines, vasculature, bladder).
        - ii. Histopathological characteristics: Spindle-shaped cells with single central nucleus; non-striated (no sarcomere bands), looks very *homogenous*
            1. 

iii. Involuntary

2. Functions of the Muscular System
    a. Movement
    b. Maintaining Posture
    c. Supports soft tissues (i.e. abdominal wall and pelvic floor)
    d. Guard entrances and exits (sphincters located in digestive and urinary tracts)
    e. Maintaining body temperature (shivering)
        i. Muscle contraction generates heat




3.

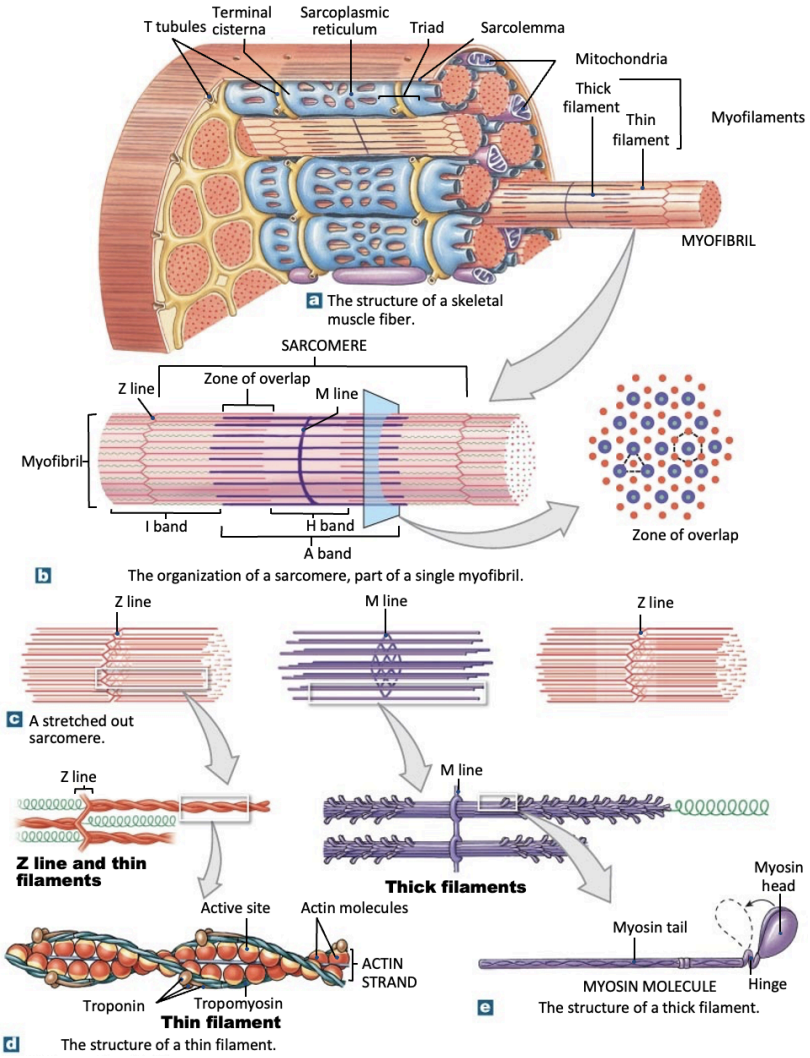
4. Connective Tissue Attachments
    a. **Tendons** are trilayered collagen fibers that attach muscle to bone
    b. **Aponeurosis** is a broad sheet of collagen fibers that connect muscle to muscle
5. Muscles (especially skeletal muscle) encompass an extensive network of blood vessels which allow for high energy use and metabolic needs
6. **Muscle Cell/Fiber Physiology**
    a. Sarcolemma: plasma membrane of the muscle fiber
        i. Has openings across the surface leading to T-tubules, unified contraction
    b. Sarcoplasm: cytoplasm of muscle cell
    c. Transverse Tubules (T-Tubules): network of openings that allow for electrical stimulation to travel through the muscle
    d. Myofibrils: actin + myosin bundles
        i. Hundreds of myofibrils compose each muscle cell
        ii. Surrounded by T-Tubules
    e. Myofilaments: bundle together to make myofibrils

i. Actin (thin)
    1. Myosin-binding active sites are covered by tropomyosin, which is held in place by troponin
ii. Myosin (thick)
    1. Composed of an actin-binding head and tail

f. Sarcoplasmic Reticulum: specialized ER formed around each myofibril
    i. Terminal cisternae: expanded end next to the T-Tubule
        1. Contains calcium ions needed for contraction to occur
    ii. Triad: 2 terminal cisternae and 1 T-Tubule

g. Sarcomere: small functional unit of muscle (10,000 sarcomere in one myofibril)
    i. Z Line – Outer boundary of each sarcomere
    ii. I Band – Region of thin filaments
    iii. M Line – At the center of each sarcomere (made of myosin)
    iv. H Band – region of thick filaments when relaxed
    v. A Band – Contains both zones of overlap
    vi. Zone of Overlap – Region of overlap between thick and thin filaments

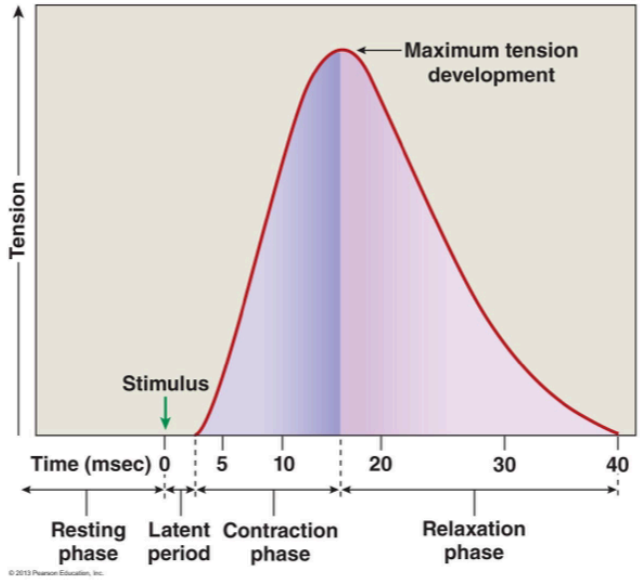
h.




7. Sliding Filament Theory

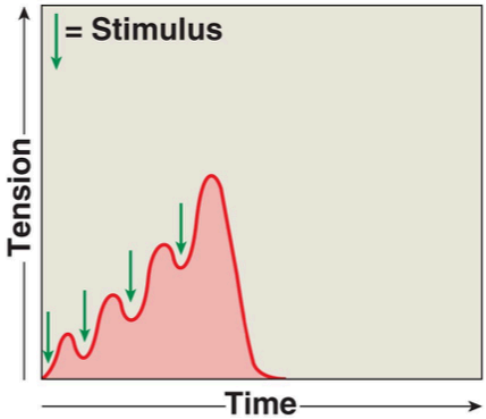
a. Theory that actin filaments move toward the M line and myosin does not move → facilitating the shrinking/contraction of the sarcomere
    i. I band gets smaller, Z lines move closer together, H band length decreases, zones of overlap increase, A band length stays the same

8. Steps for Muscle Contraction / Filament Sliding
    a. What starts a muscle contraction
        i. Motor neuron stimulates the axon terminal for acetylcholine (ACh) release
            1. Occurs at neuromuscular junction
        ii. ACh is released into the synaptic cleft
        iii. Action potential reaches the T-Tubule
        iv. Sarcoplasmic reticulum releases $Ca^{2+}$
        v. $Ca^{2+}$ binds with troponin, moving tropomyosin and exposing actin's active site
        vi. Cross-bridge forms between myosin head and actin active site
        vii. Power stroke occurs, shifting actin towards the M line
    b. What ends a muscle contraction
        i. Detachment of myosin head occurs only with presence of ATP
        ii. Acetylcholinesterase (AChE) breaks down ACh and sarcoplasmic reticulum reabsorbs $Ca^{2+}$
        iii. Actin active sites are recovered with tropomyosin and cross-bridge formation ends, ending contraction
        iv. Muscle relaxation occurs
9. Features of Muscle Contraction
    a. Tension: when muscle cells contract and pull on collagen fibers in the direction of the source of tension (i.e., action of bicep curl)
        i. Muscle cells are on or off only, there is no in between
        ii. Amount of tension is dependent on the # of cross-bridges formed, as well as the amount of overlap and the frequency of stimulation and stimulus
        iii. Myograms can measure the tension in one *twitch* (twitch = 1 stimulus, 1 contraction, 1 relaxation cycle)

1. 

a. Latent period: action potential, release of Ca, activation of troponin/tropomyosin
b. Contraction: cross-bridge formation
c. Relaxation: tension decrease and cross-bridge release

iv. Myograms and Tetanus Types




**a Summation.** Summation of twitches occurs when successive stimuli arrive before the relaxation phase has been completed.

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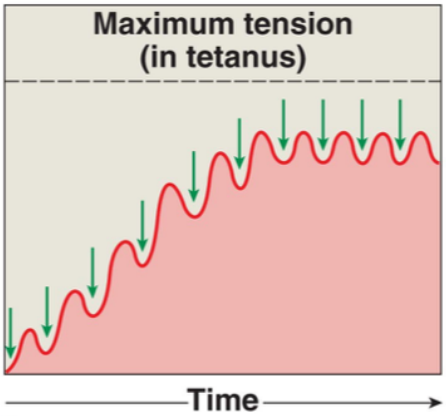
1.
a. Ex. During a rapid squat, quadriceps twitches overlap, summing tension for a stronger, explosive contraction to jump.




