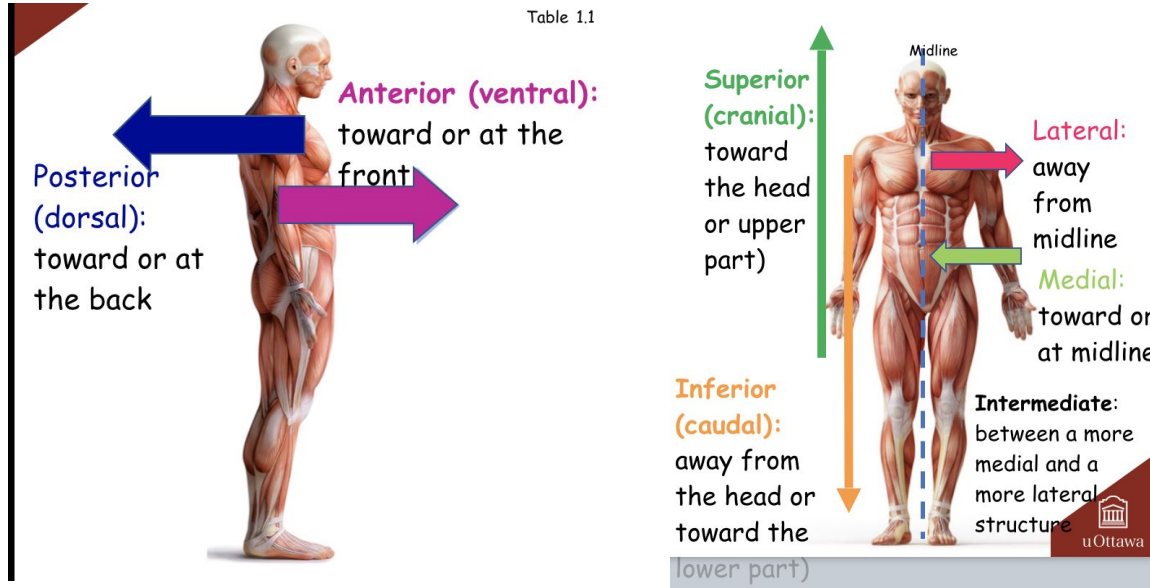


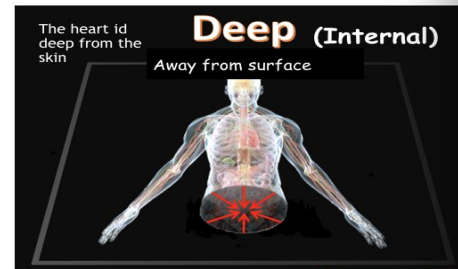
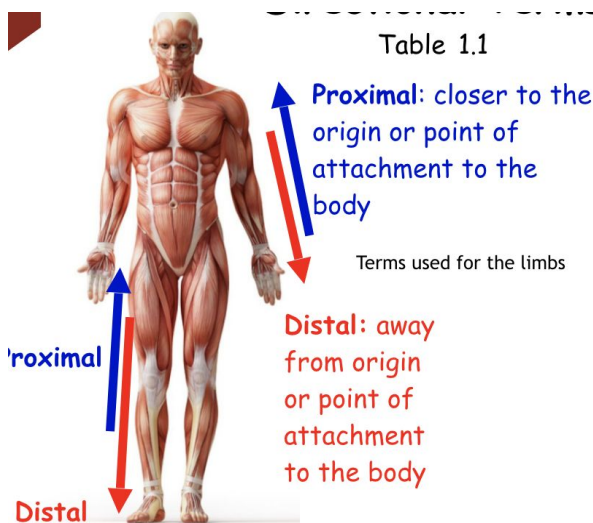
### Anatomical terms

Right and left refer to the body being viewed, not the observer

### Terms used for the trunk



### Terms used for the limbs



- The thigh is proximal/superior to the foot
- The eyes are lateral/superior to the nose
- The vertebral column is posterior to the esophagus
- The thumb is lateral to the pinkie

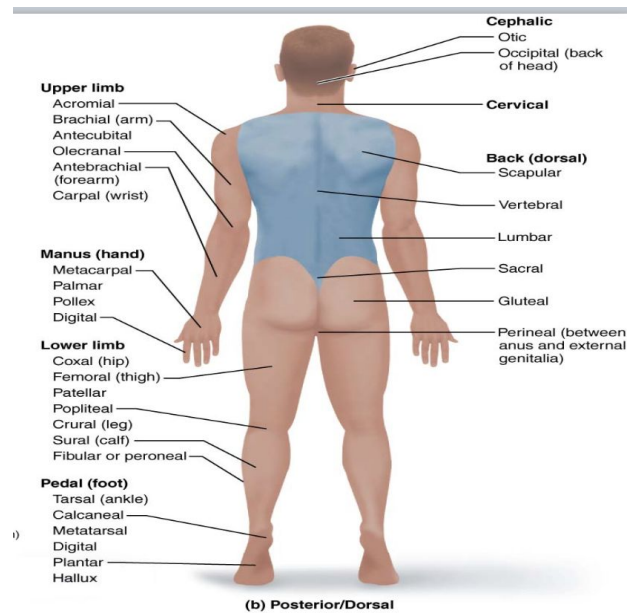
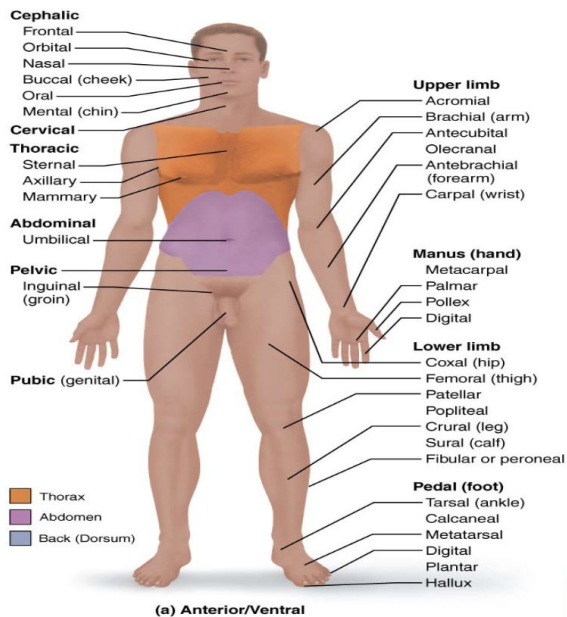
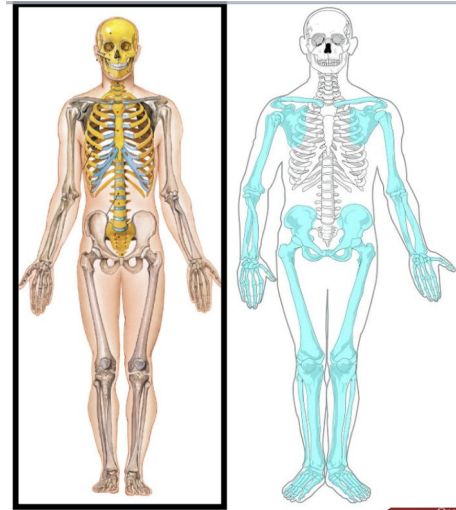
### Regional terms

Axial (yellow)

- Head, neck, and trunk

Appendicular (blue)

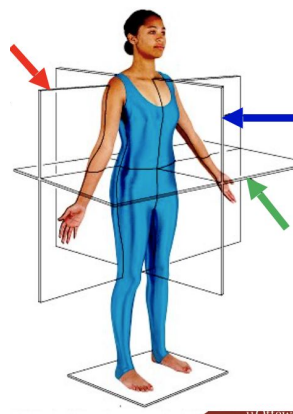
- Limbs, pelvic bones, clavicle and scapula



### Body planes

- Sagittal plane (vertical)
- Frontal (coronal) plane (vertical)
- Transverse plane (horizontal)

The plane can be anywhere along the body not just down the middle (called parts not halves)



## Sagittal Plane

- Divides left and right
- Midsagittal (median) plane: cut was made perfectly on midline
- Parasagittal plane: cut was off-centered, not on midline

