

Biology 112

Study Guide Exam 3

Chapter 6: Skin & The Integumentary System

Skin & its Tissues

The Skin (Integument): composed of 2 regions:

- **Epidermis:** outermost layer composed of epithelial cells
- **Dermis:** underlying layer composed of fibrous connective tissue; vascularized (many blood vessels)

Subcutaneous layer (hypodermis): just deep to the dermis

- mostly adipose with some areolar connective tissue
- insulates, absorbs shocks, & anchors skin loosely to muscles

Epidermis: *keratinized* stratified squamous epithelium

- **no blood vessels;** cells in lower layers (close to dermis) have adequate blood supply; as cells divide, new cells are pushed toward surface away from blood & soon die
- **keratinocytes:** dominant skin cells; produce the fibrous protein **keratin**
 - tightly connected by adhesion junctions
 - outermost cells dead & *keratinized*; lifespan of 25-45 days
 - thick skin has accelerated cell division & keratinization
 - areas subject to regular pressure may develop even greater rate of cell division (calluses, corns)
- **melanocytes:** spider-shaped cells that produce the pigment **melanin**
 - located in deepest layer of epidermis; *melanosomes* in melanocyte processes transfer melanin to keratinocytes
 - *melanin granules* protect the cell nucleus from UV radiation

Layers of Epidermis:

- **Thick skin** has 5 layers (strata)
 - Stratum basale, stratum spinosum, stratum granulosum, stratum lucidum & stratum corneum
- **Thin skin** has only 4 layers... missing stratum lucidum; stratum corneum thinner

Skin Color: dictated by 3 pigments: melanin, hemoglobin & carotene

- **melanin:** produced from amino acid *tyrosine* in melanocytes
 - color ranges from yellow to reddish-brown to black
 - amount of melanin produced is mostly genetically determined; differences in skin color generally result from differences in melanin production
 - freckles & pigmented moles are due to local melanin accumulations
 - protects cell nucleus from UV light-induced mutations; UV repair mechanisms may stimulate synthesis
- **hemoglobin:** oxygenated hemoglobin in dermal capillaries gives fair skin a pinkish color

- **carotene:** yellow-orange pigment found in plants (carrots...)
 - accumulates in stratum corneum & hypodermis; most evident in thick skin
- biochemical imbalances (liver) may lead to accumulation of pigment **bilirubin** (breakdown product of red blood cells); produces **jaundice**

Dermis: strong, flexible connective tissue

- fibroblasts, macrophages, white blood cells with collagen & elastin fibers
- rich supply of nerve fibers, blood vessels & lymphatic vessels
- houses hair follicles, oil & sweat (sudoriferous) glands
- upper layer composed of areolar connective tissue
 - dermal papillae: projections that indent the epidermis; contain capillary loops & touch receptors (Meissner's corpuscles)
 - dermal ridges on palms of hand & soles of feet form epidermal ridges - genetically determined pattern of ridges; leaves fingerprint
- lower layer composed of dense irregular connective tissue

Accessory Structures of the Skin

Nails: scalelike epidermal modifications at posterior ends of fingers & toes

- nails consist of a **nail plate** over a surface of skin called the **nail bed**
- epithelial cells at base of nail plate produce new growth - cells become keratinized to form new nail plate as they grow out over nail bed
- **cuticle (eponychium):** fold of skin over nail root
- **lunula:** whitish half moon shaped base resulting from thicker skin in the area
- blood in dermal blood vessels beneath nail give pink color to nails

Hair & hair follicles:

- **hair** are flexible strands of mostly dead, keratinized cells
- hair has shaft (above skin) & root (below skin)
- melanin from melanocytes at base of follicle produce color
- **hair follicle:** extends from epidermal surface to dermis or hypodermis
 - hair cells at base of follicle/root divide to produce the hair; cells eventually die as they move further away from blood supply through root into shaft
 - **arrector pili muscle:** smooth muscle bundle that contracts to raise hair
- **alopecia:** hair loss brought on by aging & hormones

Sebaceous glands: oil glands usually associated with hair follicles

- **holocrine** glands that secrete **sebum** (mix of oil & cellular debris) through ducts into hair follicles
 - **sebum** keeps hair & skin soft & waterproof

Sweat glands (sudoriferous glands): exocrine glands that produce watery secretion

- coiled tubular glands in the dermis/hypodermis with epithelial cells that secrete **sweat** through ducts that open through pores at skin surface
- **eccrine glands:** most numerous sweat glands; throughout skin, but most numerous in forehead, neck & back

- sweat helps to regulate body temperature in response to heat or exercise
- *sweat* is mostly water, plus small amounts of salt & wastes (urea, uric acid)
- *apocrine glands*: become active at puberty; most numerous in axillary regions & groin; activated by emotion, fear, pain
- *ceruminous glands*: modified sweat glands in external ear; secrete earwax
- *mammary glands*: modified sweat glands in breast; secrete milk

Regulation of Body Temperature

- *hypothalamus of brain* is main integrating center for thermoregulation; includes heat-loss center & heat-promoting center
- *heat-promoting mechanisms*:
 - vasoconstriction of cutaneous blood vessels (blood rerouted to internal organs)
 - increase in metabolic rate
 - shivering (contraction of skeletal muscle)
 - enhanced thyroxine release (increases metabolism & heat)
- *heat-loss mechanisms*:
 - vasodilation of cutaneous blood vessels (heat lost through skin)
 - enhanced sweating

Healing of Wounds:

- **epidermal wound healing**: abrasions & minor burns cause damage to epidermis
 - *basal cells* migrate to bridge gap in broken tissue
 - epidermal growth factor stimulates basal stem cells to divide & replace damaged cells & new strata
- **Deep wound healing**:
 - blood clot forms to loosely unite wound edges
 - *inflammation* occurs, accompanied by heat, redness, pain & swelling
 - clot becomes a scab, epithelial cells begin to migrate beneath scab to bridge wound, & *granulation tissue* forms (blood capillaries form & fibroblasts secrete collagen fibers to fill gap)
 - extensive growth of epithelial cells beneath scab, as well as growth of fibers & blood vessels
 - **fibrosis**: scar tissue formation
 - scab sloughs off once epidermis is restored