**b Incomplete tetanus.** Incomplete tetanus occurs if the stimulus frequency increases further. Tension production rises to a peak, and the periods of relaxation are very brief.

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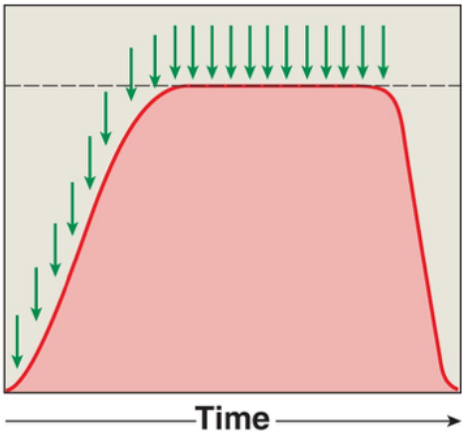
2.
a. Ex. During childbirth, uterine smooth muscle twitches overlap, summing tension for stronger, sustained contractions to push the baby out with minimal relaxation.




**C** **Complete tetanus.** During complete tetanus, the stimulus frequency is so high that the relaxation phase is eliminated; tension plateaus at maximal levels.

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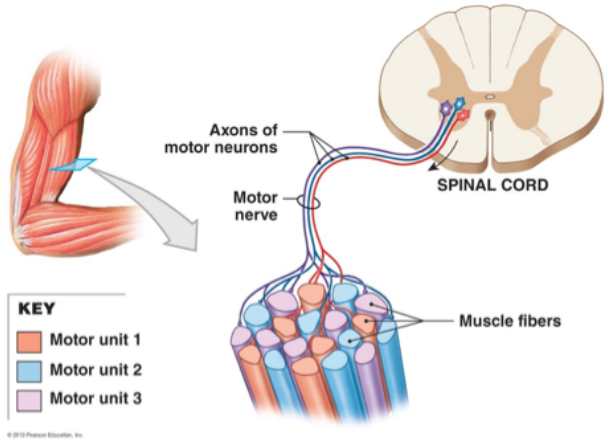
3.
    a. Ex. During a charley horse, calf muscle (e.g., gastrocnemius) receives rapid, continuous nerve signals, causing overlapping twitches with no relaxation. This sustained, maximal contraction creates intense, painful tension, locking the muscle until the spasm subsides.
    b. Resistance: force that must be overcome
    c. Compression: the force applied by pushing
        i. Muscles cannot compress, only create tension

10. Motor Units: a single motor neuron and all the muscle fibers/cells it innervates

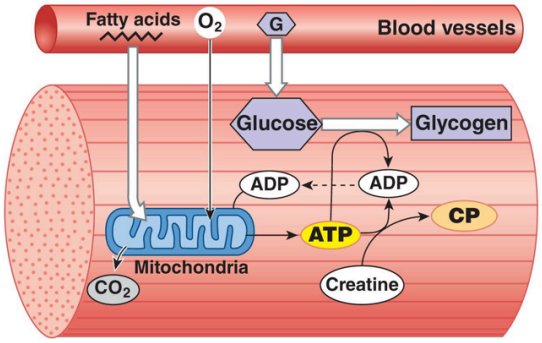



    a.
    b. Precise movements require motor units that contain very few muscle fibers controlled per neuron (aka higher neuron:fiber ratio ⇒ more control)
    c. Recruitment: activation of more motor units

11. Muscle Tone, Contraction Types, and Energy Recycling
    a. Muscle Tone: tension that exists in muscles at rest

b. Atrophy: weakness of muscle fibers due to lack of use
c. Isotonic contraction: muscle length changes → tension rises → muscle relaxes
    i. Ex. you lift a book from the ground and place on the table
d. Isometric contraction: muscle length stays the same and tension does not exceed the load
    i. Ex. you lift a book and hold it in your palms
e. ATP is the source of muscle contractions, as they enable cross-bridge detachment

i.




**a Resting:** Fatty acids are catabolized; the ATP produced is used to build energy reserves of ATP, CP, and glycogen.

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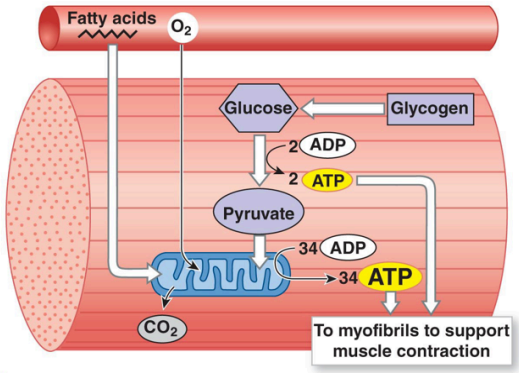
ii.




**b Moderate activity:** Glucose and fatty acids are catabolized; the ATP produced is used to power contraction.

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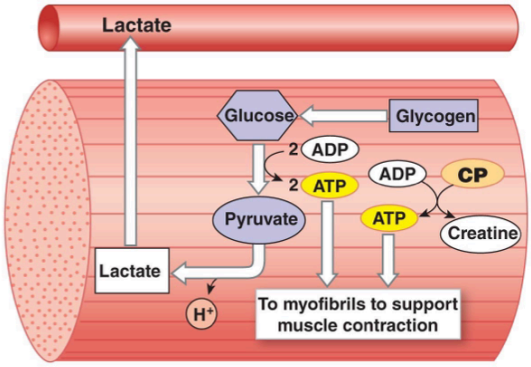
iii.




**c Peak activity:** Most ATP is produced through glycolysis, with lactate and hydrogen ions as by-products. Mitochondrial activity (not shown) now provides only about one-third of the ATP consumed.

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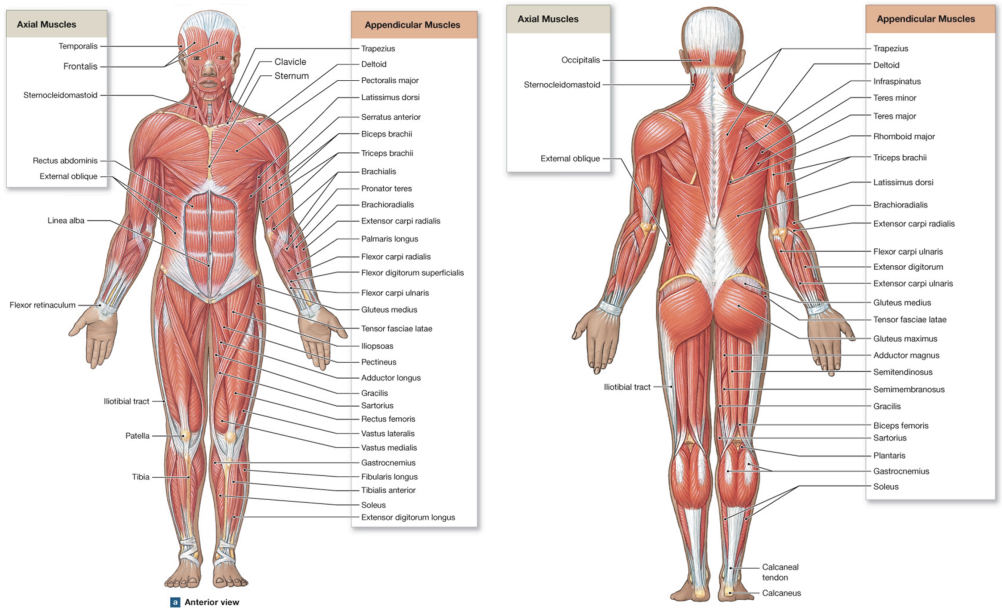
iv. Creatine Phosphate donates a phosphate to convert ADP to ATP, regenerating it
v. Muscle Fatigue and Recovery

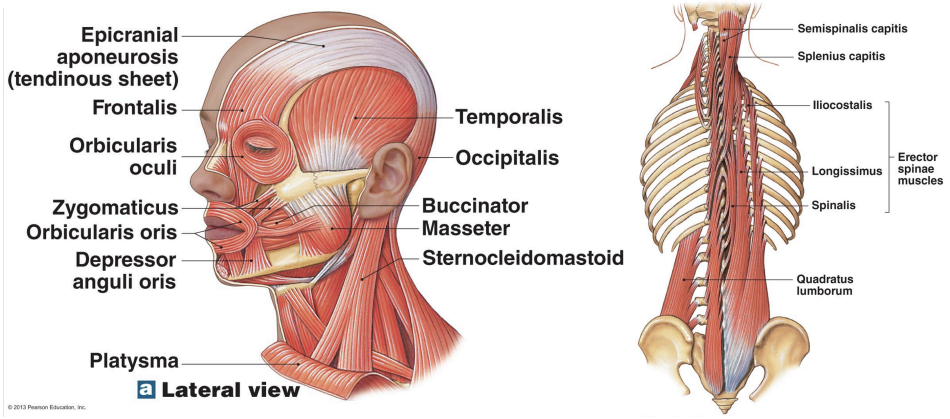
1. Muscle fatigue occurs when a muscle fiber exhausts its ATP
2. When there is no ATP, fermentation occurs, creating lactic acid (causes the feeling of soreness)
3. Recovery Period occurs when tissue restores to normal oxygen levels, ATP is restored, pH is normalized, pay off oxygen debt (increased breathing rate), increase heat loss