## Frontal (coronal) plane

- Divides into anterior and posterior parts

## Transverse plane

- Divides superior and inferior parts

## Oblique section

- Result of cuts at an angle other than 90 degrees to vertical plane

## Body cavities and membranes

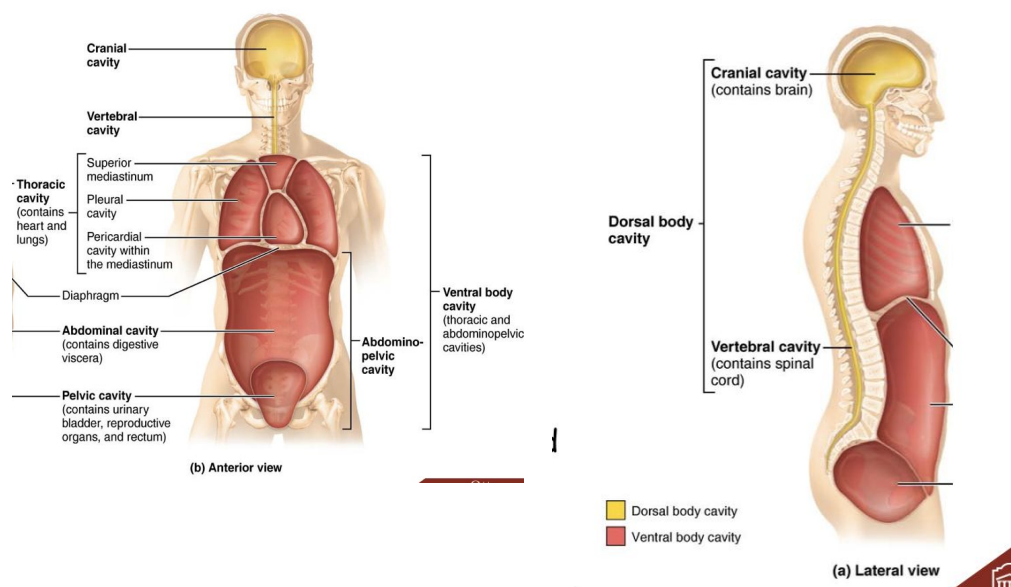
2 sets: dorsal (back), ventral (front)

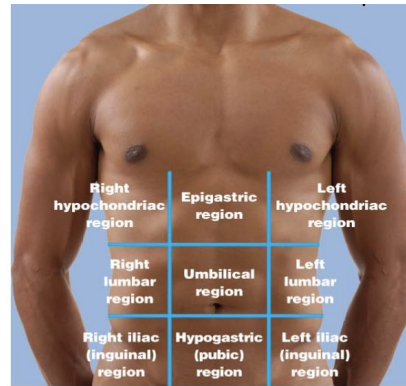
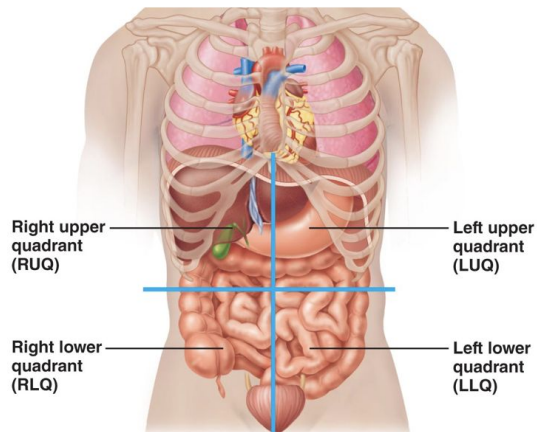
### Dorsal:

- Cranial cavity: brain and enclosed by the skull, with the membrane meninge
- Vertebral cavity: spinal cord, vertebral column, with the membrane meninge

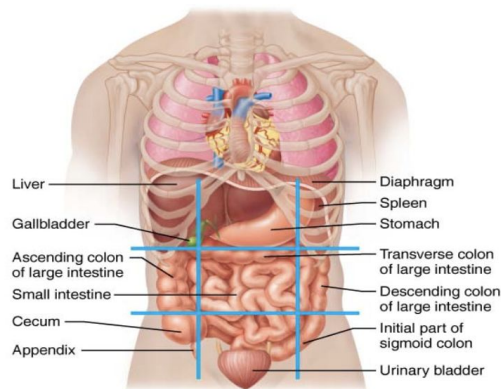
### Ventral body cavity

- **Thoracic cavity:** subdivided into
  - 2 lateral; **pleural** cavities: surround lungs
  - Central **pericardial** cavity: enclosed heart
- **Abdominopelvic cavity:** subdivided into
  - Super **abdominal** cavity: contains liver, stomach, intestines, spleen
    - Biggest cavity in the body
  - Inferior **pelvic** cavity: houses urinary bladder, reproductive organs





hypo(beneath)chondria(ribs)  
 Gastric(stomach)  
 iliac(hips)



Practice questions:

If someone has a broken leg, he has damaged the \_\_\_\_\_ division of the body

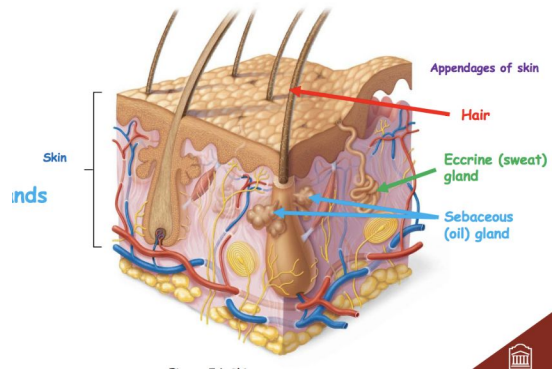
- A) Dorsal
- B) Appendicular\*\*
- C) Superficial
- D) axial

Which of the following organs is in the dorsal cavity

- A) Uterus (abdominal pelvic)
- B) Small intestine (abdominal pelvic)
- C) Spinal cord\*\*\*
- D) Heart (thoracic cavity)

## The integumentary system

- Skin and its appendages (sweat and oil glands, hair, and nails) make up this system
- 7% of body weight
- Skin is the largest organ.



### **Epidermis:**

- composed of **epithelial cells**, the outermost layer.
- **Non-vascularized**
- Nutrients reach by **diffusing** through tissue fluid from blood vessels in the dermis

### **Dermis:**

- makes up bulk of skin
- composed mostly of **dense connective tissue**.
- **Vascularized**.

### **Subcutaneous Tissues:**

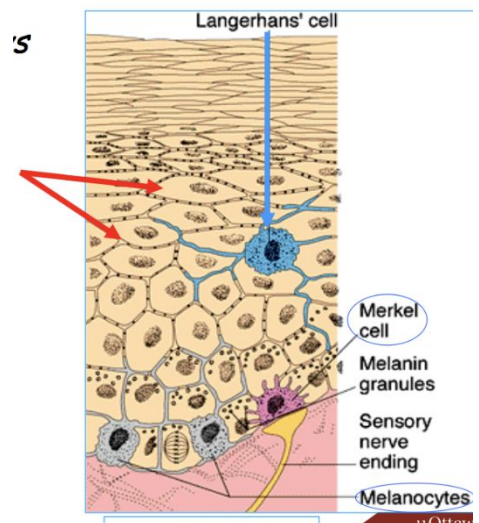
- deep to the skin, also known as the hypodermis or superficial fascia (its superficial to the tissue wrapping (fascia) of skeletal muscles)
- Not part of the skin, consists mostly of **adipose tissue**
- **Subcutaneous tissue anchors skin** to underlying structures loosely so that the skin can slide relatively freely

## Epidermis and its Cells

4 cells types and 5 distinct layers.

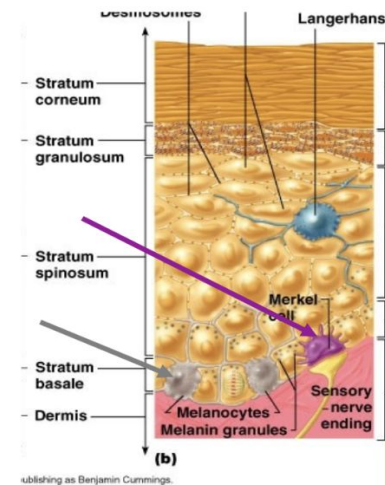
**Keratinocytes:** chief role is to **produce the fibrous protein keratin**. Most epidermal cells are keratinocytes

- **Tied together by desmosomes** and in some layers, by tight junctions to hinder movement or water between cells
- Arise in the deepest part of the epidermis, layer called **stratum basale**
- Undergo **almost continuous mitosis** in response to epidermal growth factor, a peptide produced by various cells around the body
- **Newly formed cells are pushed upwards** by the production of new ones beneath them. When keratinocytes reach skin surface, they are dead, completely filled with keratin
- Totally new epidermis every **25-45 days**.



### Melanocytes:

- spider-shaped epithelial cells, **synthesize pigment melanin**, found in deepest layer of epidermis
- Melanin is produced in membrane-bound granules, melanosomes, then transformed through the cell processes (legs) to nearby keratinocytes
- **Basal keratinocytes contain more melanin** than do melanocytes as a result. Melanin clusters on superficial “sunny” sides of keratinocyte nucleus, **forming pigment shield that protects nucleus** from damaging effects of UV radiation in sunlight.