Homeostatic imbalances of skin:

Skin cancer

- *basal cell carcinoma*
- *squamous cell carcinoma*
- *melanoma*

Burns:

- *first-degree*: only part of epidermis is destroyed
- *second-degree*: portion of epidermis & part of dermis destroyed
- *third-degree*: epidermis & full thickness of dermis & associated structures destroyed

Chapter 7: The Skeletal System

Functions of bones:

- Support
- Protection
- Movement
- Mineral storage: calcium & phosphate
- Blood cell formation (hematopoiesis): in some red bone marrow

Bone structure:

Gross anatomy of long bones:

- *compact bone*: dense outer layer of bone
- *spongy bone (cancellous bone)*: **trabeculae** - needle-like or flat pieces internal to compact bone; spaces between trabeculae filled with red or yellow bone marrow
- **epiphyses**: ends of bone (distal & proximal epiphyses); often more expanded than diaphysis; outer compact & internal spongy bone
 - o joint surfaces covered by **articular cartilage**
- **diaphysis (shaft)**: forms long axis of bone; thick collar of compact bone surrounding medullary (marrow) cavity
 - o in adults, marrow cavity contains fat - yellow bone marrow cavity
- **periosteum** covers entire surface of bone except joint surfaces
 - o **osteoblasts**: bone-forming cells
 - o **osteoclasts**: bone-destroying cells
 - o *nutrient foramen*: site of nutrient entry from vessels in periosteum at shaft of bone
 - o **endosteum**: covers trabeculae of spongy bone & canals of compact bone; contains osteoblasts & osteoclasts

Microscopic structure of bone:

Compact bone (lamellar bone): units called **osteons**

- **osteons**: cylinder oriented parallel to long axis of bone; within each cylinder is tubes (concentric circles) of bone matrix (lamellae)
- collagen fibers in lamella run in same direction.. in adjacent lamellae run in opposite direction (resists stress)
- *central (Haversian) canal*: runs through center of osteon; carries blood vessels & nerve fibers
- *perforating (Volkmann's) canal*: at right angles to long axis; connect blood vessels & nerves of periosteum to those of central canals & medullary cavity
- **osteocytes**: bone cells in small cavities called **lacunae**
- **canaliculi**: connect lacunae to each other & central canal

Spongy bone: trabeculae... a few cell layers of irregularly arranged lamellae & osteocytes connected by canaliculi

- no osteons; nutrients delivered by capillaries in endosteum

Bone development:

- **osteogenesis (ossification)**... in infants & adolescents for skeleton formation & growth; in adults for bone remodeling
- **Intramembranous ossification:** membrane bone forms from fibrous membrane
 - o Ossification center appears in fibrous connective tissue membrane
 - o Bone matrix (osteoid) is secreted within membrane
 - o Woven bone (trabeculae) & periosteum form
 - o Bone collar of compact bone forms & red marrow develops
- **Endochondral ossification:** bone forms by replacing hyaline cartilage (at primary ossification center)
 - o Bone collar forms around diaphysis of cartilage
 - o Central cartilage calcifies & cavitates
 - o Periosteal bud enters internal cavity & spongy bone forms
 - o Diaphysis elongates & medullary cavity forms
 - o Ossification of epiphyses at secondary ossification centers
- Following secondary ossification, hyaline cartilage remains only:
 - o On epiphyseal surfaces (joints)
 - o At junction of diaphysis & epiphysis (forms epiphyseal (growth) plates)

Bone Functions

Support & Protection

- bones give shape to body structures & support weight
- bones protect vital body regions (skull protects brain; ribs protect heart & lungs)

Body Movement

- *bones act as levers & joints act as fulcrums* in producing movement
- **lever:** rigid structure that can move around a fixed point or *fulcrum*
- 2 forces act on lever: *effort & load* (resistance)
- when load is close to fulcrum, & effort is applied far away, the lever acts at a mechanical advantage (& vice-versa)

Blood cell formation (hematopoiesis) in bones:

- Hematopoiesis occurs in red marrow (in cavities of spongy bone of long bones & diploe of flat bones)
- In infants, medullary cavity & all spongy bone have red bone marrow
- In adults, red bone marrow in the head of the femur & humerus, & diploe of flat bones & some irregular bones (hip bone)
- During anemia (blood cell deficiency), yellow marrow can revert to red marrow

Mineral storage in bone:

- mineral salts - mostly **calcium phosphates**, stored in bone
- calcium salt crystals pack around collagen fibers in matrix
- **hormonal regulation of calcium:**
 - o parathyroid hormone (PTH, from parathyroid gland): stimulates osteoclasts to resorb bone to raise blood calcium levels
 - o calcitonin (from parafollicular (C) cells of thyroid): inhibits osteoclasts & stimulates calcification of bone matrix to lower blood calcium levels

Skeletal Organization

Human Skeleton: 206 named bones

- **Axial skeleton:** 80 bones... bones of skull, vertebral column & thoracic (rib) cage. hyoid bone (supports tongue) & auditory ossicles (middle ear bones)
- **Appendicular skeleton:** 126 bones... bones of upper limbs & lower limbs, pectoral girdle (shoulder bones) & pelvic girdle (hip bones)