12. Muscle Performance
    a. Measured in:
        i. Force: max amount of tension produced by a muscle group
        ii. Endurance: amount of time an activity can be performed
    b. Force and Endurance is dependent on:
        i. Types of fibers (fast/slow)
            1. Fast Skeletal Muscle Fibers:
                a. Reach peak tension very quickly
                b. Large in diameter
                c. Majority of muscle fibers
                d. Very few mitochondria
                e. Fatigue rapidly
                f. White Muscles (not as much vasculature)
            2. Slow Skeletal Muscle Fibers:
                a. Skinny fibers
                b. 3x slower than fast fibers
                c. Specialized to contract via aerobic respiration for longer periods of time
                d. Red muscles
                e. Fatigue resistant and efficient:
                    i. More capillaries (that is why more red)
                    ii. Oxygen storage by myoglobin
        ii. Conditioning (process of training and adapting muscles to improve their performance)
            1. Anaerobic (without O2) is used for short and hard exercises
            2. Aerobic (with O2) is used for long and easy exercises
13. Actions of Muscles
    a. Prime Mover – Agonist
        i. The muscle that is chiefly responsible for producing movement
    b. Antagonist
        i. Muscle that opposes the movement of another muscle
    c. Synergist – Helps the prime mover work efficiently
14. Muscle Anatomy

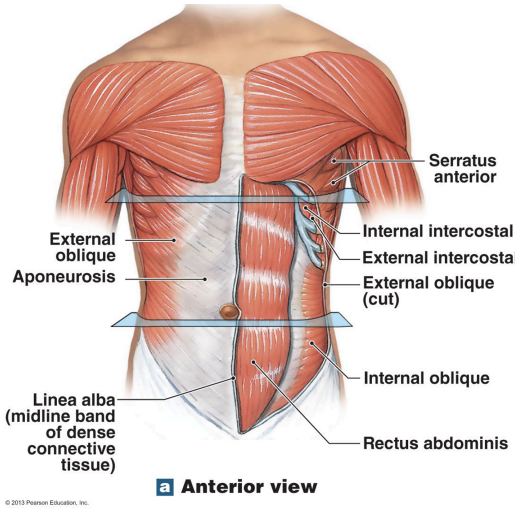
a.




b.




c.



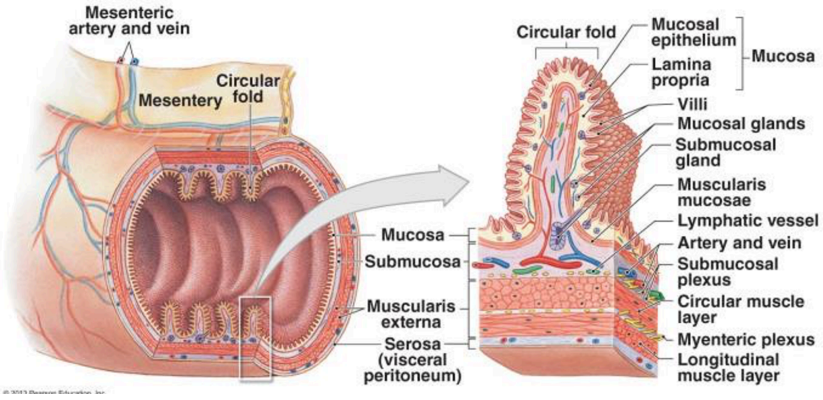

15. Aging and Muscle Tissue
    a. Ability to recover for injury is decreased
    b. Fibers decrease in diameter

c. Fibers become less elastic
d. Tolerance for exercise decreases

Kushal Khare
Mrs. Gerlach
Anatomy and Physiology Honors - 2B

# Unit 5: The Digestive System Study Guide

1. Functions of the Digestive System (also known as the 1) muscular tube, 2) alimentary canal, 3) GI tract): fuels the body to perform daily functions
    a. Major/Primary Organs (*OPESSL*)
        i. **Oral Cavity (Mouth)**: ingestion, mechanical processing, mixing and chemical processing with salivary secretions
        ii. **Pharynx (Throat)**: muscular propulsions of materials into the esophagus
        iii. **Esophagus**: transport of materials from oral cavity → stomach
        iv. **Stomach**: 1) chemical breakdown of materials by acids and enzymes, 2) mechanical processing through muscular contractions
        v. **Small Intestine**: enzymatic digestion and maximum absorption of water, organic substrates, vitamins, and ions
        vi. **Large Intestine**: dehydration and compaction of indigestible materials in preparation for defecation (where feces are stored)
            1. The rectum temporarily stores feces before elimination; elimination is facilitated by the anus (the last organ of the GI tract)
    b. Accessory Organs
        i. **Teeth**: mechanical processing via mastication
        ii. **Tongue**: sensory analysis + assists in mechanical processing
        iii. **Salivary Glands:** secrete lubricating fluid containing enzymes that break down carbohydrates (amylase)
        iv. **Liver**: secretion of bile for lipid digestion, storage of nutrients, 200+ functions
        v. **Gallbladder**: storage and concentration of bile
        vi. **Pancreas**: exocrine cells secrete buffers and digestive enzymes; endocrine cells secrete hormones
    **c. Functions of the Digestive System:**
        i. Ingestion
        ii. Mechanical Processing
        iii. Digestion
        iv. Secretion
        v. Absorption
    d. Lining of the Digestive System acts as a defense system as well:
        i. Protects from: corrosive effects of acids, physical abrasion, bacteria/pathogens that are ingested
2. Metabolism is the process of chemical reactions in the body that convert food and drink into energy to maintain life
    a. **Anabolism**: synthesizing essential compounds
    b. **Catabolism**: breaking down materials to obtain energy and nutrients
3. **Histology of the Digestive System**

a. 


**b. Mucosa (closest to the insides of the muscular tube)**

i. Consists of epithelium moistened by glandular secretions, called **mucosal epithelium** (stratified squamous), and an underlying layer of areolar tissue, the **lamina propria**

ii. Exploits surface area to increase absorption by:

1. permanent transverse circular folds
2. fingerlike projections called villi

**c. Submucosa**

i. Layer of dense irregular connective tissue that binds the mucosa to the muscular layer (muscularis externa)

ii. Contains vasculature, lymphatic vessels, and has a network of nerve fibers, sensory neurons, and parasympathetic motor neurons

1. This neural network is called the **submucosal plexus**, and it controls contractions in the smooth muscle of the muscularis mucosae and is involved in digestive gland secretion

**d. Muscularis externa (smooth muscle layer)**

i. Contains the **mesenteric plexus** (contains parasympathetic and sympathetic neurons and fibers for inhibition and activation of muscle), the mesenteric plexus + the submucosal plexus creates the **enteric nervous system (ENS)**

e. **Serosa (visceral + parietal peritoneum)** (max distance from the insides of the muscular tube)

i. A serous membrane extending from the stomach to the anus

1. A **mesentery** is a double fold of the peritoneum (a serous membrane) that attaches the intestines to the posterior abdominal wall

**4. Movement of Digestive Materials**

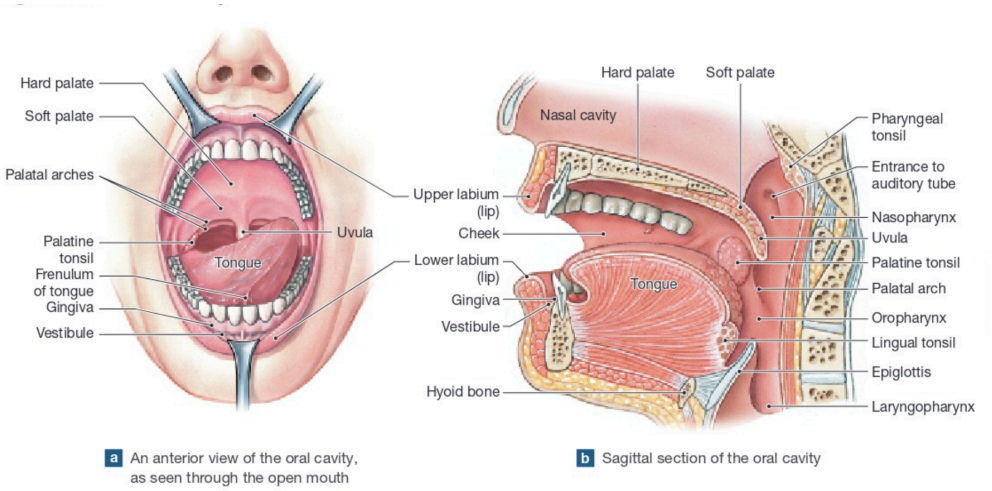
a. **Pacesetter cells** in smooth muscle trigger waves of contractions in the walls of the alimentary canal, enabling two processes:

i. **Peristalsis**: 1) circular muscles first contract behind the bolus, 2) longitudinal muscles shorten adjacent segments of the tract ⇒ propels bolus in the desired direction

ii. **Segmentation**: regions of the small intestine churn and break up digestive materials, mixing the food mass with intestinal secretions (no propulsion in any direction with segmentation)

**5. The Oral Cavity** (also called the buccal cavity or the mouth)

a. Functions of the oral cavity include:
    i. 1) senses and analyzes food before swallowing
    ii. 2) mechanically digests food through the actions of the teeth, tongue, and surfaces of the palate
    iii. 3) lubricates food by mixing it with mucus and salivary gland secretions
    iv. 4) begins *limited* digestion of carbs and lipids with salivary enzymes (salivary amylase and lingual lipase)



a An anterior view of the oral cavity, as seen through the open mouth
b Sagittal section of the oral cavity

b.