### Dendritic Cells

- Star-shaped, arise from **bone marrow and migrate to epidermis**
- AKA Langerhans cells, **ingest foreign substances**, key activators of the immune system
- Slender processes extend around surrounding keratinocytes.

### Tactile Epithelial Cells

- Occasional (AKA merkel cells)
- **Present in epidermal-dermal junction**
- Shaped like a spiky hemisphere, intimately associated with a disc like sensory nerve ending
- Functions as a **sensory receptor for touch**

### Layers of Epidermis

- Variation in these layers determine **skin thickness**
- In thick skin, epidermis has 5 layers/strata

**From deep to superficial: stratum basale, stratum spinosum, stratum granulosum, stratum lucidum, and stratum corneum**

- In thin skin, **stratum lucidum** (thin skin covers most of body) is mostly absent and other layers are thinner.
- IF including dermis, thickest skin is on upper back.

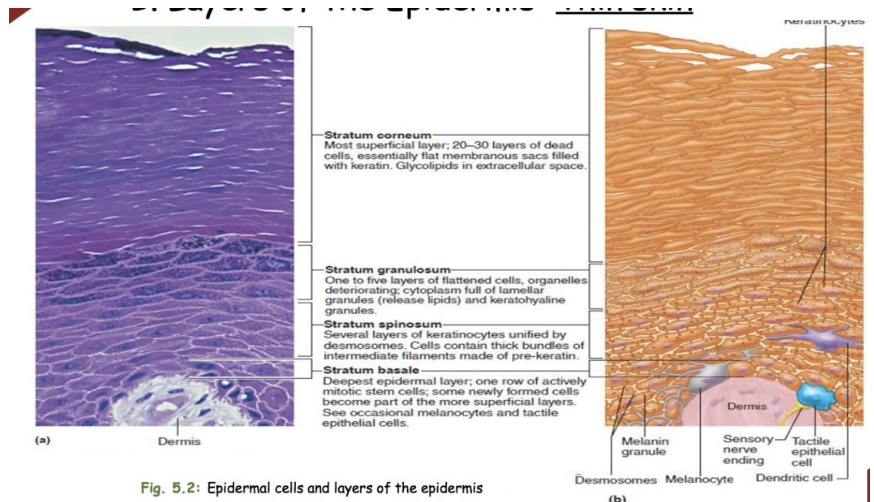


Fig. 5.2: Epidermal cells and layers of the epidermis

### Stratum Basale

getbodysmart.com/skeletal-system-quizzes

- Deepest epidermal layer, AKA stratum germinativum
- Attached to underlying dermis along a wavy borderline
- Consists of a **single row of stem cells** (continually renewing cell population) representing youngest keratinocytes
- Many mitotic nuclei seen in this region reflects this
- Each time one basal cell divides, one daughter cell is pushed into cell layer just above to begin specialization into keratinocyte
- Other daughter cell remains in basal cell to continue producing new keratinocytes
- 10-25% of cells in the stratum basale are melanocytes, their branching processes extend, reaching into more superficial stratum spinosum layer.

### **Stratum Spinosum (Prickly Layer)**

- Several cell layers thick, has spinelike extensions of keratinocytes
- These spines don't exist in living cells, they are made during tissue preparation as the cells shrink while holding tight at their desmosomes
- Cells contain thick bundles of intermediate filaments, which consist of protein pre-keratin
- There are some dendritic cells, which are most abundant in this epidermal layer.

### **Stratum Granulosum (Granule layer)**

- Thin, 1-5 layers in which keratinocyte appearances change drastically, process of keratinization begins
- The cells flatten, nuclei and organelles disintegrate, they accumulate 2 types of granules: keratohyaline granules help to form keratin in upper layers, lamellar granules contain water-resistant glycolipid that's secreted into extracellular space, play a part in slowing water loss across the epidermis.
- Proteins in keratinocytes and lipids deposited outside them make the cells tough and water-resistant
- Epidermis relies on capillaries in the underlying connective tissue (dermis) for nutrients
- Above stratum granulosum, epidermal cells are too far from dermal capillaries to survive. Their glycolipids cut them off from nutrients, and they die.

### **Stratum Lucidum**

- Found only in thick skin, seen through a microscope as a thin translucent band just above stratum granulosum
- Contains a few rows of flat, dead keratinocytes
- Electron microscopy shows that its cells are identical to those of bottom of next layer; stratum corneum

### **Stratum Corneum**

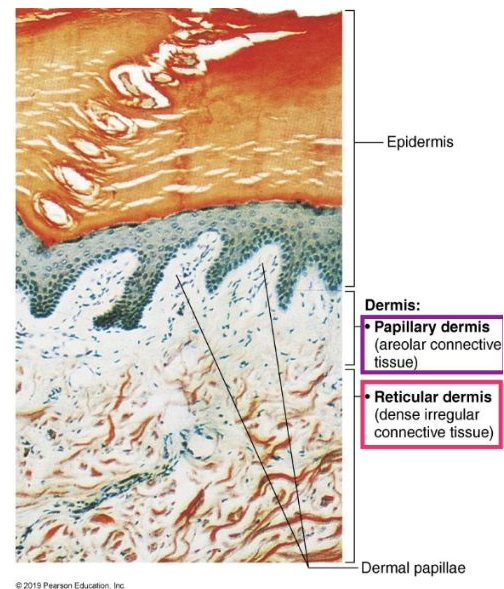
- Abrupt transition occurs between nucleated cells of the stratum granulosum and flattened, anucleate cells of stratum corneum
- 20-30 cell layers thick,  $\frac{3}{4}$  of epidermal thickness
- Consists of pre-keratin intermediate filaments embedded in a “glue” from keratohyaline granules
- Keratin and proteins that accumulate just inside plasma membrane protect skin against abrasion and penetration. Cells are shed regularly. Average person sheds 18 kg in a lifetime.

### **Dermis**

- Connective tissue
- Cells: fibroblasts, macrophages, occasional mast cells and WBC's
- Its semifluid matrix, embedded with fibers, binds entire body together
- Has two layers: papillary and reticular dermis.

### **Papillary Dermis**

- Areolar connective tissue, fine interlacing collagen and elastic fibers form a loosely woven mat containing small blood vessels
- Looseness allows phagocytes and defensive cells to wander freely
- Dermal papillae indent overlying dermis. Many dermal papillae contain capillary loops, other house free nerve endings (pain receptors) and touch receptors called tactile corpuscles or meissner's corpuscles (different, not two names for the same thing)
- In thick skin (palms of hands and soles of feet), these papillae lie atop layers of larger mounds, dermal ridges, which in turn cause overlying epidermis to form epidermal ridges. These skin ridges (friction ridges) may enhance gripping, contribute to sense of touch by enhancing vibrations detected by larger lamellar corpuscles in dermis. Genetically determined, unique to each person
- Sweat pores open along crests, making fingerprints.



### **Reticular Dermis**

- Accounts for 80% of thickness
- Consists of dense irregular connective tissue, which have thick bundles of collagen fibers parallel to skin surface
  - The collagen fibers provide strength, resiliency, and maintain skin hydration
  - Elastic fibers provide stretch and recoil

getbodysmart.com/skeletal-system-quizzes

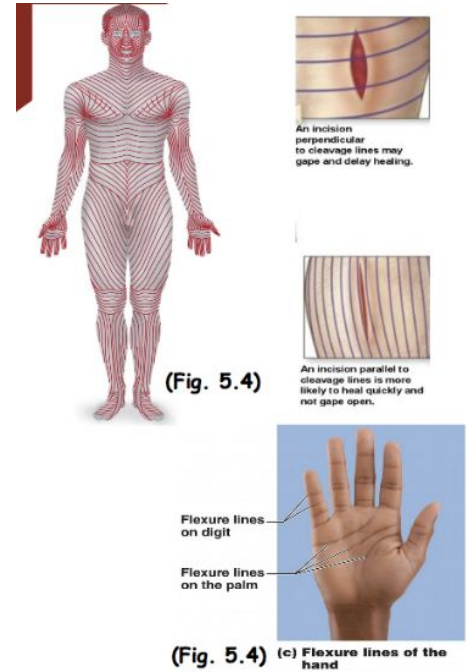
- Lines of cleavage/tension lines/Langerhans lines:

according to the collagen fibers, any surgical cut made along these lines leave minimal scarring.

- Flexure lines: dermal fold at or near joints, hands, wrists, fingers, soles, toes. Dermis closely attached to the underlying structures. The skin's inability to slide easily for joint movement causes deep creases.