Skull: 22 bones

- **Cranial Bones: 8 bones** which enclose & protect the brain
 - **frontal bone:** forms the forehead, roofs of the orbits & anterior part of cranial floor
 - *frontal sinuses:* cavities in frontal bone medial above each eye
 - **supraorbital foramen (notch):** complete (foramen) or incomplete (notch) opening above orbits
 - **parietal bones (2):** form the greater portions of the sides & roof of the cranial cavity
 - **coronal suture:** joins frontal bone with both parietal bones
 - **sagittal suture:** joins 2 parietal bones
 - **occipital bone:** forms the posterior part & most of the base of the cranium
 - **foramen magnum:** large opening at base of skull where the medulla oblongata of brain connects with the spinal cord
 - **occipital condyles:** oval processes on either side of the foramen magnum that articulate with the atlas (1st cervical vertebra)
 - **lambdoid(al) suture:** joins 2 parietal bones with occipital bone
 - **temporal bones (2):** form the inferior lateral aspects of the cranium & part of the cranial floor
 - **zygomatic process:** articulates with the temporal process of the zygomatic bone to form zygomatic arch
 - **external acoustic meatus:** ear canal
 - **mastoid process:** rounded projection posterior to external auditory meatus; point of attachment for several neck muscles (sternocleidomastoid)
 - **styloid process:** sharp, toothlike projection that serves as the point of attachment for muscles & ligaments of the tongue & neck
 - **squamous(al) suture:** joins parietal bone with temporal bone on both lateral aspects of skull
 - **sphenoid bone:** forms middle part of the base of the skull
 - articulates with all the other cranial bones, holding them together
 - *sphenoidal sinuses:* cavities at medial aspect that drain into nasal cavity
 - **sella turcica:** saddle-shaped structure on superior surface of medial aspect that houses the pituitary gland of brain
 - **ethmoid bone:** spongelike bone located on the midline in anterior part of cranial floor, intermediate to orbits
 - *ethmoidal sinuses:* air cavities between nasal cavity & orbits
 - **perpendicular plate:** forms superior portion of nasal septum
 - **cribriform plate:** in anterior floor of cranial cavity; forms roof of nasal septum

- ***crista galli***: ridge above cribriform plate; point of attachment for membranes covering brain
 - ***superior & middle nasal conchae***: lateral projections in nasal cavity; help to filter & warm inspired air
 - superior nasal conchae are usually not visible within nasal cavity
 - inferior nasal conchae are separate bones (not part of ethmoid bone)
- **Facial Bones: 14 bones**
- **maxillae (2)**: form the upper jawbone
 - articulate with every other bone of face except mandible (jawbone)
 - ***maxillary sinus***: cavity in each maxilla that empties into nasal cavity
 - ***palatine process***: forms anterior 3/4 of hard palate (roof of mouth)
 - cleft palate & cleft lip may be due to incomplete fusion of the palatine processes or palatine bones
 - **palatine bones (2)**: form posterior 1/4 of hard palate & part of the floor & lateral wall of nasal cavity, & a small portion of orbits
 - **zygomatic bones (2)**: cheek bones; form prominences of cheeks & part of lateral wall & floor of orbits
 - ***temporal process***: projection toward temporal bone that, with zygomatic process of temporal bone, forms zygomatic arch
 - **lacrimal bones (2)**: form anterior part of medial wall of orbits
 - **nasal bones (2)**: form part of bridge of nose (rest of nose is cartilage)
 - **vomer bone**: forms superior aspect of nasal septum
 - **inferior nasal conchae (2)**: lateral projections in walls of nasal cavity; inferior to middle nasal conchae of ethmoid bone
 - **mandible**: jawbone
 - only movable facial bone (other than auditory ossicles)
 - ***mandibular condyles*** (condylar processes): articulate with temporal bone to form ***temporomandibular joint (TMJ)***
 - ***coronoid processes***: anterior to mandibular condyles; point of attachment for temporalis muscle

Infantile Skull: at birth, skull is incompletely developed; fibrous membranes called ***fontanel***s connect cranial bones

- **fontanel (soft spots)**: fibrous membrane-filled spaces in fetal & newborn skull between cranial bones that allow for growth of skull & flexibility during childbirth
 - replaced later by bone to become sutures

Hyoid Bone: U-shaped bone suspended from the styloid processes of the temporal bones by ligaments & muscles

- doesn't articulate with any other bone
- located in anterior neck between mandible & larynx; supports tongue & attaches to muscles of tongue, neck & pharynx

Vertebral Column (spine or backbone): forms skeleton of trunk of the body with sternum & ribs

- encloses & protects spinal cord, supports head & is point of attachment for ribs, pelvic girdle & back muscles
- composed of 24 vertebrae, sacrum & coccyx
 - **7 cervical vertebrae** in neck region
 - **12 thoracic vertebrae** posterior to thoracic cavity
 - **5 lumbar vertebrae** in lower back region
 - **sacrum**: 5 fused sacral vertebrae
 - **coccyx**: 4 fused coccygeal vertebrae
- cervical, thoracic & lumbar vertebrae are movable; sacrum & coccyx are not
- **intervertebral discs**: fibrocartilage & elastic tissue discs between bodies of adjacent vertebrae
- form intervertebral joints; highly resistant to shock
- vertebra parts:
 - **body**: broad flat region that accommodates intervertebral disc
 - **pedicles**: connect body to processes
 - **lamina**: flat smooth surface on either side of spinous process
 - **vertebral foramen**: opening between body & processes for spinal cord
 - **transverse processes**: lateral processes on either side of spinous process
 - **spinous process**: posterior process
 - **superior articular processes**
 - **inferior articular processes**
- **cervical vertebrae (7)**
 - have transverse foramen in transverse processes for vertebral artery, vein & nerve to pass (thoracic & lumbar vertebrae do not have transverse foramen)
 - spinous process of C2 - C6 is bifid (split into 2 parts)
 - **atlas (C1)**: 1st cervical vertebra; articulates with occipital condyles at base of skull
 - lacks body & spinous process
 - joints provide up & down head movement (yes)
 - **axis (C2)**: 2nd cervical vertebra
 - dens (odontoid process): peglike projection that makes a pivot the atlas & head rotate around (no)
- **thoracic vertebrae (12)**: giraffe/elephant
 - larger than cervical vertebrae; spinous process projects inferiorly
 - articulate with ribs
- **lumbar vertebrae (5)**: moose
 - larger than thoracic vertebrae; spinous process projects posteriorly
- **sacrum (5 fused vertebrae)**
 - vertebrae begin to fuse between 16-18 years of age; ends around age 30
 - sacral tuberosity on anterior medial sides joins with ilium to form sacroiliac joint
- **coccyx (usually 4 fused vertebrae)**
 - vertebrae fuse between 20-30 years of age

Ribs (24; 12 pairs): give structural support to sides of thoracic cavity & protection to organs of thoracic cavity