c. Lined with stratified squamous epithelium and is composed of:
    i. **Labia**: upper and lower lips
    ii. **Vestibule**: space between the cheeks and the teeth
    iii. **Hard and Soft Palate**: roof of the oral cavity
    iv. **Teeth**: used for mastication (chewing)
        1. Consists of (going from outside → inside):
            a. **Enamel**: very hard crystalline form of Ca3(PO4)2
            b. **Dentin**: an acellular mineralized matrix
            c. **Pulp cavity**: receives blood vessels and nerves through the **root canals**
        2. Baby teeth are also called primary/deciduous/milk teeth
        3. Adult teeth are called secondary/permanent teeth/dentition
        4. **Teeth types:**
            a. Incisors
            b. Cuspids (canines)
            c. Bicuspids (premolars)
            d. Molars
        5. Tooth decay occurs from bacterial action → food particles create plaque
    v. **Tongue**: manipulates materials inside the mouth and is occasionally used to bring foods into the oral cavity. The majority of the tongue lies in the oral cavity, but the base extends into the oropharynx. Functions include:
        1. Mechanical digestions by compression/abrasion/distortion
            a. Chemical as well via lipid digestion through lingual lipase

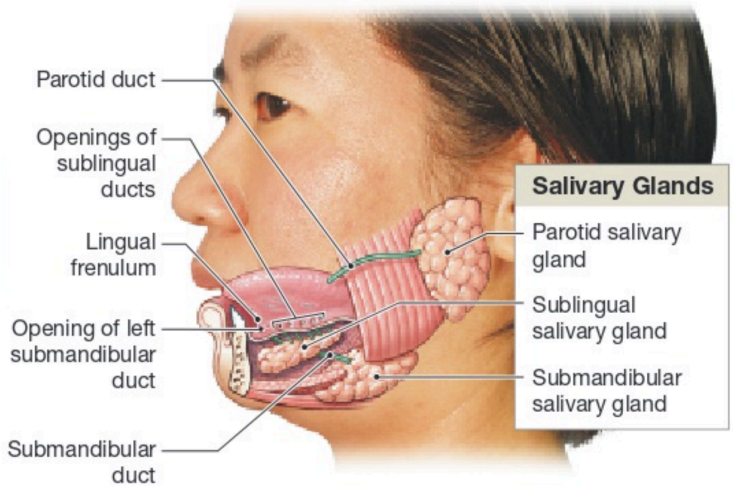
2. Manipulation to assist in chewing and to prepare for swallowing
3. Sensory analysis by touch, temp, and taste receptors

vi. **Gingivae** (gums): support and protect the teeth and the underlying bone by providing a seal that prevents harmful bacteria from entering the bloodstream

vii. **Uvula**: helps prevent food from entering the pharynx (throat) too soon; also involved in triggering the gag reflex

viii. **Salivary glands** produce 1-1.5 liters of saliva per day (7 ml per min), and contain salivary antibodies (IgA) and lysozymes that help control oral bacteria populations + salivary amylase for carb catabolism

1. Parotid salivary gland
2. Sublingual salivary gland
3. Submandibular salivary gland (70% of volume is from submandibular)



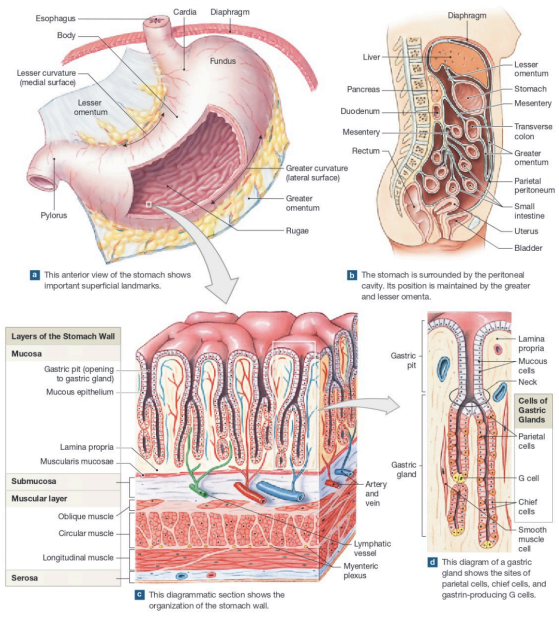

4.

6. The **pharynx** is a passageway for food, liquids, and air between the oral cavity and the esophagus
   a. The pharynx, or the throat, consists of three structures:
      i. Nasopharynx
      ii. Oropharynx
      iii. Laryngopharynx
   b. The **esophagus** is the passage from the oral cavity (more specifically, the pharynx) to the stomach (the esophagus is located posterior to the trachea)
      i. There are two **sphincters** (a muscular ring surrounding openings/closing of GI tract)
         1. **Upper Esophageal Sphincter**: at the top of the esophagus, that controls the passage of food and air into the digestive and respiratory tracts
         2. **Lower Esophageal Sphincter**: at the bottom of the esophagus that acts as a valve, opening to let food into the stomach and then closing to prevent stomach acid from flowing back up
            a. When LES is weak, it can cause GERD
      ii. The **esophageal hiatus** is the opening in the diaphragm through which the esophagus passes to reach the stomach
      iii. Esophageal Pathologies:

1. Sliding Hiatal Hernia: the stomach and lower esophagus slide up through the diaphragm, causing acid reflux
2. Paraesophageal Hiatal Hernia: stomach protrudes through the diaphragm into the chest cavity, causing difficulty breathing and shortness of breath

c. **Swallowing** (also known as **Deglutition**)
   i. **Buccal** Phase (voluntary)
      1. Bolus moves to the back of the oral cavity
         a. Starts with the compressions of the bolus against the hard palate
         b. Bolus enters the oropharynx by tongue → nasopharynx is sealed
   ii. **Pharyngeal** Phase (involuntary)
      1. Bolus moves back past the uvula → soft palate blocks passage back to the nasopharynx
   iii. **Esophageal** Phase (involuntary)
      1. Bolus moves through the esophagus via peristalsis
   iv. **Bolus Enters Stomach** (involuntary)
      1. Approach of the bolus triggers the opening of the LES → allowing the bolus to enter the stomach for digestion

7. The J-shaped **stomach** receives food from the esophagus and aids in chemical and mechanical digestion
   a. Functions of the stomach:
      i. Food storage
      ii. Food breakdown
      iii. Chemical digestion
      iv. Production of intrinsic factor
         1. For vitamin B12 absorption (necessary for the nervous system and blood cell production)
   b. Ingested substances mix with secretions of the glands in the stomach. The result is a viscous, highly acidic, soupy mixture of partially digested food called **chyme**




c.

i. The esophagus connects to the smallest region, the **cardia**. The bulge of the stomach superior to the cardia is the **fundus**. The large area between the fundus and the curve of the J is the body. The **pylorus** is the distal part of the J. It connects the stomach with the small intestine. A muscular **pyloric sphincter** regulates the flow of chyme between the stomach and small intestine.

d. Gastric Structures
   - **i. Gastric Pits**
     1. Shallow depressions in the gastric surface
     2. Contain mucous cells
   - **ii. Gastric glands**
     1. Produce gastric juice (1.5L/day)
     2. **Parietal cells** secrete intrinsic factor and HCl
     3. **Chief cells** secrete pepsinogen, which aids in protein breakdown

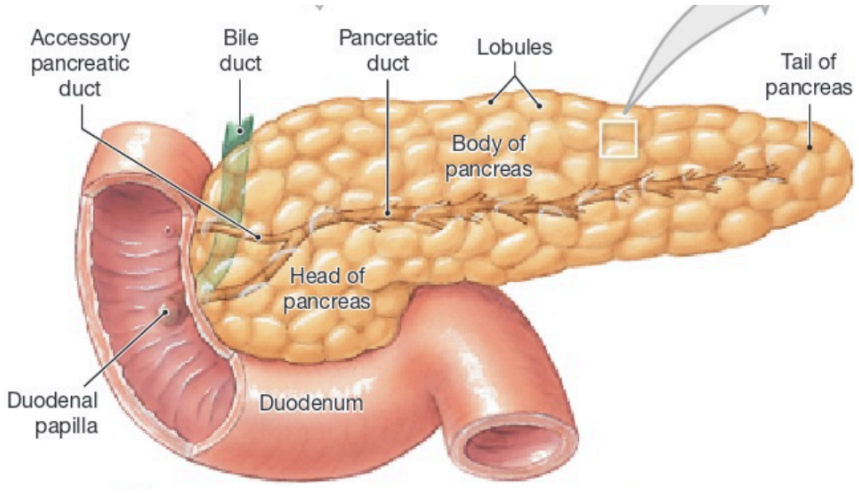
**e. The Regulation of Gastric Activity**
   - i. **Cephalic phase**: prepares the stomach to receive food.
     1. Vagus nerves innervate the submucosal plexus of the stomach
     2. Next, postganglionic parasympathetic fibers innervate mucosal cells, parietal cells, chief cells, and endocrine cells in the stomach
   - ii. **Gastric phase**: begins when food arrives in the stomach
     1. Stretch receptors in the stomach wall and chemoreceptors in the mucosa trigger local reflexes controlled by the submucosal and myenteric plexuses. Results in the secretion of mucus, pepsinogen via chief cells, and HCl from cells of the gastric glands
   - iii. **Intestinal phase**: when chyme first enters the duodenum of the small intestine
     1. Controls the rate of gastric emptying to ensure the small intestine's functional efficiency

