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Exam 1 Review

Objectives lecture outline 1-Spring 2024

I. Understand the one-word definition of anatomy as well as the more elaborated definition.
   - **Anatomy:** the scientific study that investigates the structure of the body
   - The one word definition of anatomy is **structure**.
   1. Know the elements of the full definition (shape of an organ, weight of an organ, component material of an organ, etc.

II. Describe the different approaches to studying gross anatomy and what the word "gross" means in this context.
   1. Define "gross" in this context, where does the word come from?
      - Large
      - Gross is what you can see/study without a microscope
      - The word "Gross" has German origins for big

   2. Be able to describe what performing gross anatomy would entail to someone who does not know what it is.
      - It would be the examination of bodily structures with the naked eye.

   3. What are the different approaches to doing gross anatomy? I can think of two angles of approach, can you?
      Systematic - looking at the body structures by systems (nervous system or digestive system)
      Regional- look at one specific area and what it entails (thoracic cavity or skull)

   4. Can one do a blended approach? What approach do we tend toward in this class? Explain.
   - Yes, a blended approach would be called an integrated approach. The name of this class is Integrated Human Anatomy and Physiology, so we tend to focus on this blended/integrated approach to study. Taking this integrated approach means we look at anatomy (structure) and physiology (function) in relation to one another.
   - In this class, we study anatomy from a systematic approach, instead of going through the body region by region we go through the systems

III. Describe the different categories that one can address the science of anatomy?

1. Is all anatomy performed at the "gross" level?
   - Organisms, organ systems, and organs can be examined on a "gross" level. The tissue, cell, and chemical levels are a part of microscopic anatomy.
   - There is histology which is the study of tissues or (groups of cells). This one cannot be done without a microscope.

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- There is also cytology which is the intracellular "ultrastructure" or "cell biology". This is where cells are stitched together in lumps, and sheets and the very fine details of the ultrastructure can only be seen through an electron microscope.

2. Describe in very basic terms how histology is also anatomy and how ultrastructural cytology using an electron microscope is anatomy as well.
   - Histology and ultrastructural cytology examine the microscopic structures of the body, which is a component of anatomy.

3. Why must one use a microscope for histology and an electron microscope for ultrastructural studies? In broad terms, explain the typical magnification ranges of each instrument.
   - Histology requires magnification of the tissue cells since it cannot be seen with the naked eye.
   - An electron microscope is used for ultrastructural studies because it requires additional magnification for the examination of the fine-grained details of an organelle from the cell. A regular microscope can not obtain this level of magnification.
   - Microscope: 40x to 1000x
   - Electron Microscope: 100x to 1,000,000x

IV. Understand the one- word definition of physiology as well as the more elaborate definition.
   - Physiology: the scientific study of the processes or functions of the body.
   - The one word definition of physiology is **function**.

1. What does it mean to describe the function of something?
- The way or reason something does a thing to accomplish a goal.

2. Is there a relationship between structure and function?
   - Yes, there is a relationship between structure and function. Typically, the structure and function have a mutualistic relationship that allows the body to perform as efficiently as possible.

3. Is one dependent on the other? If so, specifically describe.
- Structure determines function, how something is arranged allows it to perform a specific job.

4. We talked about how the urinary bladder has a structure that supports its function to the extent discussed in class?
   The bladder has a layer of transitional epithelium resembling squamous and cuboidal epithelial cells on the surface that can relax and stretch to fit the needs of the bladder based on the urine content. The stretching of cells allows for a greater volume of urine so the organism doesn't need to release the urine as often, and the stretching can also send a signal to the body saying it is nearing its maximum capacity.

V. Describe the different categories that one can address in the science of physiology.
   See VI. Below and the categories described on slide 1-2.

VI. Be able to integrate your descriptions of anatomy and physiology in the context of the urinary system as an example of an integrated approach to anatomy & physiology'

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1. I spent a lot of time on the third slide of this lecture, discussing all the different physiological levels (as well as some anatomical characteristics of each level and integrating the two together). You should know all the details I discussed that pertain to the levels, including but not necessarily limited to:
   The most common elements, macromolecules, and the most common molecule by far that is present in the body. How a single cell is usually found in sheets/lumps of identical cells (e.g. smooth muscle)

- Most common elements he used his name COHN for Carbon, Oxygen, Hydrogen, and Nitrogen
- Macromolecules include: Proteins, Nucleic Acids, Lipids, and Carbohydrates
- The most common molecule present in the human body is H_2O or water
- Identical cells aggregate together in sheets or lumps to form tissues.

2. Describe how the bladder is an organ and the function/significance of each of its tissues. What are the other organs of the excretory (e.g., urinary system).