- most (rib pairs 1 though 10) attach directly or indirectly to sternum
- all ribs attach posteriorly to thoracic vertebrae

- **7 true pairs of ribs:** attached directly to sternum through costal cartilage
- **5 false pairs of ribs:** attached indirectly (through cartilage-costal cartilage connection), or not at all, to sternum
 - o **2 pairs of floating ribs (rib pairs 11 & 12):** not attached to sternum
- rib fractures are most common chest injuries
 - o may puncture heart or great vessels, lungs, trachea, bronchi, esophagus, spleen, liver or kidneys

Sternum (breastbone): located in center of anterior thoracic wall

- composed of 3 parts:
 - o **manubrium:** superior rounded part
 - suprasternal (jugular) notch: depression on superior surface
 - articulates with costal cartilage of 1st & 2nd ribs
 - o **body:** long middle part
 - articulates directly or indirectly with costal cartilage of 2nd through 10th ribs
 - o **xiphoid process:** inferior, smallest part

Auditory ossicles (6; 3 in each ear)

- in each ear: **malleus** (hammer), **incus** (anvil) & **stapes** (stirrup)
- these small middle ear bones transmit vibrations due to sound waves from tympanic membrane (eardrum) to fluid & hearing receptors in inner ear

Pectoral (Shoulder) Girdle

- **clavicle (2):** (collarbone); S-shaped bone in anterior & superior thoracic cavity, above 1st rib
 - o rounded medial end articulates with manubrium of sternum
 - o flat lateral end articulates with acromion of scapula
 - o one of the most frequently broken bones (falling on arm)
- **scapula (2):** (shoulder blade); large triangular flat bone in posterior thoracic between 2nd & 7th ribs
 - o **spine:** sharp ridge running diagonally across posterior surface
 - o **acromion:** lateral end of spine; articulates with clavicle
 - o **glenoid cavity (fossa):** lateral shallow depression; articulates with head of humerus
 - o **coracoid process:** lateral projection at anterior surface; point of tendon attachment

Upper Limb (Arm) Bones

- **humerus (2):** longest & largest bone of arm; articulates proximally with scapula & distally with ulna & radius
 - o **head:** rounded superior portion; articulates laterally with glenoid cavity of scapula to form glenohumeral joint
 - o **greater tubercle:** lateral projection distal to head & neck
 - o **lesser tubercle:** projects anteriorly
 - o **deltoid tuberosity:** lateral roughened area at middle of shaft; point of attachment for tendons of deltoid muscle

- **capitulum**: lateral rounded knob that articulates with head of radius
 - **trochlea**: medial spool-shaped projection that articulates with ulna
 - **coronoid fossa**: anterior depression that receives coronoid process of ulna
 - **olecranon fossa**: posterior depression that receives olecranon of ulna
 - **medial & lateral epicondyles**: projections on either side of distal end; points of tendon attachment
- **radius**: at lateral (thumb) aspect of forearm
 - **head**: articulates with capitulum of humerus
 - **radial tuberosity**: rough process for attachment of tendons from biceps brachii
 - **styloid process**: lateral process
- **ulna**: at medial (pinkie) aspect of forearm; looks like wrench
 - **olecranon process**: superior process that fits with olecranon fossa of humerus
 - **coronoid process**: inferior to olecranon; fits with coronoid fossa of humerus
 - **trochlear notch**: receives trochlea of humerus
 - **styloid process**: medial process
- **carpals (8)**: wrist bones
 - arranged in 2 transverse rows
 - proximal row; from lateral to medial
 - **scaphoid, lunate, triquetrum, pisiform**
 - distal row; from lateral to medial
 - **trapezium, trapezoid, capitate, hamate**
 - Sally Left The Party To Take Cathy Home
- **metacarpals (5 on each hand)**
 - numbered I - V, starting at thumb
- **phalanges (14 on each hand)**
 - each finger has proximal, middle & distal phalanges, except thumb has only proximal & distal phalanges

Pelvic Girdle: Coxal Bone - connects lower limbs with sacrum & vertebral column

- **Coxal Bone (Hip Bone)**: 3 fused bones: ilium, ischium & pubis
 - **ilium**: broad flat bone; forms superior part of pelvic girdle
 - **iliac crest**: rounded /curved region at top of ilium
 - **anterior superior & anterior inferior iliac spines**
 - **acetabulum**: lateral socket for head of femur
 - **ischium**: posterior & inferior part of pelvic girdle
 - **ischial tuberosity**: rough region at posterior & inferior aspect
 - **greater & lesser sciatic notches**
 - **ischial spine**: between greater & lesser sciatic notches
 - **pubis**: anterior & inferior part of pelvic girdle
 - **pubic symphysis**: fibrocartilage joint between 2 pubic bones

- **obturator foramen**: large opening running blood vessels & nerves between ischium & pubis
- Female pelvis is wider & shallower than male's, which accommodates childbirth

Bones of Lower Limb (Leg):

- **femur (2)**: upper leg (thigh) bone
 - articulates with tibia - tibiofemoral joint
 - **head**: articulates with acetabulum of coxal bone; points medially
 - *fovea capitis femoris*: small shallow depression at center of head
 - **neck**: slender region inferior to head
 - **greater & lesser trochanters**: lateral & medial projections (greater trochanter is lateral & superior)
 - medial & lateral condyles: articulate with medial & lateral condyles of tibia
- **patella (kneecap)**: triangular bone anterior on leg at junction of femur & tibia
- **tibia (shin bone)**: wider bone of lower leg; articulates with femur & fibula at proximal end & talus & fibula at distal end
 - **anterior crest**: sharp ridge on anterior surface (close to skin surface of shin)
 - **intercondylar eminence (tubercles)**: 2 small superior projections in articulation with femur
 - **medial malleolus**: projection at inferior (distal) aspect
- **fibula**: thin, smaller bone of lower leg; articulates with tibia proximally & talus distally
 - **anterior crest**: sharp ridge on anterior surface
 - **lateral malleolus**: projection at inferior (distal) aspect
- **tarsals (7 on each leg)**: ankle bones
 - **calcaneus**: heel bone
 - **talus**: anterior & superior to calcaneus; has wheel-like projection articulates with tibia & fibula
 - **cuboid**
 - **navicular**
 - **lateral, intermediate & medial cuneiforms**
- **metatarsals (5 on each foot)**
 - numbered I - V, starting at big toe
- **phalanges (14 on each foot)**
 - each toe has proximal, middle & distal phalanges, except big toe has only proximal & distal phalanges