- Striae/Stretch marks: result from dermal tears from extreme stretching of the skin, leaving marks that look like silvery white scars.

- Blisters: acute, short-time trauma to skin (burn or repeated friction) can cause blisters that separate epidermal and dermal layers.



### Hypodermis (Superficial Fascia, Subcutaneous Tissue)

- Deep to the skin, not part of the skin, consists of areolar connective tissue and blood vessels and adipose tissue
- It is a shock absorber, stores fat, and anchors skin to underlying structures with the ability to slide.

### Skin Colour

3 pigments contribute:

1) Melanin:

- only pigment made in the skin, derived from tyrosine (an amino acid). Packaged in melanosomes and sent to shield DNA of keratinocytes from UV sunlight
- Two forms of it: reddish-yellow to brownish-black
- Skin colour depends on type, relative amount, and keratinocyte retention of pigment
- Freckles and pigmented moles are local accumulations of melanin.

2) Carotene:

- yellow to orange pigment found in plants (ex. carrots). Accumulates in the stratum corneum and the hypodermis, most obvious in palms and soles.

a) Eating too many carrots: carotenemia

3) Hemoglobin:

- gives skin a pinkish hue, visible in capillary circulation.

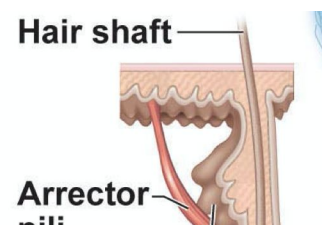
- Alterations in skin colour can indicate disease such as cyanosis, pallor, erythema, jaundice, and more)

- Cyanosis: The skin appears blue due to lack of oxygen or no oxygen in the circulation.

Pallor:

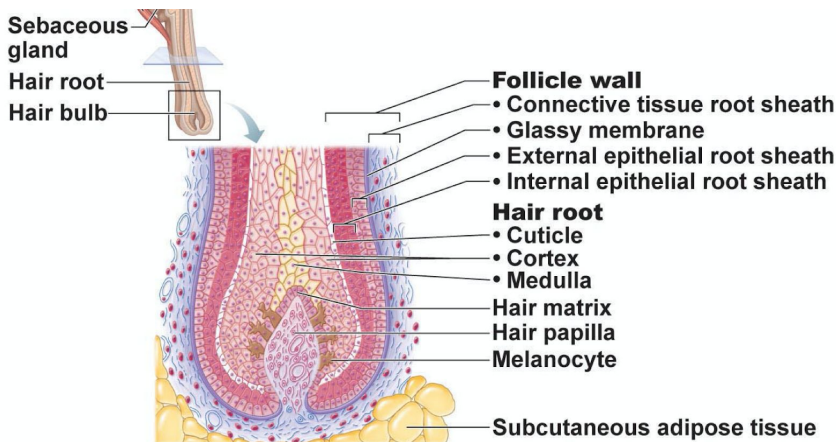
Jaundice: Can be a liver disease

### Appendages of the Skin



### Hair:

- dead-keratinized cells, does not flake, durable. Absent on palms, soles, lips.
- Functions: Alert of insects on skin, protection from heat loss, hair on head guards against physical trauma and sunlight, and hair shields eyes and filters inhaled air particles.
- Hair shaft is the part that projects from the skin, and has 3 layers indicated later
- The root is the part embedded in the skin, contained within the hair follicle
- The bulb is the expanded deep end of the follicle, has a papilla and root hair plexus
- The follicle is the outer connective tissue sheath and inner epithelial root sheath
- Arrector pili muscle is a smooth muscle/follicle which contracts to pull hair up and dimple skin
- The sebaceous gland is a holocrine gland that secretes sebum (oily-lubrication and waterproofing; bactericidal)



(c) Diagram of a longitudinal view of the expanded hair bulb of the follicle, which encloses the matrix

### Follicle Wall:

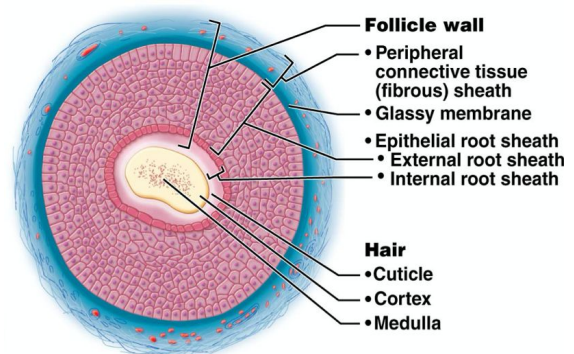
Connective tissue sheath, glassy membrane, external epithelial root sheath, and internal epithelial root sheath.

### Hair Root:

Cuticle, cortex, medulla

### Hair Shaft:

3 parts. The medulla has large cells separated by air spaces, absent in fine hair. The cortex has several layers of flattened keratinocytes; the pigment of the hair is in this place. Cuticle is a



getbodysmart.com/skeletal-system-quizzes

single overlapping of cells. The shape of the hair follicle determines if hair is straight or curly.

### **Split Ends:**

When the cuticle no longer maintains its protective function. Loss of cuticle renders hair strands more susceptible to subsequent damage and breakage, results in the appearance of split ends.

### **Gray/White Hair**

Gray/white hair results when melanin production decreases and air bubbles replace melanin in the shaft.

### **Hair Thinning and Baldness**

Vellus hair: pale, fine body hair of children and adult females.

Terminal hair: coarse, long hair (scalp, eyebrows, axillary and pubic regions, face and neck of males)

Hair growth is affected by hormones and nutrition, and the average growth is ~2mm per week.

The growth cycles: active growth phase, regressive/resting phase; each hair follicle has only a certain number of growth cycles before it is done.

### **Male Pattern Baldness**

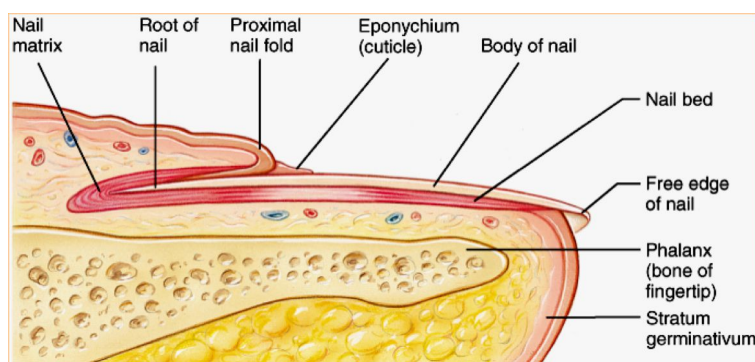
Genetically-determined, sex-influenced, altered response of hair follicle to androgen that shorten growth cycles

### **Alopecia**

Baldness, often patchy, can be autoimmune

### **Hirsutism**

Excess of hair, possibly due to polycystic ovarian tumours, causes of excess of a hormone to be produced.



### **Nails**

Scale-like modification of epidermis. Free edge, body, nail folds - 2 lateral and 1 proximal. Made of dead keratinized cells. Consists of 4 specialized epithelia: the proximal nail fold, nail matrix, nail bed, and hyponychium

### **Conditions that Can be Seen in the Nails**

### **Sweat Glands (sudoriferous glands):**

getbodysmart.com/skeletal-system-quizzes

Distributed over skin surface except nipples and parts of external genitalia, up to 3 million per person. Two main types:

**Eccrine (merocrine):** more common; especially palms, soles, forehead. Simple coiled tubular glands with pore at the surface.

**Apocrine:** Axillary and anogenital areas; larger; ducts empty into hair follicles. Same as sweat but has some fatty substances and some proteins. Odourless until decomposed by skin bacteria. The function may be the equivalent of sexual scent glands of other mammals. Activated by the SNS in times of stress. Start functioning around puberty.

**Modified Sweat Glands:** ceruminous glands, secrete wax (cerumen) in the external ear canal. Mammary glands secrete milk.

**Sebaceous (oil) glands:** everywhere except palms and soles. Develop from and secrete into hair follicles. Inactive until puberty, secrete sebum. Functions: oily holocrine secretion, bactericidal properties, lubricates hair and skin, prevents water loss in dry conditions. Acne is blocked or infected sebaceous gland.