- The bladder is an organ because it is made up of a collection of tissues that come together to perform a specific function. The function of the bladder is to store and empty urine. It is made up of transitional epithelial tissue which allows it to expand when filled and smooth muscle tissue which allows it to contract.
- Other organs in the urinary system include the ureters, urethra, and kidneys.

3. How do these organs anatomically and physiologically cohere to accomplish the purpose of the system? What is the purpose of the system?

- The kidneys filter the urine and pass it down through the ureters into the bladder. The urine then exits the body through the urethra.
- Purpose of the urinary system is to:
  - excretion: remove waste from the body: the kidneys filter out the larger molecules like protein to keep in the body and starts to make to extra smaller molecules and do ions into urine
  - regulate blood volume and pressure: the kidneys either produce a large volume of diluted urine (if the person is hydrated) or a small volume and concentrated urine (if the person is dehydrated). This production regulated blood volume which helps with controlling blood pressure
  - regulates blood concentration: the kidneys help regulate ions (sodium, chloride, potassium, phosphate, bicarbonate, magnesium) in the body
  - regulate red blood cells: the kidneys secrete erythropoietin which is the hormone that helps regulate the making of red blood cells

4. Is the general rule that systems are functionally dependent on one another or independent of one another?
   Systems are functionally dependent on one another. There are 12 body systems that all depend on each other as for example a tissue can take down an organ, and that organ can take down that organ system, and can ultimately take down the organism itself. An example given in class of all systems completely failing if one goes wrong is a heart attack.

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Objectives lecture outline 2- Fall 2023

I. Define a tissue and its relationship to an organ.

Organs = object in the body that is made up of at least two **tissues** that combine together to form a larger structure that has a specific function.

1. We went into this during the first lecture, but you should probably make sure you really understand it again. Is each bone in the body an organ?
    a. Yes, there are 208-213 depending on age.

2. Is each skeletal muscle an organ? If so, how so?
   Skeletal muscle is an organ because it is made up of muscle tissues and performs a specific function (contraction/relaxation).

3. Though organs, by definition, must be made of more than one tissue type, must each type be present to a certain defined extent?
   No, each tissue type has a unique distribution pattern throughout the body:
    - Connective tissue = everywhere
    - Epithelial tissue = lining surfaces
    - Muscle tissue = where forces are needed
    - Smooth muscle tissue = hollow organs that need to contract, non-conscious control.

4. In very general terms, define a tissue?
- A group of cells that all work together to perform a specific function

5. What are the 4 main tissue types?
    a. Epithelial
    b. Connective
    c. Muscle
    d. Nervous tissue

II. Describe the essential materials needed to do histology?

1. Why do you need a microscope to do histology? What other materials/ equipment do you need and why do you need these things?

- A microscope is needed to do histology because samples of tissues need to be magnified greatly in order to accurately study the tissue/cells that the tissue is comprised of. The structures and details of tissues are not able to be seen with the naked eye and need a microscope to be seen. Microscopes used for histology must have at least 1000x magnification with high resolution.
- Other materials you need are:
    A. Microtome: to make ultra thin slices of tissue to use as samples
    B. Broad array of solutions and stains: to help bring out certain features so that identifications can be made
    C. High quality light microscope

2. Define “pathology”? Based on your definition, what is “histopathology”?

- pathology: the study of disease
- Histopathology: the study of diseased tissue

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III. Understand the centrality of histopathology's role in medicine.

1. Explain how Histopathology is an area of specialization as a physician. Histopathology is an area of specialization where tissues are being studied for diseases

2. What, for short, are medical histopathologists usually called?
   Pathologist

3. What is a biopsy and what is its significance in modern medicine?
   Biopsy is the process of removing tissue samples from patients surgically or with a needle for diagnostic purposes.

4. How and why is a biopsy central to the practice of pathology?
   Biopsies are what allow pathologists to obtain tissue samples that help them diagnose patients. Pathologists are experts on what both normal and abnormal tissue looks like. From biopsies and this knowledge, pathologists can diagnose tissue and plan proper treatment

IV. Describe the overarching structure/function of the 4 major tissue types.

1. Mostly focused on slide 2-5 Are tissues equally distributed throughout the body? Know the salient features discussed on the 5th slide of this lecture to the extent discussed in class.
   Epithelial
   a. Locations: lines body surfaces, makes up glands
   b. Structure: cells take up maximum volume (are right next to each other), and there is little extracellular space. Typically have a basal and apical surface. Specialized connections between -cells called Desmosomes help keep cells together in the face of frictional force on the apical surface
   c. Function: protection/barrier for small particles (ex skin) ; synthesis/secretion of molecules/solutions (ex glands); absorption (ex lining of intestines)

   Connective:
   a. Locations: many different types, found everywhere
   b. Structure: cells take up small volume, large space between cells, most volume in extracellular matrix. Extracellular Matrix
   c. Function: connecting things together. n

   Muscle:
   a. Location: Where forces are needed
   b. Function: having multiple cells that make up the tissue, coordinates together, shortens at the same time, and exert forces on something.