Joints

Classification of Joints:

- Structural Classification: Fibrous, Cartilagenous & Synovial Joints
- Functional Classification:
 - o synarthroses: immovable joints (sutures...)
 - o amphiarthroses: slightly movable joints (symphyses...)
 - o diarthroses: freely movable joints (most joints)

Fibrous Joints: bones joined by fibrous tissue; no joint cavity

- most are immovable or slightly movable
- **sutures:** between bones of the skull; initial connective tissue ossifies in middle age
- **syndesmoses:** bones (e.g.: radius & ulna) connected by ligament; slightly movable
- **gomphoses:** tooth in bony socket; connected by short *periodontal ligament*

Cartilagenous Joints: bones joined by cartilage; no joint cavity

- **synchondroses:** bones joined by hyaline cartilage; almost always synarthrotic
 - o epiphyseal plates; joint between costal cartilage of first rib & sternum
- **symphyses:** articular surfaces of bone covered with hyaline cartilage fused to plate of fibrocartilage (absorbs shock; slightly moveable)
 - o examples are intervertebral joints (discs) & pubic symphysis

Synovial Joints: bones separated by fluid-containing joint cavity

- all are freely movable
- rich supply of blood vessels & nerve endings (sense stretch)
- **articular cartilage:** hyaline cartilage protects bone ends
- **joint (synovial) cavity:** potential space with synovial fluid (reduces friction)
- **joint capsule:** external fibrous capsule (dense irregular CT) & internal synovial membrane (loose CT)
 - o **synovial membrane** lines all internal joint surfaces except hyaline cartilage
- **reinforcing ligaments:** capsular, extracapsular or intracapsular ligaments
- **fatty pads:** cushioning in some synovial joints
- **menisci (articular discs):** fibrocartilage discs in some synovial joints
 - o separate articular surfaces & improve fit between bones
- **bursae:** flattened fibrous sacs lined with synovial membrane & containing film of synovial fluid

Types of Synovial Joints:

Ball & Socket Joints: ball-shaped head of one bone fits into cuplike socket of another

- example: shoulder & hip joints

Condyloid (Ellipsoidal) Joints: oval condyle of one bone fit into depression of another

- example: radiocarpal joints

Plane (Gliding) Joints: flat joint surfaces, allow only short slipping/gliding movements

- example: joints between vertebral articular processes

Hinge Joints: convex projection of one bone fits into concave surface on another

- example: interphalangeal joints

Pivot Joints: rounded end of one bone protrudes into a bony ring/sleeve on another

- example: atlas & axis articulation

Saddle Joints: resemble condyloid joints; each bone has both concave & convex articular surfaces (like saddle); greater freedom of movement

- example: carpometacarpal joints

Joint Angular movements: increase or decrease angle between 2 bones

- includes flexion, extension, abduction, adduction & circumduction
- **flexion:** decreases angle of joint & brings bones closer together
- **extension:** increases angle of joint & moves bones away from each other
 - o **hyperextension:** moving head backwards beyond straight
- **dorsiflexion:** lifting foot
- **plantar flexion:** depressing foot
- **abduction:** movement of limb away from midline
- **adduction:** movement of limb toward midline
- **rotation:** turning of bone around its long axis
 - o medial rotation: toward the midline; lateral rotation: away from midline
- **circumduction:** moving a limb so that it describes a cone in space
- **pronation:** rotating forearm medially so the palm faces posterior/inferiorly
- **supination:** rotating forearm laterally so the palm faces anterior/superiorly
- **eversion:** turning the sole of the foot laterally
- **inversion:** turning the sole of the foot medially
- **retraction:** nonangular posterior movement (moving jaw backward)
- **protraction:** nonangular anterior movement (moving jaw forward)
- **elevation:** lifting a body part superiorly
- **depression:** lowering a body part inferiorly
- **opposition:** touching thumb to tip of other digits

Chapter 8: The Muscular System

Skeletal muscle tissue: attach to & cover bony skeleton

- longest of muscle types; *striated*; under *voluntary* control

Skeletal Muscle Anatomy:

Connective Tissue wrappings:

- **fascia:** layers of connective tissue separating skeletal muscles
- **aponeuroses:** broad fibrous connective sheets attaching muscles to adjacent structures
- **epimysium:** dense irregular CT surrounding whole muscle
- **perimysium:** fibrous CT surrounding individual muscle fascicles (bundles of muscle fibers (cells))
- **endomysium:** reticular CT surrounding individual muscle fibers (cells)

Skeletal Muscle Fibers:

- skeletal muscle cells long (hundreds of cm) & wide; multinucleate
- **sarcolemma:** plasma membrane of muscle
- **sarcoplasm:** like cytoplasm of normal cell; contains many glycosomes (store glycogen) & myoglobin (carries & stores oxygen)
- **myofibrils:** contractile elements of skeletal muscle
 - o composed of **thin filaments** (*actin, tropomyosin & troponin complex*) & **thick filaments** (*myosin*)
 - o **myosin** composed of long central tails & laterally oriented heads (cross-bridges) that bind actin
 - o **tropomyosin** covers myosin binding sites on actin molecules in resting muscle
 - o **troponin complex** consists of: TnI (inhibits actin), TnT (binds tropomyosin & positions it on actin) & TnC (binds calcium to start contraction)
 - o striations result from alternating dark **A bands** (thick filaments with overlapping thin filaments) & **I bands** (thin filaments)
 - o **A bands** have lighter central *H zone* (no thin filaments) with central darker *M line* (desmin protein)
 - o **I bands** have darker central **Z disc** (connexin protein)
 - o **Elastic filaments** (composed of titin) hold thick & thin filaments in place & recoil to reform shape when muscle relaxes)
 - o A **sarcomere** is the region of a myofibril between adjacent Z discs
- **sarcoplasmic reticulum:** smooth ER of muscle cells; store calcium
 - o wraps around myofibrils; terminal cisternae are cross channels at A-I junctions
 - o terminal cisternae form **triad** with **T-tubules** of sarcolemma; triads sense voltage & regulate calcium release

