* **Joints**
* Joints: articulations/points where bones meet and connect
  + Degrees of mobility:
    - Diarthrotic joints: freely moveable
      * Ex: shoulder, knee, wrist, etc.
    - Amphiarthrotic joints: slightly moveable
      * Ex: intervertebral discs
    - Synarthrotic joints: immovable
      * Ex: tooth in socket
  + Joints change with age
    - Synostosis: 2 bones fused into one by bone tissue
      * Formed at various ages, when bones fuse at joint
      * No mobility
      * Not considered a joint
      * Ex: coxal bone fuses from 3 parts (by adulthood), skull bones fused together (after middle age)
* Joint classification
  + Fibrous joints:
    - Bones joined by dense regular CT = ligament (connects bone to bone)
    - Mobility: synarthrotic to diarthrotic
    - Types of fibrous joints:
      * Suture:
        + Ex: between skull bones (synarthrotic)
      * Syndesmosis: length of fibers varies -> determines mobility
        + Ex: distal tibiofibular joint (synarthrotic), interosseous membrane in forearm (diarthrotic)
      * Gomphosis:
        + Ex: between tooth and socket (synarthrotic)
  + Cartilaginous joints:
    - Bones joined by cartilage
    - Types of cartilaginous joints:
      * Synchondrosis: bones joined by hyaline cartilage
        + Ex: epiphyseal plate (synarthrotic), 1st sternocostal joint (synarthrotic)
      * Symphysis: main cartilage is fibrocartilage, may contain hyaline cartilage as well
        + Ex: intervertebral disc (amphiarthrotic), pubic symphysis (amphiarthrotic)
  + Synovial joints:
    - Bones separated by a fluid-containing joint cavity
    - All are freely moveable -> diarthrotic
      * Ex: knee, shoulder, knuckle, wrist, between most ribs and sternum, between ear bones, etc.
    - Anatomy of synovial joint:
      * Joint cavity:
        + Contains synovial fluid
        + Blood filtrate
        + Lubricates
      * Articular capsule:
        + Inner layer: synovial membrane (produces synovial fluid by filtration
        + Outer layer: fibrous capsule with dense irregular CT
      * Articular cartilage:
        + Made of hyaline cartilage
        + Function: absorbs compression forces -> protects bones
        + Nourished by weight bearing intermittently
      * Reinforcing ligaments:
        + Dense regular CT that connects bone to bone
        + Three kinds:

Capsular: thickened part of the capsule

Extracapsular: outside the capsule

Ex: fibular and tibial collateral ligaments of knee

Intracapsular: inside the capsule

Ex: anterior and posterior cruciate ligaments of knee

* + - * Articular disc (meniscus):
        + In a few synovial joints
        + Function:

Evens out the distribution of compression forces

Helps stabilize joint

Allows additional movements

Ex: temporomandibular (jaw) joint

* + - * + Ex: knee
        + Tissue type: fibrocrtilage
      * Bursae and tendon sheaths
        + Closed sacs of synovial fluid
        + Prevent friction among structures
        + Bursitis: inflammation of a bursa
        + Tendon sheath: a bursa that wraps around a tendon
* Movements of joints
  + Terms of orientation in anatomy
    - Axes: infinite line that has a specific orientation
      * Anterior-posterior axis: anterior to/from posterior
      * Superior-inferior axis: superior to/from inferior
      * Left-right axis: left to/from right
  + Describing movements using planes and axes
    - Movements:
      * Transitional (linear) = move in straight line (not in planes)
        + Specific directions:

Elevation: move superiorly

Depression: move inferiorly

Protraction: move anteriorly

Retraction: move posteriorly

Feature of temporomandibular joint that is useful for these movements is articular disc

* + - * Around an axis:
        + Angular movement: change angle between two bones

Flexion: decrease joint angle (sagittal)

Extension: increase joint angle (sagittal)

Abduction: move away from midline of body (frontal)

Adduction: move toward midline of body (frontal)

Circumduction: movement that describes a cone in space (transverse)

Special movements of the feet:

Dorsiflexion: turn foot upward (sagittal)

Plantar flexion: turn foot downward (sagittal)

Inversion: turn sole of foot medially (frontal)