   Nervous:
   a. Multiple cells, gonna focus on neurons.
   b. Structure: extension of dendrites to take information from other neurites, and send information to other neurons through axon terminals.
   c. Function: form a network of cells that can communicate to each other and make decisions and send appropriate signals to control the body.

2. Understand how the histology of the alveolar wall and the capillary wall maximize the efficiency of gas exchange between the lung and the cardiovascular system.
   Because the alveolar wall is made up of squamous epithelial tissue that is 1 cell thick, it allows fast passage of oxygen into the capillary wall.

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3. Was there another epithelial tissue type mentioned in class that has a key function of NOT LETTING most things across it. If so, specifically how is it structurally different from the alveolar epithelial tissue?
   Transitional epithelium. It is a mixture of different epithelial cells to allow it to be stretchy.

4. Slides 6-12 of this lecture describe salient aspects of the structure and function of each of the 4 major tissue types. Know all that was specified for the structure and function of each tissue to the extent specified in class.
   a. Epithelial tissue- lines the body surface, major tissue type of glands (ex. Endocrine and Exocrine glands), specialized connections between adjacent cells= desmosomes, synthesis and secrete molecules or solutions
   b. Connective tissue- most abundant, links everything to one another, binds bones together through ligaments and tendons, helps in support and movement (scaffolding), storage (adipose tissues- fat storing), adds padding and insulation, transports blood, overall protection.
   c. Muscle tissue- three types:
      i. Skeletal- large, cylindrical, multinucleated, and striated
         1. Function: large powerful cells, controlled consciously, only activated by nervous system, moved skeleton, amitotic
      ii. Smooth-fusiform shaped, mononucleated, not striated, embedded across many organ systems.
         1. Function: not large, high endurance, never controlled consciously, can be controlled by nervous, endocrine system ect., the muscular component of all organs other than heart.
      iii. Cardiac- mostly mononucleated, only found in the heart, contains “gap junctions”
         1. Not large spectacular endurance, keeps working until moment of death, never controlled consciously, controlled by “pacemaker”, influenced by the nervous system.
   d. Nervous tissue- neurons and glial cells, very large

V. Compare/Contrast salient characteristics of the 4 major tissue types
   1. You should be able to recognize how member of any of the four tissue types compare structurally and functionally with any of the other types to the extent discussed in class

Epithelial tissue

Structure	Function
Thin cells	Mechanical protection
Cells take up max volume, minimal extracellular space	Barrier for chemicals and small particles
Lines body surfaces	Passage of certain molecules
Basal surface and apical surface	Synthesize and secrete molecules or solutions

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Specialized connections between adjacent cells	absorption

Connective Tissue

Structure	Function
Cells can inhabit a relatively small volume with much of the volume	Binding → Ligaments & Tendons
Found between cells in an extracellular matrix (collagen, reticular fibers, elastic fibers, ground substance, interstitial fluid)	Support and movement
	Storage → bone & adipose tissue
	Padding & Insulation → adipose tissue
	Transport → blood
	Protection → mechanically skeleton is best protector

Muscle Tissue

Structure	Function
Skeletal: can be large, cylindrical, multinucleated, striated	Skeletal: Large powerful cells. Always can be controlled, can only be activated by the nervous system, moves the skeleton, and amitotic
Smooth: fusiform shape, mononucleated, embedded across many organs, not striated	Smooth: not large, can have high endurance, never voluntary, regulates the size of the lumen of hollow organs (except the heart), can be controlled by the nervous system & endocrine system.
Cardiac: mostly mononucleated, only in heart, contains gap junctions	Cardiac: not large, but has spectacular endurance, never voluntary (can be emotionally influenced). Contraction stimulated by "pacemaker" which can in turn be influenced by the nervous system.

VI. Describe key subcategories belonging to each of the 4 main tissue types.

1. On slides 6-12, I mentioned specific types of cells belonging to sub categories of each tissue. Know the structural and physiological features characteristic of each. For example know the structural and physiological differences between the 3 types of muscle tissue types, the structural and functional difference between neurons and glial cells to the extent discussed in class .
   Epithelial tissue
   - Simple squamous → diffusion & filtration

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- Simple cuboidal → secretion & absorption
- Simple columnar → absorption & secretion
- Stratified squamous → protection
- Pseudostratified columnar → secretion mucus
- Transitional → stretchy

Muscle Cells: look at table above

Nervous tissue

- Have dendrites and axon terminals branched out to receive and send electrochemical signals to communicate with other neurons.