### Major Functions of the Skin

- 1) protection : 3 types of barriers
  - a) chemicals : acidic secretions (sweat contains dermcidin and other antibacterial agents) and melanin
  - b) Physical: barrier to trauma and bacterial invasion; waterproofing
  - c) Biological: dendritic cells of the epidermis and macrophages in dermis
  - d) Not impermeable to: gases, fat-soluble vitamins and steroids, plant oleoresins, organic solvents, salts of heavy metals, penetration enhancers for drug administration
- 2) Body temperature:
  - a) Sweating (0.5-12L fluid/day)
  - b) Vasoconstriction
- 3) Cutaneous Sensation: 3 nerve endings for pain, different receptors for temperature and touch
- 4) Metabolic: eg. vitamin D, carcinogens, conversion of topically applied cortisone to hydrocortisone
- 5) Blood reservoir: dermis can hold ~5% of total blood volume
- 6) Excretion: Ammonia, urea, uric acid in sweat

### Burns

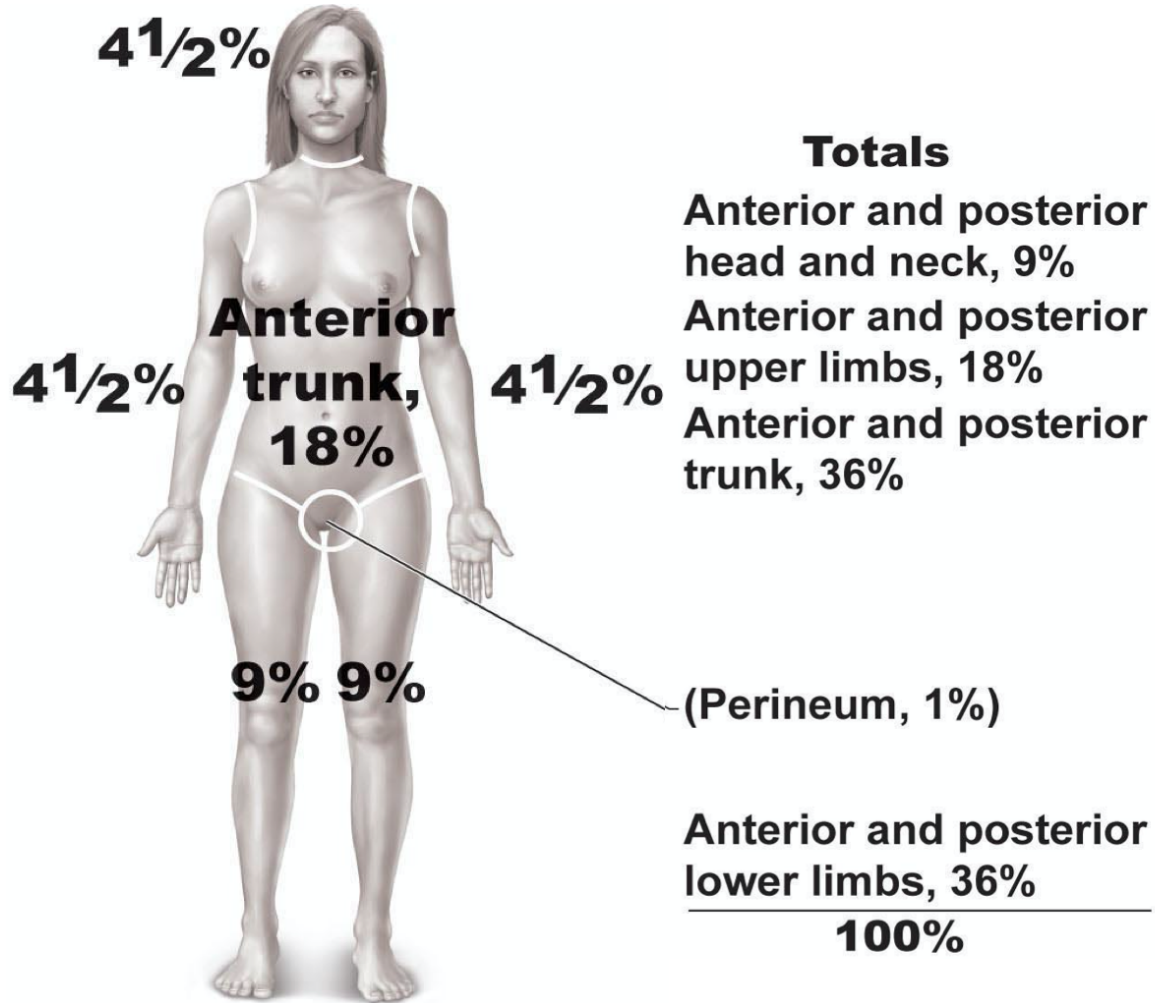
From heat, electricity, radiation, chemicals.

Concerns: dehydration, stopping the spread, correct electrolyte balance, prevent infection.

First degree burn: only epidermis. Redness and edema

Second degree burn: epidermis and upper dermis, blisters occur

Third degree: entire thickness of skin (epidermis and all of dermis). Potential for repair: debriding, skin grafts, antibiotics



### Anatomy of the skeletal system

#### **Facts about Bones**

Babies are born with 270 bones, adult body only has 206 bones

A giraffe's neck has as many vertebrae as a human neck

Smallest bone in the human body is found in ear, called stapes (0.28cm)

#### Cartilage

- Human skeleton is initially made of cartilage and fibrous membranes, of which bone replaces some
- Very tough but flexible

getbodysmart.com/skeletal-system-quizzes

- Avascular, devoid of nerve fibers
- up to 80% H<sub>2</sub>O
- Ground substance contains lots of glycosaminoglycans (GAGs) chondroitin sulfate and hyaluronic acid- also chondronectin (adhesive protein)
  - Chondroitin sulphate and hyaluronic acid- sugars, keep water inside to insure that the cartilage is hydrated
- Collagen fibers (can have some elastic fibers)

#### Terms:

##### Perichondrium

- In damaged areas, perichondrium can form scar tissue because poorly vascularized cartilage repairs badly; ossification of cartilage with aging
- Acts as a reinforcement to resist outward expansion when the cartilage is compresses
- Contains blood vessels that nourish the cartilage cells
- The thickness of the cartilage is limited by the distance nutrients can diffuse through the matrix to reach the cells

##### Chondroblasts

- Immature cartilage cells actively form cartilage
- As they move in further they become mature and become chondrocytes

##### Chondrocytes

- Mature cartilage cells maintain cartilage
- Can be in clusters (in diseases, osteoporosis, mitosis)

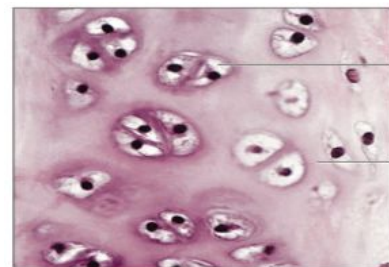
##### Lacunae

- Localized clusters of chondrocytes in cartilage

### 3 types of cartilage

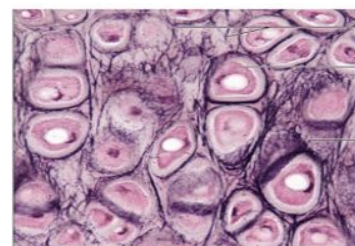
#### Hyaline cartilage

- Most abundant
- location : embryonic skeleton, articular (ends of long bones), epiphyseal plates in growing children, costal cartilages of ribs, cartilages of nose, trachea, larynx
- Firm support + pliability
- lots of collagen
- Appears glassy blue-white
- Chondrocytes- only 1-10% of volume
- function : supports and reinforces; resilient cushioning and resists compressive stress
- Skeletal hyaline cartilages include: **articular** (covers the end of most bones at movable joints), **Costal** (connect ribs to sternum), **Respiratory** (larynx), **nasal**



#### Elastic

- Contains more elastic fibers than hyaline

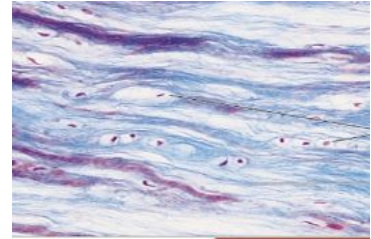


getbodysmart.com/skeletal-system-quizzes

- Withstand repeated bending
- We need movement (epiglottis), ear (some animals move ear to hear certain sounds)
- location : external ear, epiglottis
- Function: maintains shape while giving lots of flexibility

### Fibrocartilage

- Parallel rows of chondrocytes alternating with rows of thick collagen fibers
- Structural intermediate between hyaline cartilage and dense regular CT
- Function: tensile strength, shock absorbing
- Location: intervertebral discs, pubic symphysis, menisci of knee joints (where hyaline cartilage meets a ligament or a tendon)



### GROWTH OF CARTILAGE

- Has a flexible matrix to accommodate mitosis
- Cartilage grows in 2 ways
  - **Appositional growth:**
    - The cartilage forming cells in the surrounding perichondrium secrete new matrix against the external face of the existing cartilage tissue
  - **Interstitial growth:**
    - Lacunae-bound chondrocytes divide and secrete new matrix expanding cartilage

### BONES and SKELETAL TISSUES

bone :