Contraction of Skeletal Muscle Fiber: activation of myosin's cross bridges

- **sliding filament mechanism:** during contraction, the thin filaments slide past the thick filaments so that actin & myosin overlap to a greater degree
- nerve impulse leads to depolarization & calcium release from sarcoplasmic reticulum

- calcium binds to TnC, which changes shape & moves tropomyosin away from myosin binding sites on actin
- with myosin binding sites accessible on actin, activated myosin heads bind actin (cross bridge attachment)
- as myosin heads bind actin, they pivot as they change from high-energy shape to low-energy shape, pulling thin filament toward center of sarcomere
 - o ADP & P are released from myosin head
- a new ATP molecule binds the myosin head & myosin loses hold of actin (cross bridge detachment)
- hydrolysis of ATP to ADP + P by ATPase releases energy to return myosin to high-energy state... provides potential energy for myosin to again bind actin

Regulation of contraction:

- the axon of a **motor neuron** forms a **neuromuscular junction** with a muscle fiber
- the **neurotransmitter acetylcholine** (ACh) is released in synaptic vesicles from the axon terminal of the nerve cell into the synaptic cleft between the nerve cell & muscle cell
- the motor end plate of the muscle cell has ACh receptors that bind ACh; this binding opens sodium channels in the sarcolemma... sodium rushes in & triggers an action potential in the muscle cell:
 - o muscle cells are polarized with slight negative charge in resting state
 - o depolarization of the muscle cell results from the excess positive charge caused by the influx of sodium ions
 - o the local depolarization spreads to the rest of the muscle cell
 - o repolarization occurs as potassium ions flow out of the muscle cell to restore the resting potential
- ACh is degraded by **acetylcholinesterase** in synaptic cleft
- Excitation-contraction coupling: transmission of action potential past triads causes sarcoplasmic reticulum to release calcium ions into sarcoplasm
 - o Some calcium binds to troponin... (see above)
 - o Calcium signal is short-lived (30 ms); ATP-dependent calcium pump moves calcium back into sarcoplasmic reticulum
 - o As intracellular calcium levels drop, tropomyosin again blocks myosin binding sites on actin... relaxation occurs

Muscle metabolism: muscles need constant supply of ATP

ATP Sources:

- **Direct phosphorylation:** creatine phosphate converted to creatine by creatine kinase... phosphate released added to ADP to form ATP
- **Anaerobic glycolysis & lactic acid formation:** 2 ATP yield per glucose
 - o Lactic acid build up in muscles - causes fatigue
 - o **Oxygen debt:** need additional oxygen to oxidize & remove lactic acid from muscle cells
- **Aerobic respiration:** yields 36 or 38 ATP per glucose

Muscular Responses

Threshold stimulus: minimal strength of stimuli to cause a contraction

Muscle twitch: response of muscle to a single brief stimulus... can be measured in lab using myogram; includes:

- latent period
- period of contraction
 - o **tetanus:** sustained muscle contraction - can be incomplete or complete
- period of relaxation
- **muscle tone:** most important stabilizing factor for most joints
 - o tendons kept taught by muscle tone - a low level of contractile activity in relaxed muscles

Smooth muscle tissue: occurs in walls of visceral organs (stomach, bladder), respiratory passageways & blood vessels

- forces fluids & other substances through body channels
- **nonstriated; involuntary**
- slow & sustained contractions

Smooth Muscle: spindle-shaped cells with centrally located nucleus

- has thin endomysium; no perimysium or epimysium
- lines walls of most blood vessels & hollow organs... 2 layers in most cases: longitudinal layer & circular layer
 - o 2 layers alternate contraction & relaxation: leads to peristalsis - moves contents along tube
- myofilaments: thick filaments (myosin) & thin filaments (actin & tropomyosin (no troponin))

Contraction of Smooth Muscle:

- uses sliding filament mechanism
- no troponin or TnC... calcium binds calmodulin & myosin light chain kinase to activate myosin

Regulation of Smooth Muscle Contraction:

- can use similar mechanism to skeletal muscle... neurotransmitter release at neuromuscular junction generates action potential, which leads to rise in intracellular calcium
- however, signal can be stimulatory or inhibitory for contraction
- can use a variety of neurotransmitters (ACh, norepinephrine...), whereas skeletal muscle cells use ACh
- smooth muscle cells can spontaneously depolarize in response to chemical stimuli

Cardiac muscle tissue: occurs only in walls of heart

- **striated; involuntary**
- pacemaker cells set rate of contraction

Major Skeletal Muscles

Muscle Attachment Sites:

- **origin:** site of muscle's attachment to more stationary bone
- **insertion:** site of muscle's attachment to more movable bone

Coordination within muscle groups

- movements are often the result of several muscles acting as a group
- most muscles are arranged in opposing pairs:
 - o **agonist (prime mover):** contracts while **antagonist** stretches
 - o agonist & antagonist often located on opposite sides of bone (biceps brachii & triceps brachii)
- **synergists:** contract & stabilize intermediate joints (joint in between agonist & primary joint) to prevent unwanted movement
 - o wrist extensors contract to prevent wrist from flexing when fingers flex
- **fixators:** stabilize origin of prime mover so it acts more efficiently
 - o *fixators hold scapula steady while arm moves*

Principal Skeletal Muscles (figures 8.15 through 8.30; tables 8.4 through 8.15)

Muscles of the Head & Neck:

- **epicranius (occipitofrontalis)**
 - o origin: epicranial aponeurosis (frontal belly); occipital bone & mastoid process of temporal bone (occipital belly)
 - o insertion: skin over orbit (frontal belly); epicranial aponeurosis (occipital belly)
 - o action: draws scalp anteriorly (frontalis); draws scalp posteriorly (occipitalis)
- **orbicularis oculi**
 - o origin: medial wall of orbit
 - o insertion: circular path around orbit
 - o action: closes eye
- **orbicularis oris**
 - o origin: muscle fibers surrounding mouth opening
 - o insertion: skin at corner of mouth
 - o action: closes & protrudes lips (assists in speech)
- **buccinator**
 - o origin: alveolar processes of maxilla & mandible
 - o insertion: orbicularis oris
 - o action: presses cheeks against teeth & lips (whistling & blowing); draws corner of mouth laterally; assists in chewing
- **zygomaticus major & minor**
 - o origin: zygomatic bone
 - o insertion: skin at angle of mouth & orbicularis oris (z. major) & upper lip (z. minor)
 - o action: z. major draws mouth superiorly & laterally (smiling & laughing); z. minor raises upper lip

- **platysma**
 - origin: fascia over deltoid & pectoralis major muscles
 - insertion: mandible, muscles around mouth & skin of lower face
 - action: draws outer lower lip inferiorly & posteriorly (pouting) & depresses mandible
- **muscles that move eyeballs** (6 muscles): superior, inferior, lateral & medial rectus muscles, & superior & inferior oblique muscles
- **masseter**
 - origin: maxilla & zygomatic arch
 - insertion: angle & ramus of mandible
 - action: elevates mandible (closes mouth) & retracts mandible
- **temporalis**
 - origin: temporal bone
 - insertion: coronoid process & ramus of mandible
 - action: elevates & retracts mandible
- **suprahyoid muscles**: elevate hyoid bone
- **infrahyoid muscles**: depress hyoid bone
- **sternocleidomastoid**
 - origin: sternum & clavicle
 - insertion: mastoid process of temporal bone
 - action: flex cervical portion of vertebral column; extend head & elevate sternum during forced inhalation; laterally flex & rotate head side to side

Muscles that move the pectoral girdle (primarily scapula)

- **pectoralis minor**
 - origin: 2nd or 3rd through 4th or 5th ribs
 - insertion: coracoid process of scapula
 - action: abducts & inferiorly rotates scapula; elevates 3rd through 5th ribs during forced inhalation (when scapula stabilized)
- **serratus anterior**
 - origin: superior 8 or 9 ribs
 - insertion: vertebral border & inferior angle of scapula
 - action: abducts & superiorly rotates scapula; elevates ribs (when scapula stabilized)
- **trapezius**
 - origin: occipital bone (superior nuchal line & ligamentum nuchae) & spines of 7th cervical & all thoracic vertebrae
 - insertion: clavicle; acromion & spine of scapula
 - action: elevates scapula & helps extend head; adducts & depresses scapula & rotates scapula upward; stabilizes scapula

Muscles that move the humerus

- **pectoralis major**
 - origin: clavicle, sternum & costal cartilage of 2nd to 6th ribs (sometimes 1st to 7th ribs)
 - insertion: greater tubercle of humerus & intertubercular sulcus of humerus

- action: adducts & medial rotates arm at shoulder joint; flexes arm (clavicular head) & extends arm (sternocostal head)
- **latissimus dorsi**
 - origin: spines of inferior 6 thoracic vertebrae & lumbar vertebrae; crests of sacrum & ilium & inferior 4 ribs
 - insertion: intertubercular sulcus of humerus
 - action: extends, adducts & medially rotates arm at shoulder joint; draws arm posteriorly & inferiorly
- **deltoid**
 - origin: acromial extremity of clavicle; acromion & spine of scapula
 - insertion: deltoid tuberosity of humerus
 - action: abducts arm at shoulder joint (lateral fibers); flexes & medially rotates arm at shoulder joint (anterior fibers); extends & laterally rotates arm at shoulder joint (posterior fibers)
- **infraspinatus**
 - origin: inferior to spine of scapula (infraspinous fossa)
 - insertion: greater tubercle of humerus
 - action: laterally rotates & adducts arm at shoulder joint
- **teres major**
 - origin: inferior angle of scapula
 - insertion: intertubercular sulcus of humerus
 - action: extends arm & assists in adduction & medial rotation of arm at shoulder joint
- **teres minor**
 - origin: inferior lateral border of scapula
 - insertion: greater tubercle of humerus
 - action: laterally rotates, extends & adducts arm at shoulder joint

Muscles that move the radius & ulna

- **Flexors:**
- **biceps brachii**
 - origin: tubercle above glenoid cavity of scapula (long head); coracoid process of scapula (short head)
 - insertion: radial tuberosity of radius (& bicipital aponeurosis)
 - action: flexes forearm at elbow joint; supinates forearm at radioulnar joints & flexes arm at shoulder joint
- **brachialis**
 - origin: distal anterior surface of humerus
 - insertion: ulnar tuberosity & coronoid process of ulna
 - action: flexes forearm at elbow joint
- **brachioradialis**
 - origin: lateral border & distal end of humerus
 - insertion: superior to styloid process of radius
 - action: flexes forearm at elbow joint; supinates & pronates forearm at radioulnar joints

- **Extensors:**
- **triceps brachii**
 - origin: inferior to glenoid cavity of scapula (long head); lateral & posterior surface of humerus (lateral head); posterior surface of humerus (medial head)
 - insertion: olecranon of ulna
 - action: extends forearm at elbow joint & extends arm at shoulder joint
- **Pronators:**
- **pronator teres**
 - origin: medial epicondyle of humerus & coronoid process of ulna
 - insertion: midlateral surface of radius
 - action: pronates forearm at radioulnar joints & weakly flexes forearm at elbow joint

