Organization
- Human body contains several organ systems (e.g. digestive systems)
  - Composed of organs (e.g. stomach)
  - Organs composed of tissues (e.g. smooth muscle tissue)
  - Tissues composed of cells (e.g. an individual muscle cell)

- The 4 Primary Tissue Types of the Human Body:
  1) Epithelial
  2) Connective
  3) Muscle
  4) Nervous
- Let's look at how all of these tissues may interact to form an organ, such as the stomach

Epithelial Tissue
- Mostly, a tissue that lines organs
  - May be very thin, as in intestinal lining
  - May be thick, as in skin
  - 2 Kinds: Glandular and Membranous
- Membranous epithelium lines organs
  - Protective
  - Different shapes of cells
  - Simple or stratified
- Glandular epithelium forms glands
  - Exocrine Glands (e.g. sweat glands): connected to epithelia via ducts
  - Endocrine Glands (e.g. thyroid gland): not connected to other epithelial tissue by ducts

- Epithelial tissues are classified according to cell shape
  - Squamous epithelium: one or more layers of flattened cells
    - Example: outer surface of skin; lining of blood vessels, lungs, mouth, and throat
    - Simple = single layer
    - Stratified = multiple layers

- Skin Health
  - Too much UV exposure to the skin can cause skin cancer
    - “squamous cell carcinoma” is a cancer of the upper layers of the skin, which have the squamous shape
“melanoma” is cancer of the melanocytes, which are cells that produce the pigment melanin
– UV light causes mutations in the DNA of these cells, making them divide too quickly
– Green Tea has been shown to reduce skin cancer risk; how?
  • An antioxidant called EGCG in green tea causes cells to produce more interleukin-12 (IL-12)
  • This, in turn, causes the body to make more T cells and natural killer cells which may help fight off cancer
  • Also, IL-12 reduces the growth of new blood vessels (angiogenesis), which is important in tumor growth

Cuboidal epithelium: cube-shaped cells
  • Forms kidney tubules and covers surface of ovaries
  • Simple or stratified

Columnar epithelium: tall, rectangular cells
  • Lines parts of digestive tract, some reproductive organs, and the larynx
  • Simple or stratified

Beneath layer of epithelial cells lies the basement membrane
  – Non-cellular
  – Attaches epithelia to connective tissue beneath

Epithelial cells attach to each other via cell junctions
  – Tight junctions: seal together plasma membranes of adjacent cells so nothing can pass between cells
  – Adhesion junctions: protein filaments that attach cells but allow greater movement between cells
  – Gap junctions: connecting channels made of protein that permit movement of ions and water between adjacent cells

Connective Tissue
  • Composed of few cells; mostly matrix
  • Generally involved in holding various cells and tissues together, but has many other functions
  • “Fibrous Connective Tissue”
    – Composed of fibers and cells embedded in gel-like ground substance
      • Collagen fibers: made of protein; give strength and flexibility
      • Elastic fibers: thinner than collagen fibers; made of protein called elastin, which can stretch without breaking; found around organs that must stretch
      • Reticular fibers: thinner fibers of collagen that are found in liver, spleen, and lymph nodes

– Ground substance: gel-like to rubbery
– Fibroblasts: cells that produce proteins that make up the collagen, elastic, and reticular fibers
– Fat cells: store energy
– Mast cells and white blood cells: immune system

– Types of Fibrous Connective Tissues:
  – Dense connective tissue: has more collagen; strong; few blood vessels
    – Examples: Ligaments – connects bones to bones at joints
    – Tendons – connect muscles to bone

– Loose connective tissue: most common type; surrounds many organs, muscle, and blood vessels; fewer collagen fibers and no pattern to elastic fibers give it greater flexibility

– Reticular connective tissue: aka lymphoid tissue; found within soft organs such as liver, and also in lymphoid organs (spleen, tonsils, and lymph nodes)
  – Elastic connective tissue: surrounds organs that have to change shape or size frequently
    • Example: stomach

– Specialized Connective Tissues
  – Cartilage (structural support)
    • Hyaline cartilage (most common; ends of long bones)
    • Elastic cartilage (flexible; ears)
    • Fibrocartilage (rare; in intervertebral disks)