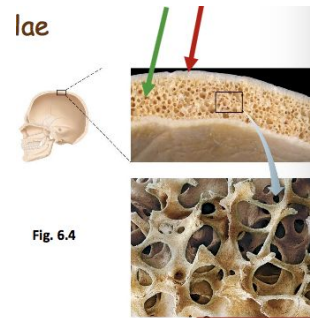
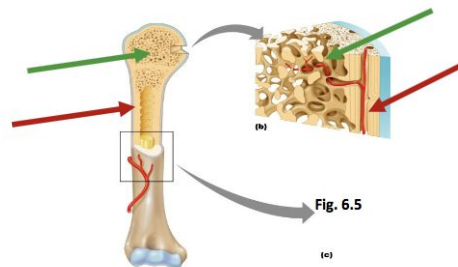
- Calcium salts; adds hardness and strength for support/protection of softer tissues
- Cavities for fat storage and synthesis of blood cells

getbodysmart.com/skeletal-system-quizzes

- Reacts to the amount **of force** applied by increasing both the density and amount of roughening on bone or decreasing density when force is reduced or eliminated (eg. paralysis)
  - deposition vs resorption; Bone is resorbed by osteoclasts, and is deposited by osteoblasts in a process called ossification
- Bone stores **calcium**- absorbed and transferred to bloodstream when needed
- Functions: support, protection, anchorage and movement (attachment of ligaments, short and long bones), mineral storage, blood cell formation, fat storage, hormone production (osteocalcin)
  - Osteocalcin do the same action as the adrenal gland (study done)

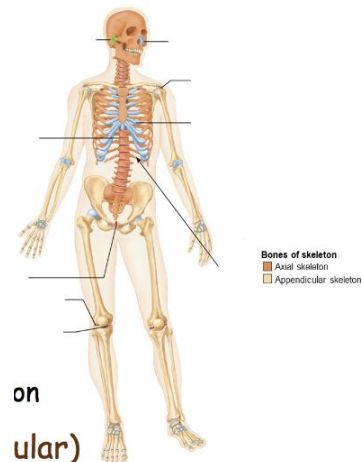
### CLASSIFICATION

- Lots of variation in size and shape
  - Eg, femur; longest bone of the body with a hollow cavity making it very strong
- Structure is the same for all bone shapes
  - **Compact bone:** provides the external surface (superficial layer)
  - **Spongy (trabecular) bone:** a honeycomb of trabeculae



### Based on their LOCATION

- **Axial skeleton**
  - Long axis of body
  - Skull, vertebral column, rib cage
- **Appendicular skeleton**
  - Bone of upper and lower limbs
  - Girdles attaching limbs to axial skeleton
- \*\* based on shape (long short, flat irregular) NOT size



### BONE SHAPES (4)

Long bones:

- Much longer than wide
- Found in the limbs (femur, humerus)

getbodysmart.com/skeletal-system-quizzes

- 2 ends and a shaft
- Mostly compact bone with marrow cavity; spongy bone near joint ends

Short bones:

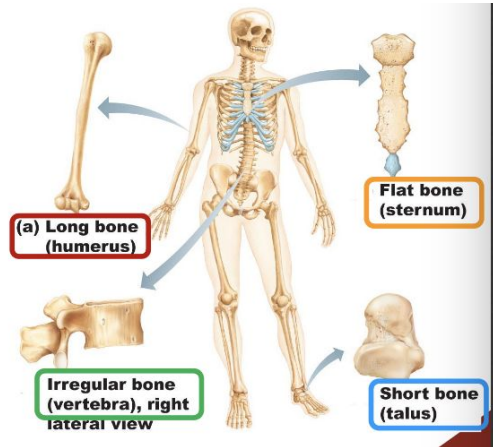
- Roughly cube shaped
- E.g wrist, ankle
- Primarily spongy bone + thin layer of compact bone

Flat bone:

- Thin, flattened and sometimes curved
- Include skull bones, ribs and sternum

Irregular bones:

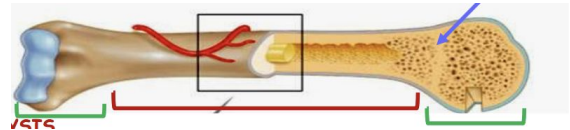
- Leftovers (vertebra and hip bones)
- Complicated shapes: primarily spongy bone + thin covering layer of compact bone



## STRUCTURE OF LONG BONES

### 1. **Diaphysis** (shaft)

- Tubular **shaft** of a long bone - long axis of the bone
- Collar of compact bone surrounding marrow cavities (medullary cavity)
- In adults, medullary cavity contains fat (yellow marrow)



### 2. **Epiphyses** (ends)

- Rounded **extremities** of a long bone; for articulation with other bones
- Compact bone forms thin outer layer; interior filled with spongy bone

### 3. **Epiphyseal line** (between)

- Between diaphysis and each epiphysis; remnant of **epiphyseal plate**

### 4. **Membranes**

- Cover outer layer (**periosteum**) and inner (**endosteum**) surfaces of long bones
- Both contain osteoblasts

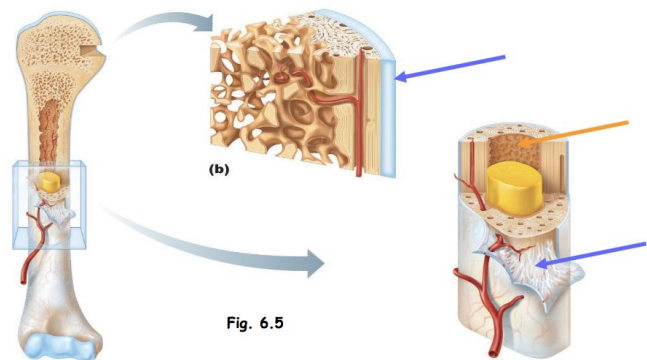


Fig. 6.5

## **Calcified tissue:**

- **Compact bone:** dense, outer layer
- **Spongy (trabecular) bone:**
  - Trabeculae (red or yellow bone marrow found in spongy bone)

### Linings

- **periosteum** : outer fibrous layer + inner osteogenic layer
- **Endosteum**: covers trabeculae of spongy bone and lines canals of compact bone

### **Red bone marrow:**

In newborns:

- Medullary cavities, all spongy bone

In adults:

- axial skeleton, epiphysis & metaphysis of long bones, diploe of flat bones (spongy bone), some irregular bones

Why does the marrow become more yellow: because of fat cell storage

Metabolism decreases so you don't need the red bone marrow you need yellow to store fat

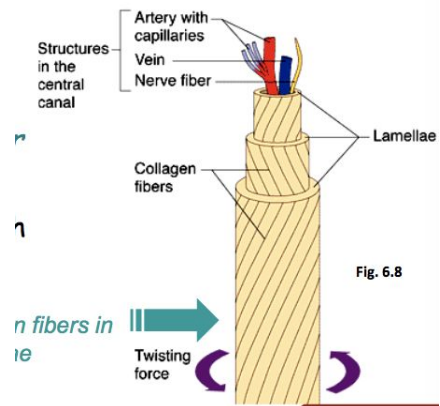
### STRUCTURE OF OTHER BONE TYPES

- All 3 other types have similar structure
- Compact bone outside; spongy bone inside
- Compact covered with **periosteum** and spongy lined with **endosteum** not cylindrical so no shaft, marrow cavity or epiphyses- but do contain **bone marrow** between trabeculae

### MICROSCOPIC STRUCTURE OF COMPACT BONE

#### **Osteon system**

- Structural unit of compact bone
- **Osteon**: an elongated cylinder oriented parallel to the long axis of bone
  - cylinder/tube that contains collagen fibers
  - A single osteon is a group of hollow tubes of **bone matrix**
  - Each matrix is called lamellar bone
- How its arrangement gives it more structural strength (lamella is perpendicular)



Central (Haversian) canal:

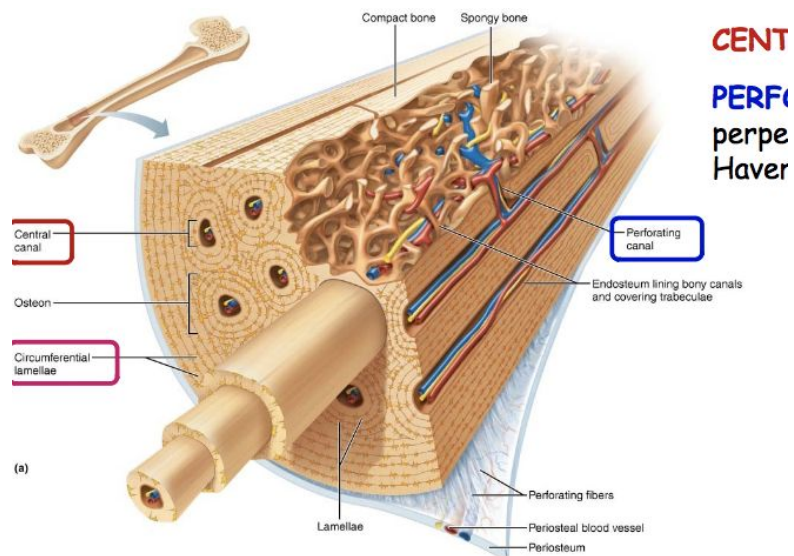
- **Perforating canal**: Perpendicular to long axis of bone (and to Haversian canals).....'