Muscles that move the wrist, hand, thumb & fingers

- **Flexors:**
- **flexor carpi radialis**
 - origin: medial epicondyle of humerus
 - insertion: 2nd & 3rd metacarpals
 - action: flexes & abducts hand at wrist joint
- **palmaris longus**
 - origin: medial epicondyle of humerus
 - insertion: flexor retinaculum & palmar aponeurosis
 - action: weakly flexes hand at wrist joint
- **flexor carpi ulnaris**
 - origin: medial epicondyle of humerus; coronoid process of ulna; ridge along anterior surface of radius
 - insertion: pisiform, hamate & base of 5th metacarpal
 - action: flexes & adducts hand at wrist joint
- **Extensors:**
- **extensor carpi radialis**
 - origin: lateral supracondylar ridge of humerus
 - insertion: 2nd metacarpal
 - action: extends & abducts hand at wrist joint
- **extensor digitorum**
 - origin: lateral epicondyle of humerus
 - insertion: distal & middle phalanges of each finger
 - action: extends distal & middle phalanges of each finger at interphalangeal joints; extends proximal phalanges of each finger at metacarpophalangeal joints; extends hand at wrist joint
- **extensor carpi ulnaris**
 - origin: lateral epicondyle of humerus & posterior border of ulna
 - insertion: 5th metacarpal
 - action: extends & adducts hand at wrist joint
- **abductor pollicis longus**
 - origin: posterior surface of middle of radius & ulna

- insertion: 1st metacarpal
- abducts & extends thumb at carpometacarpal joint & abducts hand at wrist joint

Muscles of abdominal wall

- **rectus abdominis**
 - origin: pubic crest & pubic symphysis
 - insertion: cartilage of ribs 5-7 & xiphoid process
 - action: flexes vertebral column & compresses abdomen
- **external oblique**
 - origin: lower 8 ribs
 - insertion: iliac crest & linea alba
 - action: compresses abdomen & flexes vertebral column
- **internal oblique**
 - origin: iliac crest, inguinal ligament & thoracolumbar fascia
 - insertion: cartilage of last 3 or 4 ribs; linea alba
 - action: compresses abdomen & flexes vertebral column
- **transverse abdominis**
 - origin: iliac crest, inguinal ligament, lumbar fascia & cartilage of lower 6 ribs
 - insertion: xiphoid process, linea alba & pubis
 - action: compresses abdomen

Muscles used in breathing

- **diaphragm**
 - origin: xiphoid process of sternum, costal cartilage of lower 6 ribs & lumbar vertebrae
 - insertion: central tendon
 - action: increases height & volume of thoracic cavity, resulting in inhalation
- **external intercostals**
 - origin: superior rib
 - insertion: inferior rib
 - action: elevates ribs & increases width & depth of thoracic cavity, resulting in inhalation
- **internal intercostals**
 - origin: superior rib
 - insertion: inferior rib
 - action: further decreases width & depth of thoracic cavity during forced exhalation

Muscles that move the femur

- **gluteus maximus**
 - origin: iliac crest, sacrum, coccyx & aponeurosis of sacrospinalis
 - insertion: iliotibial tract & linea aspera under greater trochanter of femur
 - action: extends thigh at hip joint & laterally rotates thigh
- **gluteus medius**
 - origin: ilium
 - insertion: greater trochanter of femur

- action: abducts thigh at hip joint & medially rotates thigh
- **tensor fasciae latae**
 - origin: iliac crest
 - insertion: iliotibial tract (& tibia)
 - action: flexes & abducts thigh at hip joint
- **adductor longus**
 - origin: pubic crest & pubic symphysis
 - insertion: linea aspera of femur
 - action: flexes & adducts thigh at hip joint & medially rotates thigh
- **pectineus**
 - origin: superior ramus of pubis
 - insertion: pectineal line of femur (between lesser trochanter & linea aspera)
 - action: flexes & adducts thigh at hip joint

Muscles that act on the femur, tibia & fibula

- **Extensors:**
- **sartorius**
 - origin: anterior superior iliac spine
 - insertion: medial surface & body of tibia
 - action: flexes leg at knee joint; flexes, abducts & laterally rotates thigh at hip joint
- **Quadriceps femoris muscle group:**
- **rectus femoris**
 - origin: anterior inferior iliac spine
 - insertion: patella (via quadriceps tendon) & tibial tuberosity (via patellar ligament)
 - action: extends leg at knee joint; flexes thigh at hip joint
- **vastus lateralis**
 - origin: greater trochanter & linea aspera of femur
 - insertion: patella (via quadriceps tendon) & tibial tuberosity (via patellar ligament)
 - action: extends leg at knee joint
- **vastus medialis**
 - origin: linea aspera of femur
 - insertion: patella (via quadriceps tendon) & tibial tuberosity (via patellar ligament)
 - action: extends leg at knee joint
- **Flexors:**
- **Hamstring muscle group:**
- **biceps femoris**
 - origin: ischial tuberosity (long head); linea aspera of femur (short head)
 - insertion: head of fibula & lateral condyle of tibia
 - action: flexes leg at knee joint & extends thigh at hip joint
- **semitendinosus**
 - origin: ischial tuberosity
 - insertion: proximal medial surface of shaft of tibia
 - action: flexes leg at knee joint & extends thigh at hip joint

- **semimembranosus**
 - origin: ischial tuberosity
 - insertion: medial condyle of tibia
 - action: flexes leg at knee joint & extends thigh at hip joint

Muscles that move the foot & toes

- **tibialis anterior**
 - origin: lateral condyle & body of tibia (& interosseus membrane between tibia & fibula)
 - insertion: 1st metatarsal & medial cuneiform
 - action: dorsiflexes foot at ankle joint & inverts foot at intertarsal joints
- **extensor digitorum longus**
 - origin: lateral condyle of tibia, anterior surface of fibula & (& interosseus membrane between tibia & fibula)
 - insertion: middle & distal phalanges of toes 2-5
 - action: dorsiflexes foot at ankle joint; extends distal & middle phalanges of each toe at interphalangeal joints; extends proximal phalanx of each toe at metatarsophalangeal joint
- **fibularis (peroneus) longus**
 - origin: head & body of fibula & lateral condyle of tibia
 - insertion: 1st metatarsal & medial cuneiform
 - action: plantar flexes foot at ankle joint & everts foot at intertarsal joints
- **gastrocnemius**
 - origin: lateral & medial condyles of femur & capsule of knee
 - insertion: calcaneus (via calcaneal tendon)
 - action: plantar flexes foot at ankle joint & flexes leg at knee joint
- **soleus**
 - origin: head of fibula & medial border of tibia
 - insertion: calcaneus (via calcaneal tendon)
 - action: plantar flexes foot at ankle joint