– In a fetus, “bones” are made of cartilage
  • Gradually, cartilage cells replaced with bone cells
    – = ossification
    – Begins at about 2 months after conception
  • Even a young baby still has many “bones” made of cartilage
    – Fontanelles, or “soft spots” on head fully ossified by age 2
    – Knee caps complete by age 3-5
Bone (structural support)
- Compact
  - Osteocytes – with canaliculi, for nutrient and waste flow
- Spongy
  - In some bones (femur, humerus, sternum), contains red bone marrow
  - Yellow bone marrow of many bones stores fat

Bone Marrow
- Red → blood cells
  - In adults, mainly found in ribs, pelvic bones, vertebrae, and skull
- Yellow → fat
  - Found in shafts of long bones

Blood
- Transport of oxygen and carbon dioxide (red blood cells)
- Components of the immune system (white blood cells)
- Platelets (for clotting)
- 55% plasma

Adipose Tissue
- Specialized for fat storage
  - A store of energy
- Few connective tissue fibers
- Almost no ground substance
- Mostly composed of adipocytes (fat cells)

Adipose tissue plays other important roles:
- Stores vitamins
  - Vitamins A, D, E, and K are “fat soluble” and stored in adipose tissue and liver
- Acts as an “endocrine gland” secreting hormones called adipokines
  - Examples: leptin (appetite regulation) and resistin (high levels cause insulin resistance)

Muscle
- Excitable tissue that causes body parts to move
- May be under our voluntary control, or not
• **Skeletal Muscle**
  – Attach to skeleton via tendons
  – Under voluntary control
  – Form long fibers with many nuclei

• **Cardiac and Smooth Muscle**
  – Not under voluntary control

– Cardiac Muscle – found only in the heart
– Smooth Muscle – surround blood vessels and a variety of organs (such as stomach and intestine)
  • Often arranged in sheets in the walls of organs

27  **Nervous Tissue**

• Composes the brain, spinal cord, and nerves
• Nerve cells, or neurons, transmit impulses
  – Cell body, dendrites, and axons
• **Glial cells** --nonconductive
  – Variety of functions: physical support, carry nutrients to neurons, etc.
  – Most numerous cells in brain and spinal cord
  • 9:1 ratio glial cells to neurons

28  **Organs & Organ Systems**

• Organs: composed of two or more tissue types; perform specific functions
• Organ systems: groups of organs that function together
  – Example: digestive system includes mouth, esophagus, stomach, small intestines, large intestines, etc.

29  **Describing Body Position or Direction**

• 3 planes divide the body:
  – Midsagittal: divides body into left and right
  – Frontal: divides body into anterior and posterior
  – Transverse: divides body into superior and inferior sections

30  – Anterior: “at or near the front”
  – Posterior: “at or near the back”
  – Superior: ”situated above” or “directed upward”
  – Inferior: “situated below” or “directed downward”

31  **Homeostasis**

• Environment surrounding cells of the body is the internal environment
  – Composed of interstitial fluid
– Cells get nutrients from this fluid
– Cells also release their wastes into this fluid
– Composition of this fluid must be kept fairly constant
  • Nutrients replaced
  • Wastes removed
• Relative constancy of internal environment = \textit{homeostasis}

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• Conditions within the body are maintained within an acceptable range
  – NOT absolutely constant
• What types of conditions?
  – Temperature
  – Blood pressure
  – Hormone levels
  – Nutrient levels

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• How is homeostasis maintained?
  – \textit{Negative feedback mechanisms}
    • An action which reverses the direction of change
    – Example: when house gets too hot, thermostat turns off heat
  • \textit{Controlled variable} = any physical or chemical property that may vary but must be controlled to maintain homeostasis

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• In the body, \textit{sensors} monitor current values of the controlled variable
• Sensors send this info to the \textit{control center}, which compares this value to the “set point” (correct value)
• Control Center then sends signals to \textit{effectors} which take action to correct conditions when necessary
• Mostly automatic responses
  – Nervous system
  – Hormonal

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• Nervous system examples
  – Body temperature drops \rightarrow\text{ skeletal muscles shiver to generate heat}
  – Carbon dioxide levels rise \rightarrow\text{ lungs take in oxygen and expel carbon dioxide}
• Hormonal examples
  – Blood sugar levels drop \rightarrow\text{ pancreas releases glucagon into bloodstream, which increases blood glucose levels}

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• Our environments can disrupt homeostasis (stress, pollution, etc.), making us sick
• Interactions with environment and health will be discussed throughout the quarter

37 \textbf{Biological Rhythms & Sleep}
From Cells to Organ Systems

Joints

Know your bones!