Eversion: turn sole of foot laterally (frontal)

* + - * + Rotation: bone moves around its own longitudinal axis

In axial region (transverse):

Left rotation: turn anterior surface to left

Right rotation: turn anterior surface to right

In appendicular region (transverse):

Medial rotation: turn anterior surface toward midline

Lateral rotation: turn anterior surface away from midline

Special movements of forearm:

Pronation: turn palms posterior (transverse)

Supination: turn palms anterior (transverse)

These are medial/lateral rotation of the forearm

* + - Movement around an axis corresponds to movement within a plane
* Synovial joints classified by shape
  + Described by:
    - Shape of articulating bone surfaces
    - Number of axes around which movement can occur:
      * Change angle between bones (angular movement)
      * Move bone around its longitudinal axis (rotation)
  + Plane joint (gliding joint):
    - Only translational (linear) movement
    - Nonaxial (no axes)
    - Ex: intercarpal and intertarsal joints
  + Hinge joint:
    - Flexion/extension (typically)
    - Uniaxial (1 axis)
    - Ex: elbow
  + Pivot joint:
    - Rotation
    - Uniaxial (1 axis)
    - Ex: proximal and distal radioulnar joints
  + Condylar joint:
    - Movements around all axes except axis of rotation (oval so can’t spin)
    - Biaxial (2 axes)
    - Ex: metacarpophalangeal (knuckle) joints
  + Saddle joint:
    - Movement around all axes except axis of rotation (similar to condylar joint)
    - Biaxial (2 axes)
    - ONLY 2 Ex: 1st carpometacarpal joint (base of thumb) and sternoclavicular joint
  + Ball-and-socket joint:
    - Most freely moving joint
    - Movements around all axes including rotation (circular so can spin)
    - Multiaxial/triaxial (3 axes)
    - ONLY 2 Ex: shoulder and hip joints
* Joint health and pathology
  + Injuries
    - Dislocation: bones forced out of normal positions
    - Sprain: ligaments are stretched or torn
      * Has poor blood supply so slow healing
      * Stretched ligaments make joint less stable
    - Cartilage injury: heals even slower
  + Joint stability: resistance to dislocation
    - Inversely related to range of motion (mobility)
      * Ex: shoulder has large range of motion-> low stability, elbow has small range of motion-> high stability
    - Factors affecting stability:
      * Shape of articular surface
        + Ex: shoulder vs. elbow
      * Ligaments
        + Ex: knee, wrist
      * Muscles
        + Ex: shoulder

Rotator cuff: 4 tendons (= 4 attached muscles) wrapped closely around joint capsule

* + Diseases
    - Arthritis: inflammatory or degenerative joint diseases
      * Osteoarthritis:
        + Wear and tear from normal aging
        + Occurs in most elderly people
      * Rheumatoid arthritis:
        + An autoimmune disease
        + Begins with inflammation of synovial membrane
      * Gouty arthritis (gout):
        + Caused by excess uric acid retention -> deposited in synovial membrane
* **Muscle**
* As a tissue and as an organ
* Organs are made of tissues, which are made of cells, not other tissues!
* Examples of tissues that are components of a muscle organ
  + Muscle tissue
  + Blood
  + Other connective tissues
  + Nervous tissue, etc.
* Functions
  + Exert force: movement, maintain posture
  + Stabilize joints
  + Produce heat
* Special features of muscle tissue
  + Contractile: exerts force by contracting (shortening) -> pulls things together
  + Electrically excitable: like nervous tissue, allows rapid stimulation of the whole cell at once
* Types of muscle tissue
  + Skeletal: voluntary (typically)
  + Cardiac: heart
  + Smooth: walls of other hollow organs
* Skeletal muscle
  + Function: to move bones
  + Attachments:
    - Origin: the less moveable attachment (proximal)
    - Insertion: the more moveable attachment (distal)
  + Actions:
    - Must cross a joint to act on that joint
    - Action depends on side bone attachment is on
    - Muscles do work by shortening, not by lengthening
      * Antagonist muscle: different muscle to “undo” another’s action
      * Agonist (prime mover): muscle that has major responsibility for a particular action
      * Synergist: a muscle that helps the agonist
  + Basic anatomy:
    - Sheaths of connective tissue organize muscle fibers (cells)
      * Epimysium: surrounds entire muscle
      * Perimysium: surrounds each fascicle (bundle of muscle fibers)
      * Endomysium: surrounds muscle fiber (cell)
      * Tendon: extension of the sheaths, connects the muscle to bone
      * Fascia surrounds groups of muscles
  + Microscopic anatomy:
    - Muscle fiber (cell):
      * Typically nearly as long as whole muscle
      * Contains many myofibrils = long organelles made of actin (thin) and myosin (thick) filaments
        + In muscle cells, both actin and myosin are organized into myofilaments (a type of microfilament)
        + Each section of myofibril is called a sarcomere = the basic functional unit of skeletal muscle contraction
      * Multinucleate (has many nuclei)
      * Striations: indicate repeating groups of protein filaments (actin, myosin, etc.)
      * Cells cannot divide after birth
      * In strength training, each muscle fiber thickens by adding more protein filaments
        + Strength is proportional to total cross-sectional area of fibers attached to tendon