**f. Digestion in the Stomach**
   - i. The stomach carries out the preliminary digestion of proteins by **pepsin**
   - ii. As the pH approaches 2, pepsin activity increases and protein disassembly begins. Pepsin typically breaks down complex proteins into smaller peptide/polypeptide chains before chyme enters the small intestine
   - iii. Why are nutrients not absorbed in the stomach?
     1. The epithelial cells are covered by a blanket of alkaline mucus and are not directly exposed to chyme
     2. The epithelial cells lack the specialized transport processes found in cells lining the small intestine
     3. The gastric lining is impermeable to water
     4. Digestion cannot be completed by the time chyme leaves the stomach

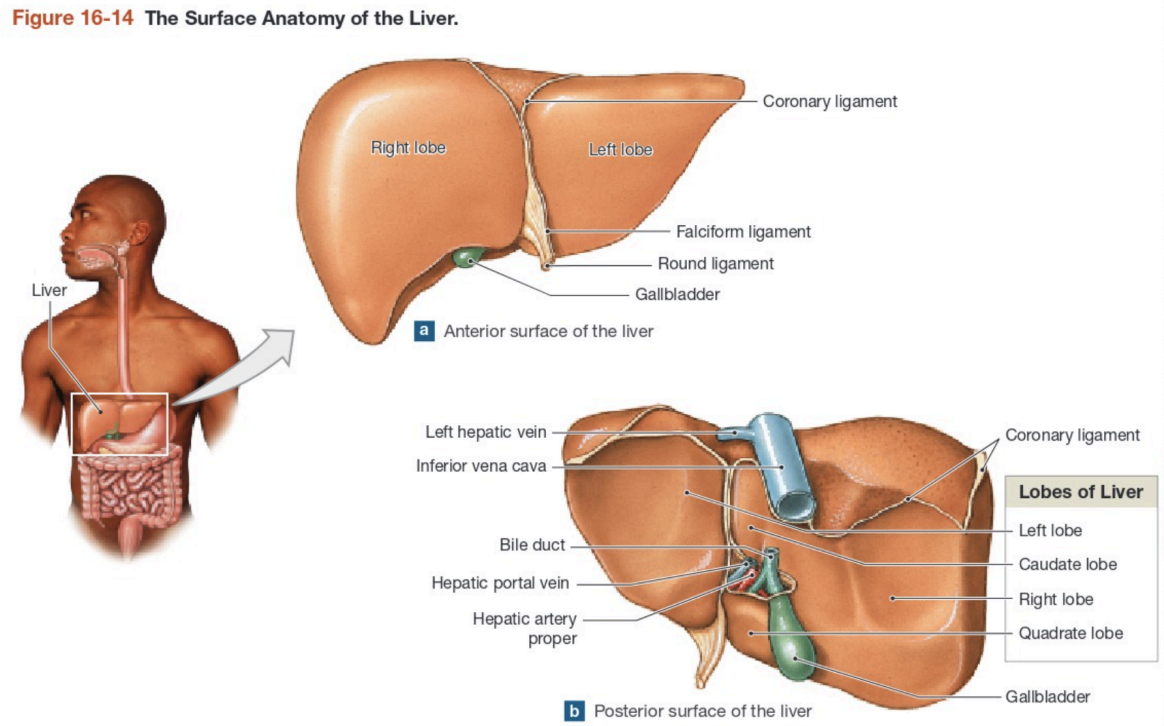
8. The **small intestine** chemically digests and absorbs nutrients (90% of absorption occurs here)
   a. There are 3 segments of the small intestine:
      - i. **Duodenum**: mixing bowl
        1. Stomach chyme + liver/pancreatic secretions
      - ii. **Jejunum**: maximum nutrient absorption here
      - iii. **Ileum**: ends with the ileocecal valve, which is the opening to the large intestine

b. Two ways to increase absorption by surface area:
    i. **Villi**: contains a network of capillaries for transport, lymph capillaries that transport fats, and intestinal glands that secrete juices
    ii. **Circular Folds**
c. Movements and Reflexes in the Small Intestine
    i. **Gastroenteric reflex**
        1. Initiated when the stomach stretches → empties the duodenum
    ii. **Gastroileal reflex**
        1. Releases the ileocecal valve → pushes material into the large intestine

9. **Intestinal Hormones**: duodenal endocrine cells produce various peptide hormones that coordinate the secretory activities of the stomach, duodenum, pancreas, and liver
    a. **Gastrin** (Target: Stomach)
        i. Stimulates the production of acids and enzymes
    b. **Secretin** (Target: pancreas, stomach, liver)
        i. Stimulates the production of alkaline buffers
        ii. Inhibits gastric secretion and mobility
        iii. Increases the rate of bile ejection
    c. **Cholecystokinin** (CCK)
        i. Stimulates the production of pancreatic enzymes
        ii. Stimulates the contraction of the gallbladder
        iii. Causes relaxation of the sphincter at the base of the bile duct
        iv. Inhibits gastric secretion and mobility
        v. May reduce hunger
    d. **Gastric inhibitory peptide** (GIP)
        i. Stimulates the release of insulin by pancreatic islets
        ii. Inhibits gastric secretion and mobility
10. The **pancreas, liver, and gallbladder** are accessory organs that assist with chemical digestion in the small intestine
    a. The pancreas lies posterior to the stomach and secretes insulin and glucagon through **islets** (endocrine) and produces enzymes (pancreatic amylase, lipase, nuclease, and protease), buffers, and juice that empties into the duodenum via **acinar cells** (exocrine)
        i.



b. The **liver** is the largest visceral organ and has **4 lobes** (left, right, caudate, quadrate) and 2 main cell types: **hepatocytes** and phagocytic **Kupffer Cells**




**c.**

d. Functions of the liver (200+ known functions):

   **i. Metabolic Regulation**

      1. Extract absorbed nutrients or toxins
      2. Monitor levels of nutrients
         a. High blood sugar → glycogen release
         b. Low blood sugar → glucose release

   **ii. Hematological Regulation**

      1. Remove damaged cells, debris, and pathogens
      2. Make plasma proteins
      3. Determine blood concentration
      4. Transport nutrients
      5. Compose clotting systems

   **iii. Bile Production**

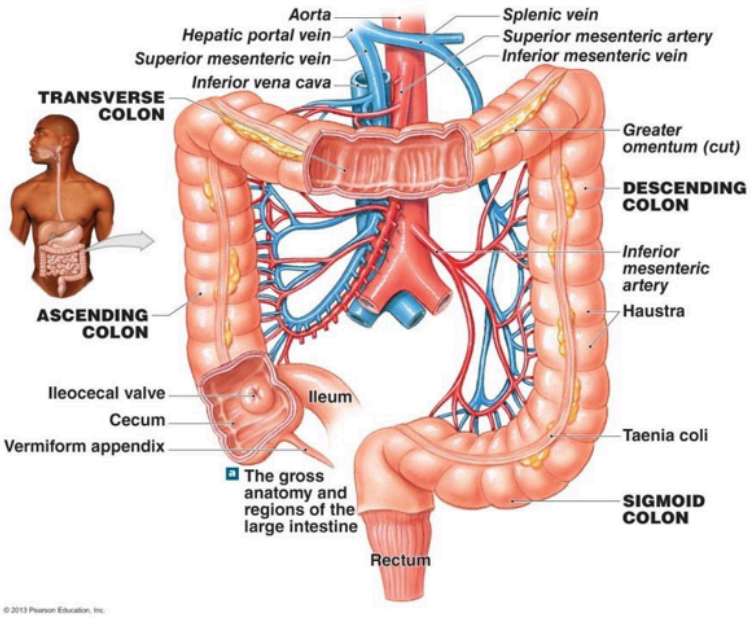
      1. Bile helps break down fats and is composed of H2O, ions, bilirubin, cholesterol, and bile salts

e. The **gallbladder** concentrates and stores bile

   i. **Gallstones** are hardened deposits of digestive fluid that form in the gallbladder. They form when there is an imbalance in the substances that make up bile, such as cholesterol and bilirubin, which can solidify into stones

11. The **Large Intestine** is where the following occurs:

   a. Reabsorption of water, bile salts, and vitamins
   b. Absorption of vitamins

c. Regulation of organic waste (bilirubin)
d. Breakdown of toxins
e. 

f. Movements of the Large Intestine:
    i. Gastroileal and gastroenteric reflexes move material into the cecum
    ii. **Mass Movements**: Slow, powerful peristalsis that occur a couple of times a day
    iii. **Defecation**: 2 positive feedback loops
        1. Shorter loop: stretch receptors and peristalsis moving material to the anus
        2. Longer loop: increased rectum distention
**g. Two anal sphincters release feces:**
    i. Internal: involuntary, external: voluntary (therefore skeletal muscle)
h. Associated pathologies:
    i. Hemorrhoids: distended veins in the anal canal
    ii. Diverticulosis: a common condition where small, sac-like pouches (diverticula) form in weak spots of the colon wall. Most people have no symptoms
    iii. Vomiting: a reflex where the brain signals muscles to contract, forcing stomach contents (chyme) upward and out
    iv. Cholera: a bacterial infection of the intestines caused by Vibrio cholerae, leading to severe, watery diarrhea that can cause rapid dehydration and death

**12. Where the digestion of nutrients occurs:**

a. Carbohydrates:
    i. Begin in the mouth with salivary amylase
b. Lipids:
    i. Begin in the mouth with lingual lipase, then in the pancreas with pancreatic lipase
c. Proteins (most complex and time-consuming):
    i. Technically begins with chewing in the oral cavity, mainly starting in the stomach with pepsin, followed by digestion with pancreatic proteases