2. On slide 2-12, I mentioned both structural and functional aspects of neurons and glial cells, though the side only has only "structure" in the posted outline.
   Glial cells – independent to almost all neurons. Necessary for function

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Objectives lecture outline 3- Spring 2024

I. Overview of the Anatomy and Physiology of the skeleton. Describe axial skeleton vs. appendicular skeleton.

1. Describe the functions of the skeleton and their significance as enumerated in slide 3-2. Know the number span of bones in the human body.
    - 206-213 bones
    - Functions:
        - Organ protections – the brain is protected by skull bone.
        - Mineral storage – calcium and phosphorous
        - Body movement – works together with the muscular system (over 650 organs known as skeletal muscles) to produce body movements like locomotion, lifting, carrying objects.
        - Blood cell production – red bone marrow is unique to be found in bones.
        - Body support – bone's dense makeup is suited for carrying the body's weight.

2. Why is it a range and not an exact number? I can think of two reasons.

    Age and bones not fusing; genetics? Lol Also, maybe because people dont have the exact same number of sesamoid bones?

3. Describe the axial skeleton and all bones or fusions of bones that make it up in class and why they are considered axial bones.
    - Axial skeleton = central pole of the body (frontal bone → coccyx)
        - Skull bone
        - Ear bones
        - 7 cervical vertebrae
        - 12 thoracic vertebrae
        - 5 Lumbar vertebrae
        - 5 fused vertebrae that make up the sacrum.

4. Describe the appendicular skeleton and all bones or fusions of bones that make it up that were listed in class and why they are considered appendicular bones.
    a. Appendicular skeletons = everything that is not axial skeleton
        i. Limb bones
        ii. Shoulder girdle
            1. Clavicle and Scapula
        iii. Hip girdle
            1. Ilium, Ischium, Pubis

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5. What are the girdles? Where are they located and what bones make them up to the extent discussed in class.
    - Girdles = bones that bridge the appendix with the axial skeleton.
    - Shoulder girdle:
        - Scapula and clavicle (x2)
    - Hip girdle:
        - Ilium
        - Ischium
        - Pubis
            - All three bones fuse together = os coccyx

6. Are the girdles part of the appendicular skeleton or the axial skeleton?

   Girdles are a part of the appendicular skeleton.

II. Describe the components of the axial and appendicular skeleton. (see I, above).

1. Describe, compare/contrast the different types of bones. You should be able to define a long bone, flat bone, irregular bone, sesamoid bone and short bone and give any examples I mentioned in class and defend why that bone is a member of that category.

   Long bones: have to be longer than they are wide; vast majority of the length is from the shaft (diaphysis) and at least one epiphysis; cylindrical shaped

   - Example: femur

   Short bones: boxy/cubic shape

   - Example: carpals

   Flat bones: very flat not cylindrical

   - Example: parietal bone and occipital bone

   Irregular bones

   - Example: vertebrae, sphenoid bone, ethmoid bone

   Sesamoid bones: seed like bones

   - Develop within a tendon
   - Other example is within hands and feet, different people have different numbers
   - Example: patella

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2. You should also know the names of all bone examples mentioned in class and what specific characteristics of that bone qualify them as a long, short, sesamoid bone, flat bone. For example, why is a rib a flat bone and not a long bone?

   A rib is a flat bone and not a long bone because the diaphysis is not cylindrical.

III. Describe the macro/ microanatomical components of compact bone using the diaphyseal wall of a femur as an example.

1. This concerns slide 5 of this lecture outline. I went over every term labelled on this slide and discussed elements of its structure and or function and you should know all of it to the extent discussed in class. I also discussed synonyms for haversian canals, perforating canals which you are responsible for knowing. I also added/drew and defined the structure/function of Sharpey's fibers.

Haversian canal = central canal]

Volkmann canal = perforating canal

2. You should know all plurals and singulars for any terms mentioned and know the definitions of diaphysis, epiphysis, metaphysis as well as plurals of these and their pronunciations. I really highlighted the significance of the canals that form a grid for blood vessels and nerves to run through, 3 crucial functions of the periosteum, and defined the phrase "bruised bone".

   Periosteum has nerves, when the nerves are damaged and ruptured here this is what causes a bruised bone.

   Function of periosteum

   - Ligaments attach here
   - Tendons attach here
   - Scaffolding for blood to have a relationship with bone

3. What is cortical bone; what is compact bone and describe its location for any bone. Does all bone have cortical bone.

Cortical bone is a synonym for compact bone. It is called cortical bone because it is always on the outside of the bone. Yes all bones have cortical bone

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Objectives lecture outline 4- Spring 2024

I. Describe the macro/ microanatomical components of spongy bone using the diaphyseal wall of a femur as an example and also a flat bone example.