An action which reverses the direction of change

Nerve cells, or

Embedded in matrix of calcium phosphate and fibers of collagen

How is homeostasis maintained?

Articulating surface of the two bones covered with hyaline cartilage

Ligaments are often found in the outer layer of the capsule

Skull

“Chrono

55% plasma

Epithelial

Hyaline cartilage (most common; ends of long bones)

production of

Several genes have been identified

Arranged in rings called

Mostly composed of

die, and cartilage dissolves and is replaced by bone

Ovaries decrease production of estrogen, which helps maintain bone

Let's look at how all of these tissues may interact to form an organ, such as the stomach

Pelvic Bones

may take several days for your body to adjust to the new day

cells that break down bone, releasing calcium to the

(rare; in

—

Spongy

Even without cues (social, physical, etc.), many rhythms persist at approximately 24-25 hours

There must be an “internal clock”

Several genes have been identified

Disruption of the circadian rhythm

Melatonin is a hormone secreted by pineal gland (in the brain) at night

— A hormone that sends information to the hypothalamus, which regulates our “biological clock”

“Jet lag” -- may take several days for your body to adjust to the new day-night cycle

A melatonin-like pill (tasimelteon) was recently approved that can relieve the symptoms of jet lag

Other applications of research dealing with biological rhythms

— Cancer treatments

• Applying therapies when normal body cells are least sensitive and/or cancer cells most active

• “Chrono-chemotherapy”

— Weight management

• Recent study: eating a large meal at breakfast may lead to weight loss, while eating a large meal for dinner may lead to weight gain

— Administration of medications

• For example, aspirin stays in body longer when taken in the morning than in the evening*

  — But because most heart attacks occur first thing in morning, if taking to prevent heart attacks, may be best to take in the evening, so that levels are still high in body early in the morning

Positive feedback: uncommon in living organisms

A change in the controlled variable brings about events that amplify the original change, rather than returning it to “normal”

Example: in childbirth, once labor has started, contractions continue and intensify until baby is born
– Once the baby is born, positive feedback mechanisms stop

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Activity:

– Name the four main types of tissues in the human body and describe their functions
– Define homeostasis
– Your roommate says that the concept of homeostasis is being violated when the rate of respiration goes up during exercise, because the rate of respiration is not being held constant. Explain where his thinking is faulty.

– When you are done, turn in your activity and we’ll take a break 😊

43 BIO 1102 Lecture 3 Part B:
Chapter 5: Skeletal System

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• 206 Bones in the Human Skeleton
• Functions:
  – Support
  – Shape
  – Protection
  – Attachment sites for tendons (which attach to skeletal muscles)
  – Bone marrow: site of production of blood cells
  – Some fat stored in bone
  – Also a store of calcium

•

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• Know your bones!
• Study Figure 5.5
  – Skull
  – Clavicle
  – Scapula
  – Sternum
  – Ribs
  – Vertebral column
  – Humerus
  – Radius
  – Ulna
  – Ilium
  – Sacrum
  – Coccyx
  – Ischium
  – Pubis
  – Femur
Patella
- Tibia
- Fibula

Pelvic Bones
- (see https://en.wikipedia.org/wiki/Pubic_symphysis)

Long Bones
- Diaphysis: the cylindrical shaft
  - Central cavity filled with yellow bone marrow
- Epiphysis: enlarged knob at each end
  - Within, spongy bone
  - Filled with red bone marrow
    - Contains stem cells that produce blood cells
- Outer surface covered by connective tissue called periosteum

Bone cells = osteocytes
- Arranged in rings called osteons
  - (in compact bone)
- Central canal: contains blood vessels feeding bone cells
- Embedded in matrix of calcium phosphate and fibers of collagen
- Most bones composed of two layers:
  - Outer layer = compact bone
  - Inner layer = spongy bone
    - Composed of a latticework of trabeculae
      - "little beams"
    - Strong but light weight

Layer of connective tissue on outside of compact bone
- Composed of connective tissue
- Called the periosteum
- Circulatory system and nerves can attach here
- Tendons and ligaments also attach to this layer