**13. Absorption of Nutrients**

a. Each day, 9L of water and secretions are added to the digestive tract (and only 150 mL are reabsorbed)
b. The alimentary canal is involved in the absorption of:
    i. Ions (K+, Na+, Cl-, Mg2+, and more)
    ii. Fat-soluble vitamins (ADEK)
    iii. Water-soluble vitamins (B and C)

**14. Aging and the Digestive System**

a. Declining rate of cell division → susceptibility to tissue injury and cancer
b. Slowing peristalsis → more constipation
c. Hemorrhoids and heartburn more common as a result of smooth muscle tone decreasing
d. Liver disease and cavities can occur from cumulative damage
e. Osmoreceptor sensitivity decreases → more dehydration
f. Decline in calcium absorption → tooth loss
g. Changes in sense of taste and smell

Kushal Khare
Mrs. Gerlach
Anatomy and Physiology Honors - 2B

# Unit 6: The Respiratory System + Vaping Study Guide

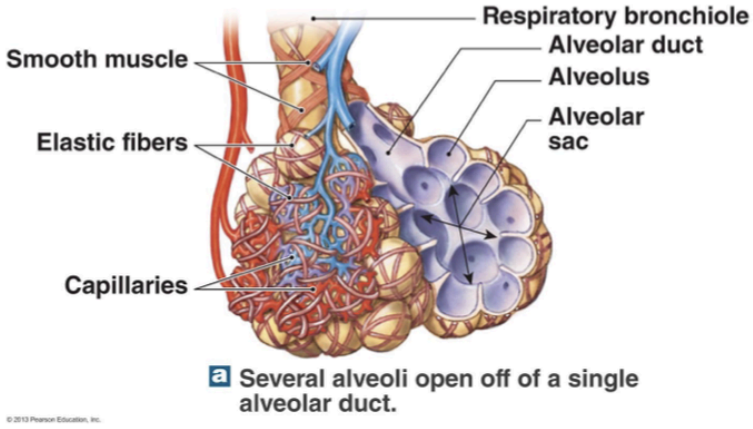
1. **Functions of the respiratory system:**
    a. Gas exchange between air and blood, which occurs in the alveoli
    b. Moves air in and out of gas exchange surfaces
    c. Protects surfaces from dehydration, temperature changes, and pathogens
    d. Produces sound
    e. Aids in smell
2. The "Respiratory Tract" is the passageways that carry air to and from exchange surfaces in the lungs, and can be broken up into a series of **functional zones**:
    a. **Conducting** (nose to bronchioles, above your neck): filters, warms, humidifies
        i. Contains **respiratory mucosa** (which contain mucous and ciliated cells)**,** where the **mucociliary escalator** allows the movement of debris and mucus to the pharynx for swallowing
    b. **Respiratory** (below your neck): contains smallest and thinnest bronchioles and alveoli and encompasses the site where gas exchange occurs
3. **The Organs and Structures of the Respiratory Track** (all anatomy on #4)
    a. **Nares** (contains the external nares and the end of the nasal vestibule) – first point of entry/exit for air
    b. **Nostril Cavity** – conchae increase turbulence to warm and humidify air, flushed by mucosa and tears
    c. **Pharynx** (throat) – nasopharynx (contains the respiratory epithelium), oropharynx (contains tonsils), and the laryngopharynx
    d. **Large Cartilage of the Larynx** – epiglottis, thyroid cartilage supports the larynx and forms Adam's Apple, cricoid cartilage
    e. **Vocal Cords**:
        i. **False vocal cords** are inelastic and prevent objects from entering the **glottis** (the true vocal cords and the space between them)
        ii. **True vocal cords** are the lower pair of ligaments and are elastic
        iii. Sound production: def. vibration of air over vocal cords
            1. Pitch is determined by diameter, length, and tension of vocal cords
                a. Short + thin = higher pitch
            2. Sound production is also dependent on the resonance in the nasal cavity
    f. **Trachea**: supported by C-shaped tracheal cartilages
    g. **Bronchi (main)**: when the trachea branches into two (right main supplies right lung, left main supplies left lung)
    h. **Bronchial Tree**: formed by the main bronchi and branches
    i. **Bronchioles**: small diameter, smooth muscle, terminal bronchioles are the smallest/thinnest

i. The **bronchopulmonary segment** contains the respiratory bronchioles (respiratory and terminal), smaller bronchi, and the alveoli

j. **Alveolar Ducts and Alveoli**

i. Alveolar ducts end in alveolar sacs, which connect to individual alveoli

ii. Each lung has 150 alveoli, increasing surface area to heighten gas exchange efficacy

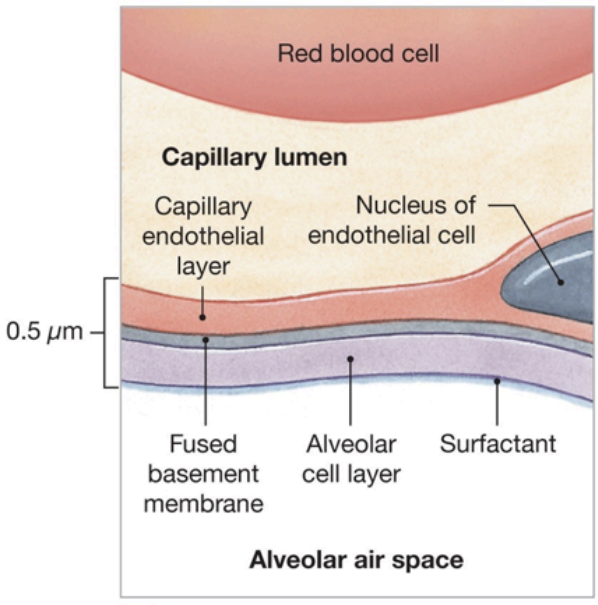
1. 


iii. Cells associated with Alveoli

1. **Pneumocytes type 1** (primary): simple squamous epithelium
2. **Roaming alveolar macrophages** (dust cells): phagocytes to remove pathogens
3. **Pneumocytes type 2**: produces surfactants – which reduces surface tension to keep alveoli open and mitigates respiratory distress

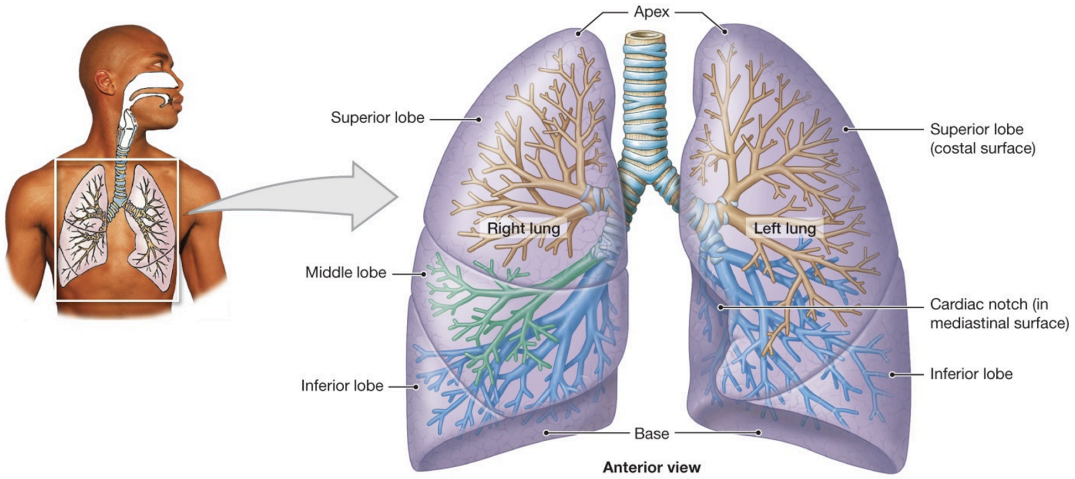
**iv. The Blood-Air Barrier / Respiratory Membrane**

1. Very thin, site of gas exchange made of 3 layers:
    a. Alveolar Cell Layer
    b. Capillary Endothelium
    c. Fused basement membrane

2. 

v. Alveolar Capillaries and Blood Pressure
    1. Endothelial cells of alveolar capillaries are main sources of **angiotensin-converting enzyme**
        a. Angiotensin-converting enzyme converts angiotensin 1 to angiotensin 2 in the blood, which potent vasoconstrictor that raises blood pressure
        b. Angiotensin-converting enzyme inhibitors can be used to reduce blood pressure

k. **The Lungs and its pathologies**
    i. **Pulmonary embolism**: when BP to the pulmonary circuit is low, which may cause a blockage of the pulmonary artery. Usually the clot forms in the veins of the lower feet through a condition called Deep Vein Thrombosis. Pulmonary embolisms may migrate to the heart or the brain.