1. Two other terms for spongy bone?

   Trabecular bone

   Cancellous bone

2. Does all bone contain spongy bone? If so, where in general is it located?

   Yes, usually in the center

3. What tissue exists in between the trabeculae of all spongy bones throughout life?

   Red bone marrow exists in between the trabeculae of all spongy bones.

4. What are the two other ways of synonymously referring to spongy bone?

   Trabecular bone

   Cancellous bone

5. What is the significance of this tissue? I can think of at least two functional attributes pediciated on spongy bone structure, can you?

   Bone remodeling

   Reduces weight of bone

   Trabecula is organized to be most efficient and have the most strength.

6. I described in detail the organization of a single trabecula. You should be able to compare/contrast the structure of a trabecula with an osteon in terms of how it is organized, its lamellae, its size and the different bone cell types present and their location and presence of endosteum?

   Trabecula differs from an osteon because it has cells on the perimeter, there is no Haversian canal, and has an endosteum surrounding it. The cells on the perimeter of the trabecula are osteoblasts and osteoclasts. Trabecula is also much larger than an osteon. They both are organized with concentric lamellae. Trabeculae is located in spongy bone while osteons are located in compact bone.

7. What is the endosteum, where would it be located and what is its significance? To the extent discussed in class on this slide, you should understand how osteoblasts and osteoclasts affect trabeculae structure.

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Endosteum is like the periosteum for spongy bone. It is a membrane that lines trabeculae and marrow. Osteoblasts will build more bone and osteoclasts will destroy more bone.

8. How do osteoblasts and osteoclasts cooperate by combining/coordinating their actions to maintain/enforce blood calcium homeostasis while also maintaining the structure of trabeculae? Is this a specific example of bone remodeling?

Yes this is an example of bone remodeling and one of the benefits of it. Our body needs calcium to maintain homeostasis, but we cannot constantly eat it to keep enough calcium in our body. So for example when we are sleeping, osteoclasts will break down some bone releasing calcium to be taken up and used as needed in the body. Then the osteoblast will build back up the bone. This allows the body to maintain calcium levels and maintain the structure of trabeculae.

9. Define bone remodeling in general. What are the participants in this remodeling? Is there another example of remodeling we discussed? (Hint: Changes in the proximal epiphysis of the femur starting during the toddler stage).

Bone remodeling is a process executed by osteoblasts and osteoclasts to design bone perfectly. When someone is a toddler their bones are not fully developed and the trabecula is not organized. As the child gets older bone remodeling will occur to organize the trabeculae most effectively.

10. How is this spongy bone remodeling of these proximal epiphyses beneficial?

Remodeling of the proximal epiphysis is beneficial so the trabeculae can become organized. When the trabeculae is organized the trabeculae is woven perfectly to have the optimal strength.

11. How is the spongy bone and compact bone proportioned in the epiphyses?

In the epiphysis, there are a lot of trabeculae. There are epiphyseal lines in adults once the bone is done growing. Then the edge is composed of all compact bone.

12. What is the proportion of compact bone to spongy bone in the diaphysis and where is the spongy bone located?

In the diaphysis the compact bone is once again found on the edges. Then the middle of the bone is majority spongy bone. This area in between the compact bone is considered the medullary cavity. This is where marrow is found in between the trabeculae.

II. For a juvenile long bone versus an adult long bone- using the femur as an example-Compare and contrast key anatomical features.

Juvenile

- Trabeculae is not organized.
- Epiphyseal plates
- Red bone marrow is found in the medullary cavity.

Adult

- Trabeculae is organized.
- Epiphyseal lines

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- Red bone marrow and yellow bone marrow are found in the medullary cavity.
    1. For a long bone, what is the name of the defining structure that must still be present for the bone to still be classified as juvenile? What is this structure made of?

The main structure to indicate if a bone is juvenile is the **epiphyseal plate.** The epiphyseal plate is made of hyaline cartilage, this is present because the bone is not done growing.

2. Once these structures disappear, what exists in its place and what is it called?

Once the individual is done growing the epiphyseal plate is gone. The remnants of the structure is called the epiphyseal line which is now calcified.

3. In the most basic terms, what does the epiphyseal growth plate promote that can no longer be promoted in its absence?

The epiphyseal growth plate promotes growth of the bone! When it is gone it cannot grow anymore.

4. What is the medullary cavity, what type of bone contains it and what inhabits it fully in the very young? As one ages to over ~20 years of life, one type of marrow recedes in the medullary cavity and another type of marrow proliferates.

The medullary cavity is the cavity that holds marrow. The spongy bone contains it. When the individual is young, the medullary cavity is full of red bone marrow only.

5. What type of tissue is this proliferating marrow, what is it called and what is its function? Can long bone continue to thicken throughout life? IF so, what is the relationship of this thickening to the location of the stresses placed upon the bone? Why is this beneficial?