Ex: pennate muscles are stronger than parallel muscle (have more cross-sectional area of fibers)

* + - Satellite cells: undifferentiated cells between the muscle fibers
      * Continue dividing through life as needed
      * Growth, strength training, or muscle damage -> satellite cells merge with muscle fibers (adds nucleus)
    - Nerve cells: direct nervous stimulation is the ONLY cause of contraction
      * Motor unit: motor neuron + all the muscle fibers it innervates
        + Motor neuron: nerve cell that controls muscle fibers
      * Neuromuscular junction: region where motor neuron contacts muscle fiber
  + Mechanism of contraction: the sliding filament mechanism
    - Myosin (thick) and actin (thin) filaments slide past one another
    - Myosin heads “crawl” along actin and drag
    - Sarcomere shortens by increasing overlap of actin
    - The filaments do NOT shorten (but everything around the does)
* Cardiac muscle
  + Found in walls of the heart
  + Involuntary
  + Muscle anatomy:
    - Branching chains of short cells
      * Stacked end-to-end
    - 1 or 2 nuclei per cell
    - Cells cannot divide after birth
    - Intercalated discs: junctions between cells
    - Gap junctions: ions carry signal between cells
    - Fascia adheres: similar to desmosomes b/c hold adjoining cells together
    - Striated (orderly structure)
      * Sarcomeres
    - Actin and myosin
  + Causes of contraction:
    - 1. Spontaneously generated (pace-maker cells)
      * Note: the rate of spontaneous contraction is affected by nervous input
    - 2. Via gap junctions from other cardiac muscle cells
* Smooth muscle
  + Muscle in walls of hollow organs (other than the heart)
  + Involuntary
  + Muscle anatomy:
    - Fusiform cells (spindle-shaped)
      * Grouped into sheets of cells having similar orientation
    - Uninucleate (1 nucleus per cell)
    - Can divide after birth
      * Regenerates/heals much better than other muscle tissues
    - Actin and myosin
    - NO striations or sarcomeres
    - Dense bodies: anchor actin to intermediate filaments to transmit force
    - Gap junctions: to coordinate contraction
    - Loose organization allows smooth muscle cells to generate force even when greatly stretched
    - Often arranged in circular and longitudinal layers:
      * Contract circular layer -> narrows the tube
      * Contract longitudinal layer -> shortens the tube
  + Causes of contraction:
    - 1. By direct nervous control (but involuntary)
    - Other chemical signals (ex: hormones)
    - Stretch
    - Via gap junctions from other smooth muscle cells
    - Spontaneously generated (like pace-maker cells)
* What all 3 muscle tissue types have in common!!!
  + Actin and myosin
  + Parts of cytoskeleton (intermediate filaments, microtubules)
  + Other organelles (mitochondria)
  + All associated with endomysium
* **Digestive System**
* Function: process food molecules and move them into the blood
* Organs of digestive system
  + Gastrointestinal (GI) tract (alimentary canal, digestive tract, gut)
    - Mouth
    - Pharynx
    - Esophagus
    - Stomach
    - Small intestine
    - Large intestine
  + Accessory organs:
    - Salivary glands
    - Liver
    - Gallbladder
    - Pancreas
* Internal/external lining of GI tract and Structure of GI tract wall:
* \*Membrane: 2 layers (epithelium lines space; connective tissue nourishes epithelium)