#### **Osteocytes:**

- mature bone cells
- Sit within small cavities (lacunae) within bony matrix in areas where adjacent lamellae meet

#### **Canaliculi:**

- small canals that connect the lacunae with each other

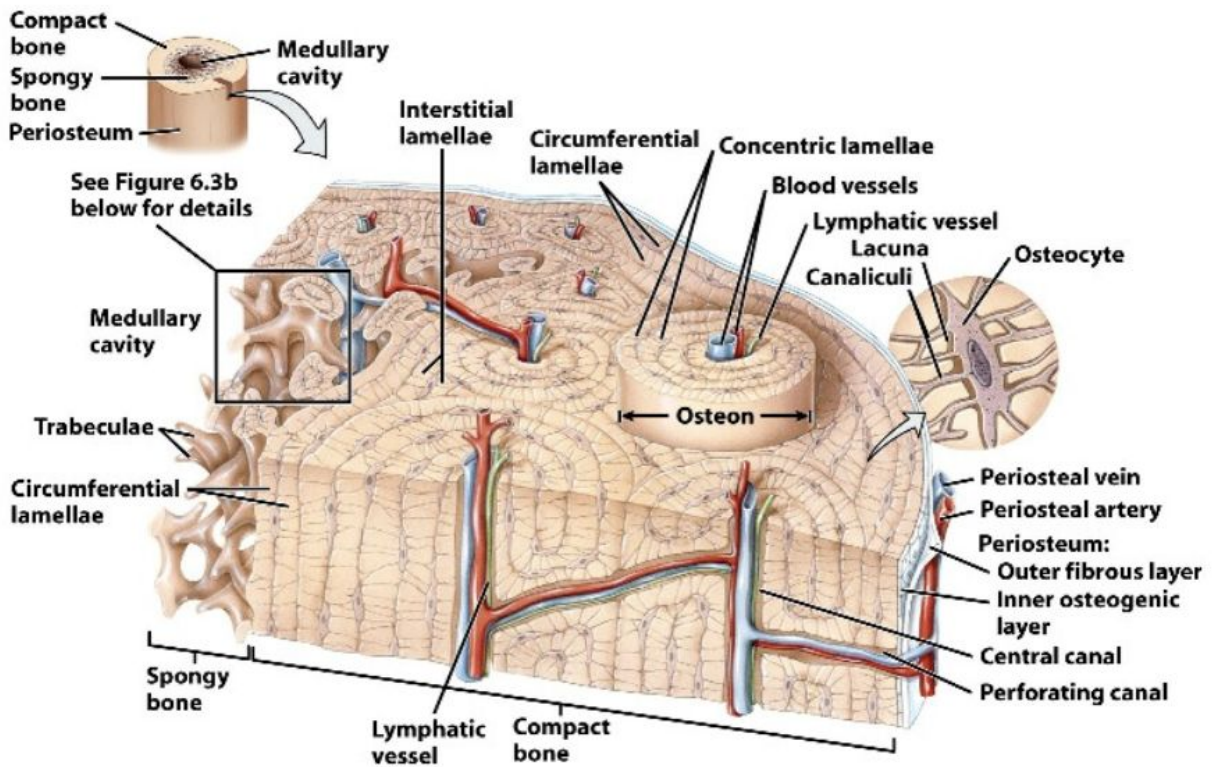
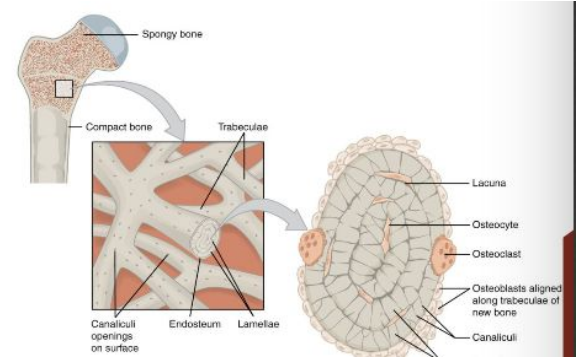


**CENT**  
**PERF**  
**perpe**  
**Haver**

- Also connected to central canal of haversian system
- **Interstitial lamellae:**
  - Fill the gaps between forming osteons or are leftovers of osteons that were partially destroyed by bone remodeling
- **Circumferential lamellae:**
  - Sheets of bone located just deep to periosteum extend around the entire circumference of shaft

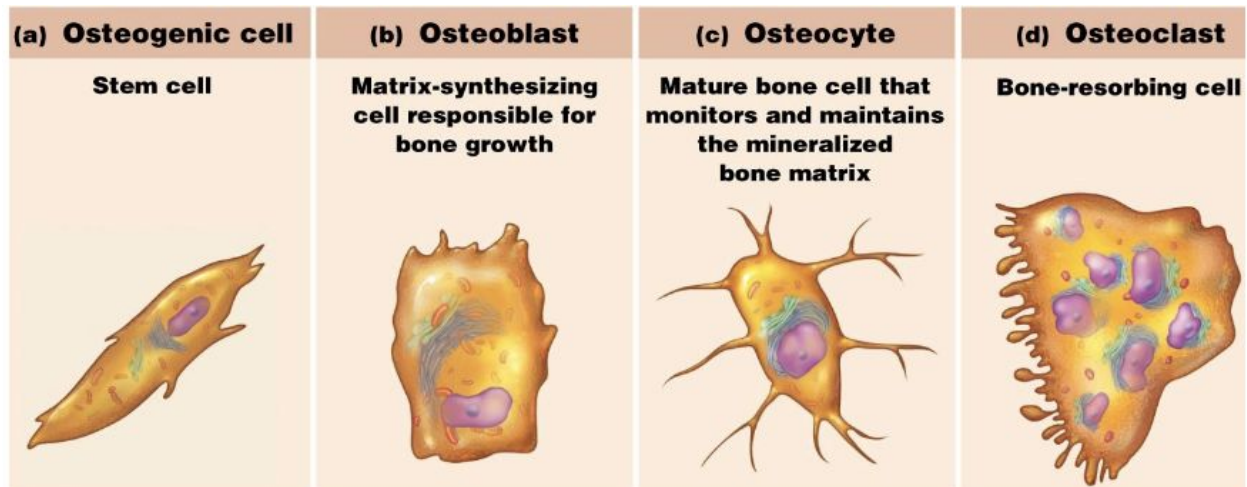
### MICROSCOPIC STRUCTURE OF SPONGY BONE

- Contains trabeculae, lamellar;y arranged osteocytes and canaliculi
- Trabeculae arranged along the lines of stress; helps bone to resist stress
- Trabeculae only a few cell layers thick; contain irregularly arranged lamellae and osteocytes interconnected by canaliculi
- There are no osteons
- Nutrients diffuse through canaliculi from the marrow spaces between the trabeculae to reach the osteocytes



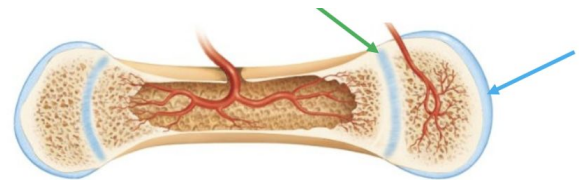
**Osteons (haversian systems) in compact bone and trabeculae in spongy bone**

## BONE CELLS



## BONE FORMATION AND REMODELING

1. Intramembranous ossification
  - a. Bone develops from fibrous CT membrane containing mesenchymal cells
  - b. Cranial bones of the skull and the clavicles - these are flat bones
  - c. Begins at about 8 weeks of embryonic development



2. Endochondral ossification
  - a. Bone development via the replacement of hyaline cartilage model
  - b. All bones below the skull (except the clavicles)
  - c. Begins in second month of development
  - d. It's more complex because there are more steps to forming a bone than intramembranous ossification

\*\* in short bones, only the primary ossification center is formed; most irregular bones are formed using several distinct ossification centers