- The proliferating marrow is called the yellow marrow. Yellow marrow is a fat reserve.
- Bone can continue to thicken throughout life. When there is stress put on certain areas of the bone the bone will thicken in order to compensate for the stress. This is beneficial because it allows our bones to adapt to the needs of our bodies. For example, tennis players have a dominant side. So, on this dominant side the humerus, radius, and ulna are likely thicker than the other side.

III. Describe the gross anatomy of long bones -Much of this is is summarized above. The slide gone over on 4-7 is a good summary of slide of much of this with the exception of the structure of the epiphyses and metaphyses which you should know from previous slides

Long bone contains the epiphyseal plate/line, periosteum that surrounds the compact bone, red bone marrow in the medullary cavity (which is made up of spongy bone) with articular cartilage at the articular ends (condyle)

IV Describe the gross anatomy of flat bones. Know the basic "sandwich structure" of flat bone? Does flat bone contain red bone marrow? If so, where?

Flat bones are like sandwiches. The bread is analogous to compact bone, and whatever you put in between is analogous to spongy bone. There is marrow in between the trabeculae, but there is not a specific cavity where the marrow is found. (medullary cavity)

V. Describe the key histological and physiological features characteristic of bone cells

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1. Describe the histology, and physiology of osteoprogenitor cells, osteoblasts, osteoclasts, and osteocytes.

Osteoprogenitor cells: are found in the periosteum and the endosteum. These cells undergo mitosis to become osteoblasts.

Osteoblast: are found in the periosteum and the endosteum. They secrete collagen, organic matrix, induce the formation of inorganic matrix, form new bone, and remodel existing bone.

Osteocytes: in lacunae within bone. Stabilize and maintain the bone matrix

Osteoclasts: are found in the periosteum and the endosteum. They reabsorb calcified bone matrices.

2. Where are these cells found and what actions do they perform?

Osteoprogenitor cells: are found in the periosteum and the endosteum. These cells undergo mitosis to become osteoblasts.

Osteoblast: are found in the periosteum and the endosteum. They secrete collagen, organic matrix, induce the formation of inorganic matrix, form new bone, and remodel existing bone.

Osteocytes: in lacunae within bone. Stabilize and maintain the bone matrix

Osteoclasts: are found in the periosteum and the endosteum. They reabsorb calcified bone matrices.

3. Which of these cells is effectively a stem cell?

Osteoprogenitor cells are effectively a stem cell

4. Which is a bone destroyer?

Osteoclast

5. Which is a bone builder? How do these “bone building cells” work?

Osteoblast is a bone builder. Osteoblasts work by releasing bone matrix that turns proteins into existing tissue.

6. Which of the 3 cells are effectively different life history stages of the same cell? Which cells participate in bone remodeling?

- Same cell at different stages: Osteoprogenitors → Osteoblasts → Osteocytes
- Osteoblasts and Osteoclasts participate in bone remodeling.

7. Which cells inhabit lacunae and which create a “Howship's lacunae”?

- Osteocytes inhabit the lacunae
- Osteoclasts create a howship's lacuna

8. How do osteoclasts work? (hint: what do osteoclasts produce that dissolves bone and how do osteoclasts produce a sealed microenvironment for this dissolution to take place?).

Osteoclasts break down the matrix through acidity and hydrolytic enzymes. The osteoclast will pump Hydrogen ions into the space within the bone which will increase the acidity of the fluid. Increasing the acidity will dissolve calcium from the bone. Osteoclasts seal off the environment with a ring.

Students, put your answers in **RED**
SI verified answers will be in **GREEN**

9. Regarding osteocytes, are they as anatomical and physiologically isolated as they might first appear under 400X magnification? If not, how not? I can think of two ways.

Osteocytes are not as physiologically isolated as they may appear due to gap junctions and canaliculi that allow transport of materials

VI. Describe the extracellular matrix of bone

A. Organic matrix- Define proteoglycans, hyaluronic acid, ground substance and the role of collagen fibers and their role in contributing to the character of bone. What is osteoid?

Osteoid is the precursor for lamellae

B. Inorganic matrix-What is hydroxyapatite? Is it salt? If so, what are its components? What is the mechanism by which hydroxyapatite is induced to form this hydroxyapatite? The role of osteoblasts and the role of positive feedback should be in your answer. What cell or cells are responsible for the formation of osteoid and hydroxyapatite? What comes first, osteoid or hydroxyapatite?

Hydroxyapatite is composed of calcium phosphate salt.

VII. Matrix components that endow

A. Compressive strength (see blue writing below)
B. Tensile strength (see blue writing below)
C. Effect of combining (A) and (B)

1. Define compressive strength.

- Compression strength is the ability of a material (In this case a bone) to resist breakdown under compression.