Cartilage
- Smoother and more flexible than bone
- Three types:
Fibrocartilage: intervertebral disks, as well as menisci of knee joint
Hyaline: covers ends of mature bones in joints
Elastic cartilage: outer ear and epiglottis

Marrow cavities
- Found inside many bones
- "Red marrow" produces red blood cells, white blood cells, and platelets
- Gradually fills with fat as person ages, becoming "yellow marrow"
  - Most marrow is yellow by adulthood
  - Red marrow remains in a few bones, such as the vertebrae and hip bones

Joints
- Connect bones of the skeleton
- Vary in their ability to move
  - Fibrous ("immovable") joints
    - Skull
      - Held in place by connective tissue
    - Pubic bones
      - Held together by cartilage ("pubic symphysis")
      - In women at end of pregnancy, hormones loosen the cartilage

Cartilaginous ("slightly movable") joints
- Bones connected by hyaline cartilage
- Connect lower ribs to sternum
- Connect Vertebrae
  - Separated by intervertebral disks
  - Connect to the vertebrae
  - Cushions impact of walking or running

Freely movable joints = synovial joints
Common features
- Bones separated by fluid-filled cavity
- Joint capsule (connective tissue) connects bones
- Ligaments are often found in the outer layer of the capsule
  - Ligaments join bone to bone at joints
- Joint capsule filled with synovial fluid, a lubricant for the joint
- Additional support often provided by tendons and muscles
- Articulating surface of the two bones covered with hyaline cartilage
Bone Development

- In early fetal development, models of future bones are created out of hyaline cartilage by chondroblasts.
- After 2-3 months, chondroblasts die, and cartilage dissolves and is replaced by bone.
  - This process is called ossification.

As cartilage dies, makes room inside shafts of bones for blood vessels to develop
- Blood vessels carry bone-forming cells called osteoblasts into the area.
  - Osteoblasts secrete protein mixture called osteoid that provides structure and strength to bone.
  - Also secrete enzymes that facilitate crystalization of mineral salts and calcium phosphate, known as hydroxyapatite.

Rate of osteoblast production of osteoid matrix and mineral deposition declines
- Osteoblasts embed in bone and become mature osteocytes.
- These mature bone cells continue to maintain the bone matrix.
- Bones lengthen throughout childhood and adolescence.
  - Narrow strip of cartilage called epiphyseal plate (aka growth plate) remains in each epiphysis.
- Bone development regulated by hormones.
  - In pre-adolescents, most importantly Growth Hormone.

Diseases & Disorders

- Joint Injuries/Diseases
  - Torn ligaments, tendons, and cartilage are common injuries.
  - Heal slowly due to few blood vessels present at the joint.
  - Arthroscopic surgery.
    - Arthroscope – a tiny camera that can be inserted into the damaged area; inserted through small incisions.

- Degenerative Arthritis (Osteoarthritis)
  - Wearing out of joints; cartilage at ends of bones may crack.
    - Results in bones directly rubbing against each other.
    - Pain and swelling.
  - Often occurs with age.
  - Most common in joints that bear the greatest weight.
–Knee
–Hip
–Spine
• Worsened by obesity

–Rheumatoid arthritis
• Inflammation of lining of joint capsule
• Often spreads to cartilage
• Can eventually wear through cartilage and begin degenerating the bone
• Joints may become disfigured
• Movement may be completely lost in the joint
• Very painful
• Most often occurs in joints of wrist, fingers, and feet
• Cause? May be an autoimmune disorder
• Surgery may be required to replace joints with artificial ones

– Calcium Levels
• Blood calcium levels regulated by hormones
• If blood calcium levels fall:
  – Parathyroid glands release parathormone into bloodstream
  – Stimulates osteoclasts – cells that break down bone, releasing calcium to the bloodstream
• If blood calcium levels rise:
  – Thyroid gland releases calcitonin
  – Inhibits the osteoclasts
  – Stimulates synthesis of new bone
  – Blood calcium levels then fall

– Osteoporosis
• Progressive loss of bone calcium; weakens bone
• Bones become brittle and easily break
• Most common among women after menopause
• Ovaries decrease production of estrogen, which helps maintain bone
• What can be done to strengthen bone and help prevent osteoporosis?
  – Get enough calcium
  – For post-menopausal women, hormone therapy can help (replacing estrogen)
  – But what else is important?
  – Exercise!

• All for today...