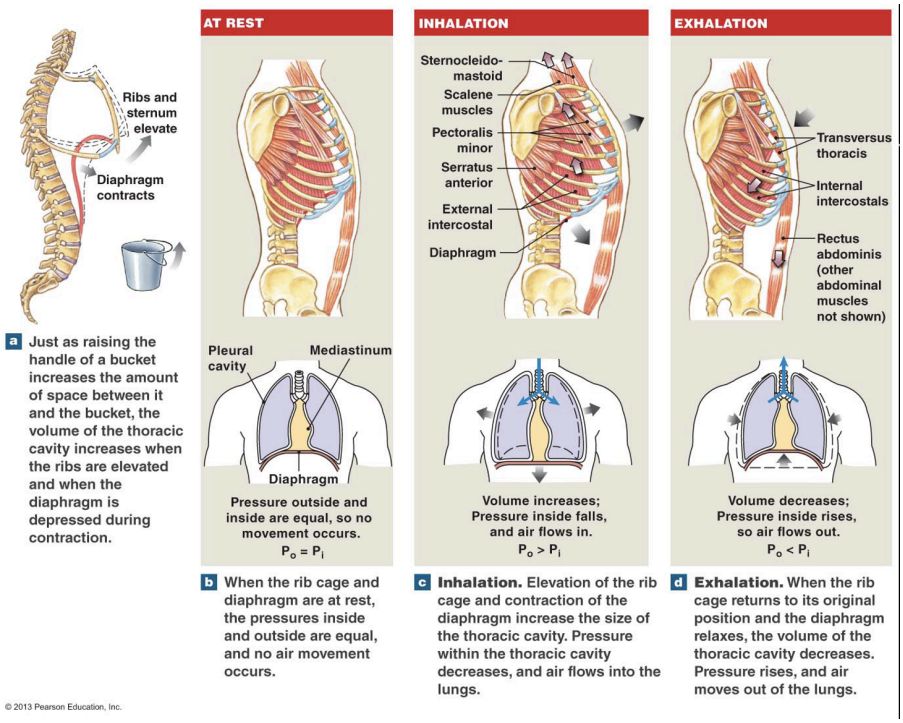

    ii.
    iii. The **pleura** is a serous membrane and secretes pleural fluid
        1. **Pneumothorax** occurs when pleura is punctured or alveoli are damaged in an accident – results in air rushing into the pleural cavity causing lung collapse

**iv. The Process of Respiration**
    **1. External Respiration**
        a. Pulmonary ventilation (physical breathing)
        b. Gas diffusion (across respiratory membrane and across the capillaries between blood and body tissues)
        c. Transport of oxygen and carbon dioxide
    **2. Internal Respiration**
        a. Absorption and use of oxygen
        b. Release of carbon dioxide
    3. When respiration fails to occur, the body may suffer from inadequate oxygen concentrations:
        a. **Hypoxia** (decreased oxygen)
        b. **Anoxia** (no oxygen)

i. Anoxic seizures are non-epileptic, convulsive fainting spells triggered by a reduced level of oxygen to the brain, most often in children

**v. Pressure in the Lungs**

1. Pulmonary ventilation is the movement of air into and out of the lungs and is reliant on a pressure gradient
    a. Increase in volume causes a decrease in pressure
    b. Decrease in volume causes an increase in pressure (Boyle's Law)




2.

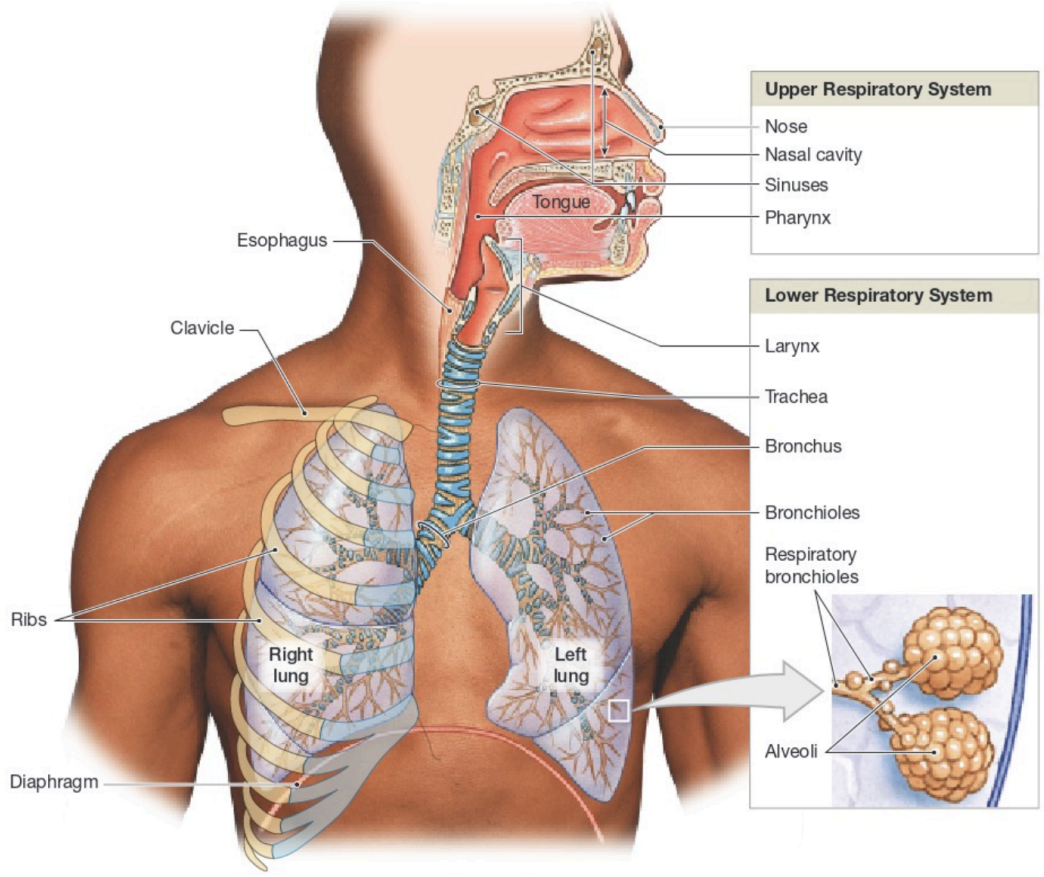
vi. **Compliance**: the ease with which lungs expand. **Emphysema** is the decrease in compliance.

**vii. Modes of Breathing**

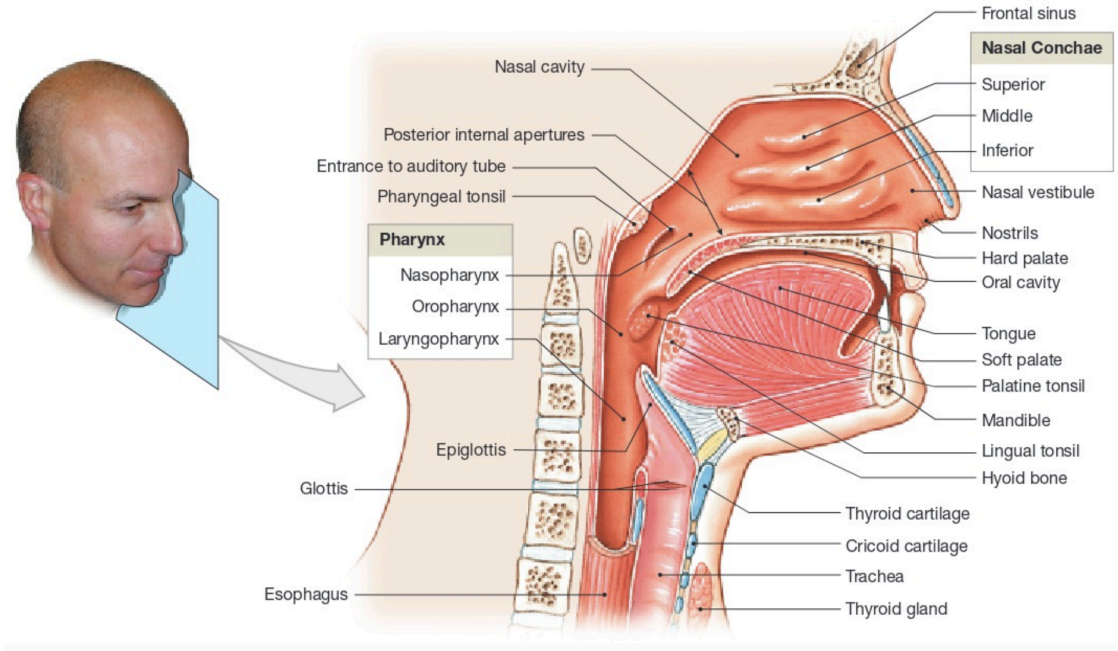
**1. Quiet Breathing**
    a. Inhalation only involves primary respiratory muscles
    b. Exhalation is passive

**2. Forced Breathing**
    a. Inhalation involves both primary and accessory muscles
    b. Exhalation uses internal intercostals and abdominals

**4. Anatomy of the the Organs and Structures of the Respiratory Track**


Upper Respiratory System
Nose
Nasal cavity
Sinuses
Pharynx
Tongue
Esophagus
Lower Respiratory System
Clavicle
Larynx
Trachea
Bronchus
Bronchioles
Respiratory bronchioles
Ribs
Right lung
Left lung
Alveoli
Diaphragm

a.


Frontal sinus
Nasal Conchae
Superior
Middle
Inferior
Nasal cavity
Posterior internal apertures
Entrance to auditory tube
Pharyngeal tonsil
Nasal vestibule
Pharynx
Nasopharynx
Oropharynx
Laryngopharynx
Nostrils
Hard palate
Oral cavity
Tongue
Soft palate
Palatine tonsil
Mandible
Epiglottis
Lingual tonsil
Hyoid bone
Glottis
Thyroid cartilage
Cricoid cartilage
Trachea
Esophagus
Thyroid gland

b.