2. Define tensile strength.

- Tensile strength is the amount of pulling force/tension a bone can withstand before it eventually breaks.

3. What element(s) of the matrix contribute to each of these?

- Collagen fibers are a large contributor to the tensile strength
- compression strength of bone – by various minerals like hydroxyapatite (Which is composed primarily of calcium and phosphate).

4. What is the effect of combining compressive strength and tensile strength in one object, such as a bone.

- Combining these two strengths in bone allows bones to undergo forces when performing regular or more extreme activities without breaking under various pressures. The risk of fracture is greatly decreased due to the elements that contribute to the matrix.

5. How is steel reinforced concrete analogous to the construction of the bone matrix collagen reinforced hydroxyapatite?

Students, put your answers in **RED**
SI verified answers will be in **GREEN**

- Reinforced concrete comprises regular cement that is then reinforced with steel. Bone matrix collagen-reinforced hydroxyapatite works similarly, being that the HA minerals are like cement and the collagen molecules are like steel. Collagen plays the role of steel in that it provides extra strength.

6. Is there a way one can evaluate the compressive strength of a bone without the tensile strength?

- Adding hydrolytic enzymes to the bone could remove the collagen fibers to be able to solely study the hydroxyapatite.
- Letting the bone rotten away for collagen fibers to degrade and then we can study the tensile strength.

7. Is there a way one can evaluate the tensile strength of a bone without compressive strength?

Put bone in acid to remove hydroxyapatite, then can evaluate collagen(tensile strength) without compressive.

Objectives lecture outline 5- Spring 2024

I. Describe the process of endochondral and intramembranous ossification:

Define the terms endochondral ossification and intermembrane ossification. How are these fitting for the process they describe? What is the state of the skeleton up to 5 weeks post conception? In 5 weeks, what ossification starts happening and where? What bones are famous for undergoing this type of ossification? Around 8-12 weeks post conception, what type of ossifications really takes off and in what bones?

Endochondral Ossification: cartilage model. Mesenchymal cells differentiate into chondrocytes, and the periosteal bud enters through the periosteum, causing osteoblasts and osteocltasts to be birthed. The chondrocytes calcify, and bone replaces it, forming the primary ossification center

Intramembranous Ossification: mesenchymal cells differentiate into osteoblasts which begin forming bone from the inside out, with the periosteum forming last

A. Describe the temporal and spatial changes occurring in endochondral ossification throughout life.

1. What are the key events that happen during endochondral ossification from beginning to end? You should work in the following vocabulary into your description, not necessarily in this order listed here: Perichondrium, periosteum, bone collar, periosteal bud(s), chondrocyte hypertrophy, chondrocyte apoptosis, osteoblasts, osteoclasts, primary ossification, woven bone, production of the medullary cavity, secondary ossification.

2. Give a timeline of primary ossification and secondary ossification.

Primary ossification typically occurs at around 8 weeks before birth and secondary ossification occurs after birth.

Students, put your answers in **RED**
SI verified answers will be in **GREEN**

B. Describe the temporal and spatial changes occurring in intermembranous ossification.

1. What are the key events that occur during intermembranous ossification from beginning to end?
2. You should work in the following vocabulary into your description, not necessarily in this order listed here. Mesenchyme, ossification centers, osteoblasts, osteoclasts, extension of ossification centers (into fingerlike projections) to form woven bone (where does this occur)? Remodeling of woven bone, into spongy bone, **differentiation of mesenchyme into a periosteum, formation of compact bone,** (Where do the last two stages underlined and emboldened occur

Objectives lecture outline 6- Spring 2024

I. Describe details of the mechanism that promotes elongation of bone growth

1. Describe the position of all the zones of the epiphyseal plate with respect to each other and with respect to the position of the diaphysis and epiphysis.
    - (Epiphysis) Zone of resting cartilage
    - Zone of proliferation (hyperplasia)
    - Zone of hypertrophy
    - Zone of calcification
    - Ossified bones (Diaphysis)
2. Histologically how do the zones appear different and physiologically what is happening to the cells in each zone.
    - (Epiphysis) Zone of resting cartilage – chondrocytes stem cells.
    - Zone of proliferation – mitosis occurs
    - Zone of hypertrophy – enlargement of cells & lacunae
    - Zone of calcification – cells calcify extracellular matrix, triggering apoptosis
    - Ossified bones – where osteoclasts & osteoblasts come in to remodel bones.
3. Be able to describe the direction of cell migration between the epiphysis and diaphysis as cells migrate through the zones.
    - Cells migrate from epiphyseal side to diaphysis side.
4. Describe how the epiphyseal line appears on x-ray and why it appears that way.
    - During bone growth, they are separated by the epiphyseal plate but then later epiphysis & diaphysis fuel together.
5. What is (are) the zones that are calcified?
    - Zone of calcification & ossified bones
6. Why does the epiphyseal plate normally not change its thickness much during the growing years?
    - Cartilage is continuously reabsorbed and replaced by bones.
7. Does the mechanism of epiphyseal plate driving long bone growth fit the “cartilage before bone” theme. Chondrocyte hypertrophy and apoptosis should be integrated into your answer.
    - Yes, since chondrocytes hypertrophy in the zone of hypertrophy and trigger apoptosis in the zone of calcification.