* Mucosa (mucous membrane):
  + Line lumen (interior space) of GI tract
  + Simple columnar epithelium through most of its length
    - Endocrine cells: release product into blood (inside body)
    - Exocrine cells: release product into lumen (outside body)
      * Ex: mucus
    - Has other epithelial cells for absorption
    - Rate of cell turnover is rapid
  + Lamina propria = CT
    - MALT = mucosa-associated lymphoid tissue (with immune cells)
    - Blood/lymph vessels, nerves
    - Glands (exocrine)
  + Muscularis mucosae
    - Layer of smooth muscle
    - Unique to digestive system
    - Twitches to dislodge sharp objects
* Submucosa = CT:
  + Tough but flexible
  + Submucosal nerve plexus (network of nerves)
    - Part of enteric nervous system
  + Blood/lymph vessels, nerves
  + Glands (exocrine)
* Muscularis externa = muscle layer:
  + Ex: peristalsis = pushing food along the GI tract
    - Circular muscle – contraction narrows tract
    - Longitudinal muscle – contraction shorten tract
    - Myenteric nerve plexus – part of enteric nervous system
* Serosa (serous membrane): called the peritoneum in abdominopelvic cavity
  + Lines peritoneal cavity (space between organs)
    - Cavity is narrow, crowded by organs
  + Visceral peritoneum (deep inner lining of cavity/outer layer of organ wall): produces serous fluid by filtration (mostly)
    - CT
    - Visceral Mesothelium: simple squamous
  + Peritoneal cavity
  + Parietal peritoneum (superficial outer lining of cavity/inner layer of body wall)
    - Parietal Mesothelium: simple squamous
    - CT
* \*Mesentery: double layer of peritoneum connecting parietal and visceral peritoneum (technically an organ)
  + Supports GI tract
  + Carries vessels and nerves
  + Stores fat
  + During development, some organs in abdominopelvic cavity become buried in body wall and lose mesentery = secondarily retroperitoneal
    - Still has peritoneum on one side (side not on body wall)
    - Have adventitia (CT between organs on body wall) on other side
    - Ex: pancreas
  + Organs that keep mesentery = intraperitoneal
    - * Ex: stomach
* Steps in food processing
  + 1. Ingestion: food taken into the mouth
  + 2. Mechanical breakdown and mixing -> more surface area exposed to chemical action (no chemical bonds broken!)
  + 3. Secretion (enzymes, mucus, etc.)
  + 4. Chemical digestion: breaking down large nutrient molecules (ex: protein) into smaller ones (ex: amino acids)
  + 5. Absorption: small molecules actively taken up by epithelium -> moves into blood or lymph
  + 6. Propulsion: move food along tract by swallowing and peristalsis
  + 7. Defecation: eliminate indigestible material from anus
* Organs of the GI tract
* \*Proximal and distal describe relative positions of organs along the tube from mouth to anus (follow the tube)
* Mouth (oral cavity):
  + Epithelium type: non-keratinized stratified squamous
  + Chewing forms bolus of food
  + Accessory organs:
    - Salivary glands: secrete saliva into the mouth
      * Includes enzyme to initiate carbohydrate digestion in the mouth
* Pharynx:
  + Sections belonging to GI tract:
    - Oropharynx
    - Laryngopharynx
  + Epithelium type: non-keratinized stratified squamous
  + Swallowing: skeletal muscles propel food through pharynx (mostly reflex = involuntary)

Esophagus:

* + Function: delivers food from pharynx to stomach
  + Location: mediastinum (area between the lungs)
  + Characteristics:
    - has both smooth and skeletal muscle (all involuntary) -> peristalsis
    - Cardiac sphincter at exit into stomach with thickened smooth muscle
      * Circular muscle layer of muscularis externa is thick
        + Prevents reflux from stomach
        + If fails to close (ex: due to hiatal hernia) -> GERD (gastroesophageal reflux disease)
    - Epithelium type: non-keratinized stratified squamous
* Stomach:
  + Function:
    - Stores food
    - Churns food (for mechanical breakdown and mixing) -> chyme
    - Begin chemical digestion of proteins
    - Secretion:
      * Mucus and bicarbonate (exocrine)
      * Acid (HCl) – sterilizes, separates molecules (exocrine)
      * Digestive enzyme – to break down proteins (exocrine)
      * Gastrin – a hormone (messenger via blood) to stimulate acid secretion (endocrine)
    - Absorption: some water and ions, but no nutrients (molecules that can be broken down for energy)
* \*Stomach is not essential for survival
  + Gross Anatomy:
    - Pyloric sphincter: circular muscle at distal end of stomach that evens out flow of chyme to small intestine
    - Rugae: folds of mucosa and submucosa, allow distention
  + Microscopic Anatomy:
    - Muscularis externa: has 3rd muscle layer = oblique (deepest)
    - Mucosa:
      * Simple columnar epithelium
        + Surface epithelium (includes gastric pits) secretes bicarbonate (alkaline-neutralizes acid) and mucus
      * Gastric glands:
        + Mucous neck cells: secrete bicarbonate and mucus
        + Parietal cells: produce HCl
        + Chief cells: produce pepsinogen (inactive enzyme)
        + Enteroendocrine cells: produce gastrin (hormone)
        + Stem cells: at pit/gland boundary, maturing cells migrate
    - No goblet cells in stomach!
* Small intestine:
  + Function:
    - Chemical digestion
      * Primary site of digestion
    - Absorption
      * Primary site of nutrient absorption
    - Secretion
    - Mixing by segmentation
  + Gross Anatomy:
    - Duodenum:
      * Shortest part of small intestine
      * Receives secretions from pancreas and gallbladder
      * Duodenal glands (submucosa):
        + Secretes bicarbonate (neutralizes stomach acid)and mucus
    - Jejunum:
      * Most absorption occurs here
    - Ileum:
      * Has Peyer’s patches (aggregated lymphoid nodules)
        + An example of MALT
        + In lamina propria and submucosa
  + Wall of the small intestine
    - Epithelium type: simple columnar
    - Plicae circulares (“circular folds”): folds of mucosa and submucosa
      * Permanent unlike rugae
      * Slows down passage of chyme
      * Increases surface area
    - Villi: projections of mucosa -> increase surface area
      * Absorption of nutrients (from gut lumen to blood/lymph)
        + Sugars and amino acids absorbed by blood capillaries
        + Lipids absorbed by lacteals (special lymph vessels)
    - Microvilli: folding of plasma membrane of enterocytes (absorptive cells)
      * Increase surface area
    - Goblet cells:
      * Function: secrete mucus
    - Intestinal crypts (glands):
      * In mucosa, between villi
      * Secretes intestinal juice
        + Maintains liquid state of chyme
      * Enteroendocrine cells
      * Stem cells
* Large intestine:
  + Function:
    - Absorb water, ions, some vitamins, but no nutrients
    - Passageway for materials that cannot be absorbed = feces
  + Gross Anatomy:
    - Cecum:
      * Ileocecal valve: prevents backflow into small intestine
    - Vermiform appendix:
      * Has lymphoid tissue
      * Appendicitis: inflamed appendix
      * Peritonitis: inflamed peritoneum
        + Occurs if appendicitis is not treated
    - Colon:
      * Ascending colon
      * Transverse colon
      * Descending colon
      * Sigmoid colon
    - Rectum:
      * Muscular, specialized for defecation
    - Anal canal:
      * Opening guarded by:
        + Internal anal sphincter (smooth muscle) - involuntary
        + External anal sphincter (skeletal muscle) - voluntary
  + Walls of large intestine:
    - Teniae coli: three thickened bands of longitudinal muscle layer
    - Haustra: bulges due to contraction of teniae coli
    - Epithelium type: mostly simple columnar
      * Colonocytes: absorptive cells
      * Goblet cells
      * Distal part of anal canal: non-keratinized stratified squamous
    - Plenty of MALT
    - Intestinal crypts (glands)
      * Goblet cells
      * Stem cells