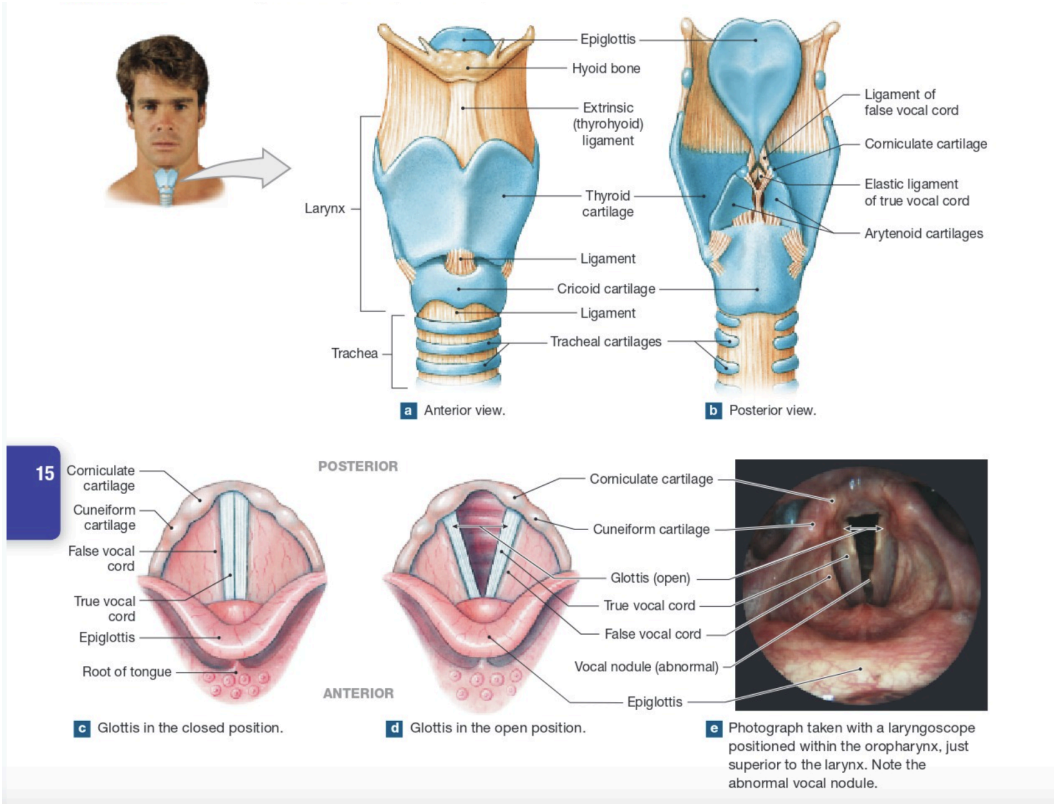



**Figure 15-5 The Anatomy of the Trachea.**

c.

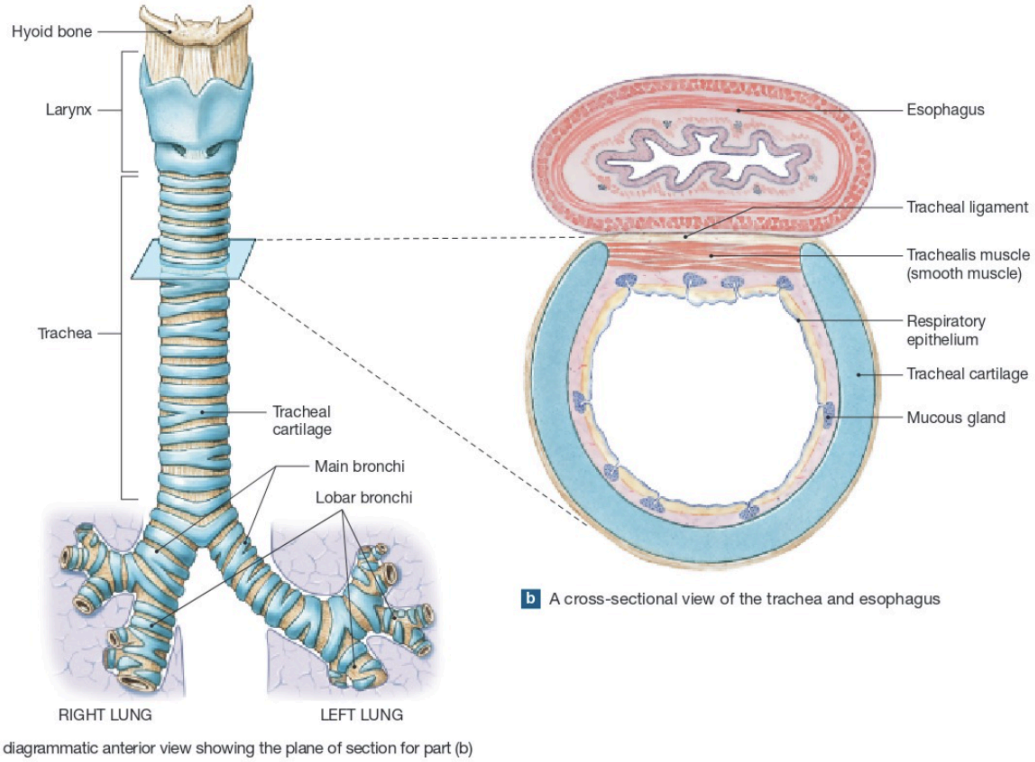
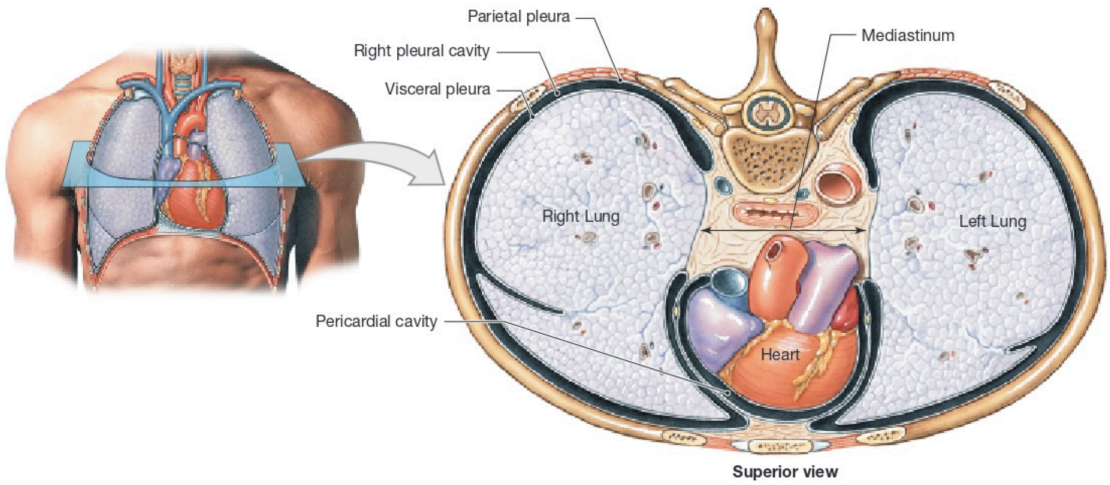


Figure 15-9 **Anatomical Relationships in the Thoracic Cavity.**




**d.**

**5. Terms associated with lung volume and capacity:**

a. **Tidal volume**: Air inhaled or exhaled in normal, resting, quiet breathing cycle.
b. **Expiratory Reserve Volume**: Extra air exhaled forcefully after normal, resting tidal exhalation completed.
c. **Inspiratory Reserve Volume**: Additional air inhaled forcefully after normal, resting tidal inspiration ends.
d. **Vital Capacity**: Maximum air exhaled after deepest possible inhalation; includes all mobilizable.
e. **Residual Volume**: Air remaining in lungs after maximal exhalation; prevents lung collapse.
f. **Minimal Volume**: Air remaining after lungs collapse, confirming lungs had previously inflated.

**6. Addiction and Vaping**

a. 3 Factors are used to determine "addiction":
   i. Duration
   ii. Amount
   iii. Frequency
b. Five Levels of Substance Abuse
   i. Abstinence
   ii. Experimentation
   iii. Social/Recreational
   iv. Abuse
   v. Addiction
c. The primary role of the survival/reward pathway of the brain is to pass your genes on / reproduce, and this pathway is controlled by a *Go!* and a *Stop!!* "switch." When drug-seeking behavior is observed, that person's *Stop!!* switch is disabled. This is why an addict cannot just stop, since everything is *Go!*
d. Data for new learning and generating emotions affecting survival go → *working memory*

e. When we learn or do some task repeatedly, neuronal pathways strengthen and new dendritic connections form, as axons get myelinated by specialized glial cells so the speed of the nerve impulse increases
    i. The more we fire such neuronal pathways → the easier it is to fire for future firings
f. **Why is nicotine so addictive?** Nicotine impersonates acetylcholine (excitatory when binds to nicotinic receptors) and is a stimulant that releases extra dopamine (reward system, pleasure) in the brain. This then leads to **tolerance…**
    i. Tolerance is when your homeostasis levels up to accommodate the substance you are taking. Such tolerance results in **tissue dependence**, where your tissues begin to build systems to function in the presence of that substance. Consequently, when you take that substance away (**withdrawal**), your homeostasis lowers, but unregulated withdrawal can be lethal.
g. E-Cigs and Vapes are not just vapor, they contain **aerosols** as well (think volcanic ash, dust, sea spray, emissions from burning fossil fuels, etc…)
    i. Examples of carcinogenic, deadly non-natural-to-the-human-body substances found in vapes: **Nickel, Menthol, Benzene, Formaldehyde**
    ii. Vape flavors, such as the *Banana and Chocolate* flavor, can have physiological impacts as well, such as: increased release of inflammatory cytokines and phagocytosis
**h. Four ways that vaping can physiologically damage lung tissue:**
    i. Chronic Lung Disease and Scarring of the Lung Tissue
    ii. Oxidative Stress
    iii. Lipoid Pneumonia
    iv. Pneumothorax