Students, put your answers in **RED**
SI verified answers will be in **GREEN**

8. What other bone development/growth event(s) mentioned on the previous review sheet fit the "cartilage before bone" motif?

II. Describe details of the mechanism that promotes bone widening.

1. Describe how, during bone widening of the diaphysis of a long bone, the diaphyseal wall can thicken and the medullary cavity can widen proportionally.

When the diaphysis is widening the osteoblast activity is higher than the osteoclast activity. This ensures that the wall remains proportional to the medullary cavity. If the osteoblast activity equals the osteoclast activity, then the cavity would widen, but the diaphyseal wall would never thicken. Furthermore, if the osteoclast activity was higher than the osteoblast activity then the cavity would widen but the diaphyseal wall would also thin.

2. For this proportional widening, what cells are cooperating and where are they located?

To allow this proportional widening, osteoclasts and osteoblasts are cooperating. The osteoblasts are located on the periosteum and the endosteum. The osteoclasts are going to be destroying bone from the medullary cavity.

3. During this process, how does osteoblast activity compare with osteoclast activity and why is the balance or imbalance essential to the proper proportional widening of the diaphysis?

During this process osteoblast activity is higher than osteoclast activity. The imbalance is crucial for the bone to widen proportionally. If the osteoblast activity equals the osteoclast activity, then the cavity would widen, but the diaphyseal wall would never thicken. Furthermore, if the osteoclast activity was higher than the osteoblast activity then the cavity would widen but the diaphyseal wall would also thin.

4. Is all this another example of bone remodeling? Explain.

Yes this is another example of bone remodeling. The osteoclasts and osteoblasts are working together to change the bone structure and remodel it.

III. Describe Wolff's law/remodeling

1. Who was "Wolff" and what is the definition of the "law" that he observed?

German anatomist and surgeon Julius Wolff. The law states that our bones become thicker and stronger over time to resist forces placed upon them and thinner and weaker if there are no forces to act against

2. Describe how one might see evidence of Wolff's law upon comparing left and right arm bones of a professional bowler, pitcher, or tennis player? Explain your answer. The bones in a tennis player's dominant arm may be up to 20% thicker than the bones in their non-dominant arm. This effect is called Wolff's Law. It states that our bones become thicker and stronger over time to resist forces placed upon them and thinner and weaker if there are no forces to act against.

Students, put your answers in **RED**
SI verified answers will be in **GREEN**

3. Would changing the organization of the trabeculae in the epiphysis/metaphysis of the proximal epiphysis of the femur be an example of bone remodeling/Wolff's law? If so, how so?

Yes this is all considered an example of bone remodeling. The bone is changing and adapting to be most efficient, this is the bone remodeling.

4. In order to bone thicker, denser, stronger within the parts of a bone that are undergoing more compressive forces in, say, the diaphysis of a long bone, what must have to happen in terms of the balance between osteoclast activity and osteoblasts

For the bone to grow thicker the osteoblast activity would have to be higher than the osteoclast activity. If the osteoclast activity was higher, then the bone would be getting thinner. Also, if the activity was the same then there the bone would not grow in thickness.

III. Skull
A. Structure Function-How many bones make up the skull (aside from the ossicles-and what are the ossicles?). What is the standard number of cranial bones that make up the skull? What is the number of facial bones that make up the skull? What defines a cranial bone? Name and know the location of all the cranial bones to the extent discussed in class. Keep in mind that there are two parietal bones and two temporal bones. What is the calvaria and what does removing it reveal once the brain is also removed? What is a foramen and what are foramina? In general, what are the function(s) of canals, fissures and foramina in the skull? What skull bone(s)transmit nerves through the superior orbital fissure, foramen rotundum, foramen ovale and foramen spinosum (there are two of each of these, one on the right lateral side and one on the left lateral side) and foramen magnum? To the extent discussed in class, what differentiates cranial nerves from spinal nerves. How many cranial nerves are there? Do they occur in pairs? What is the relationship between
cranial nerves and many of the foramina of the skull? Where is
the superior orbital fissure located and what is its significance regarding the number and identity of cranial nerves that it transmits?
B. Function- What are the functions of the skull and how does the anatomy of the skull facilitate these functions? (Hint: eating, breathing, special senses, brain.)