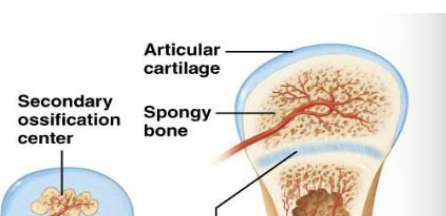
When secondary ossification is complete, hyaline cartilage remains:

1. On the epiphyseal surfaces as the articular cartilages
2. At the junctions of diaphysis and epiphysis where it forms the epiphyseal plates, this is the area where long bones continue to grow

Fig. 6.10 - Endochondral ossification in a long bone

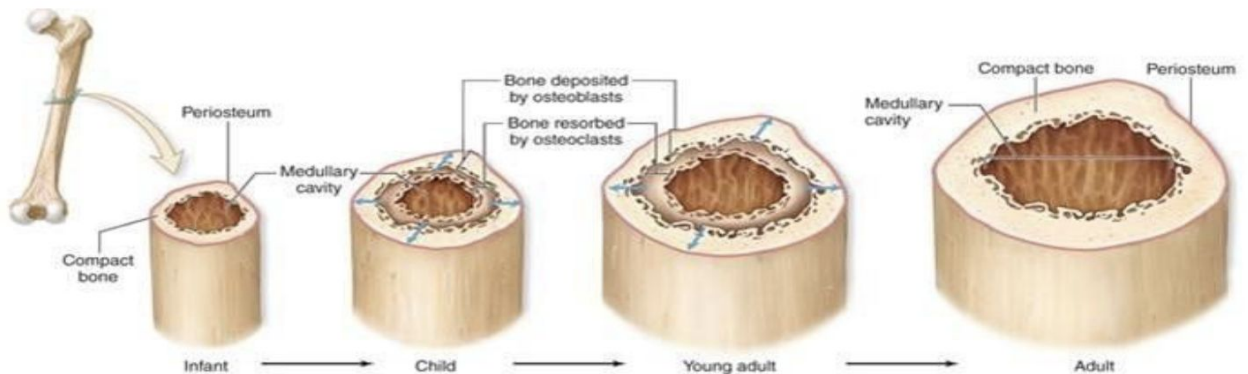
Area of

Epiphyseal blood vessel

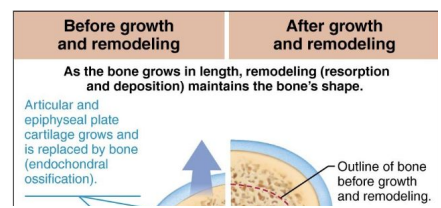


### MECHANISMS OF BONE GROWTH

- During infancy and youth, long bones lengthen entirely by interstitial growth of the epiphyseal plates and all bones grow in thickness by appositional growth
- Most bones stop growing during adolescence or in early adulthood
- some facial bones (eg nose and lower jaw) continue to grow throughout life
- Growth in length of a long bone at the epiphyseal plate (interstitial growth) Microscopic view of a knee bone



### BONE REMODELLING



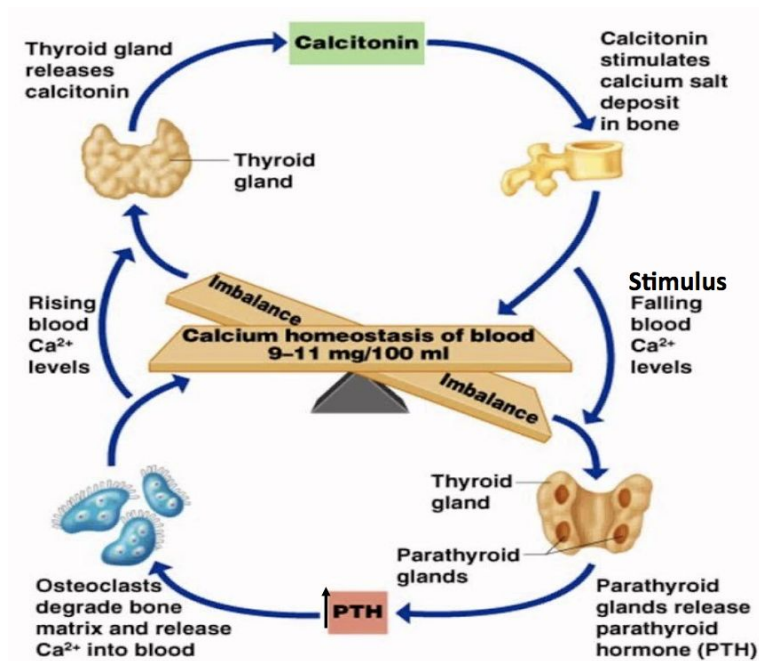
getbodysmart.com/skeletal-system-quizzes

- As the long bone lengthens, the ends must be reshaped (remodeling)
- Remember that the ends are wider than the shaft
- As length increases, external surface of ends made similar while internal surface is thickened
- In summary, bone is destroyed by osteoclasts and laid down by osteoblasts on both the inner and outer surfaces of a growing long bone
- Epiphyseal plate stays approx same size throughout childhood and adolescence
- Epiphyseal plate then becomes thinner (cartilage cells in zone 1 multiply more and more slowly)
- Longitudinal growth ends when bone of the epiphysis and diaphysis fuses = epiphyseal plate closure (about 18 in females; age 21 in males)

GROWTH IN WIDTH (appositional growth)

- layers of bone are laid down on top of one another
  1. Osteoblast on periosteal side secrete bone matrix (bone deposit)
  2. Osteoclasts on the endosteal side remove bone matrix (bone reabsorption)
- These 2 processes should occur at the same rate

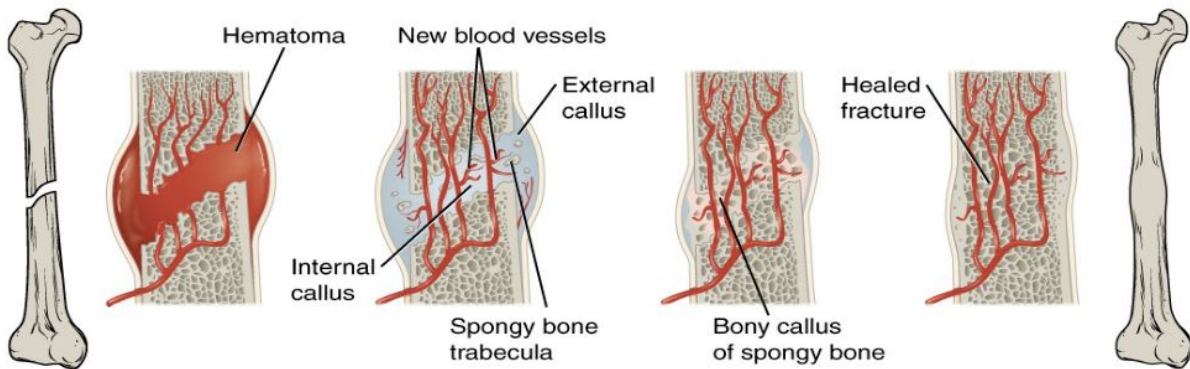
Thyroid and parathyroid gland hormones regulate blood calcium levels



KEY EVENTS IN BONE FRACTURE REPAIR

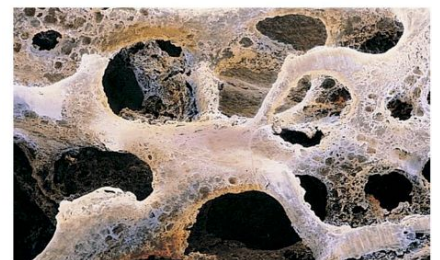
- Formation of **hematoma**; local bone cells are deprived of oxygen and die; inflammation causes pain

- Formation of **fibrocartilaginous callus** (soft); invaded by blood vessels that also bring macrophages to clean up the area; osteoclasts also reabsorb damaged bone; fibroblasts, chondroblasts, osteoblasts get busy laying collagen fibers and tissue components to span the break
- Conversion to **bony callus**; cartilage converted to trabecular bone; complete in 2 month
- **Bone remodeling**; any extra bony material is removed; bone of shaft walls converted to compact bone and bone regain original shape; can take a few years



### Osteoporosis

- Bone resorption outpaces bone formation; bones become porous
  - Some areas of skeleton especially vulnerable: spine, neck of femur
  - Age factor; estrogen and testosterone promote bone health by restraining osteoclast activity and promoting deposition of new bone
  - Other contributing factors include: insufficient exercise, diet poor in calcium and protein, abnormal vit D receptors, smoking
  - Some treatments include anti-reabsorption medicine or physical activity
    - Physical activity can help increase **mineral content** and reduce bone loss by stimulating **osteoblast activity**
    - However, it is believed that stopping physical activity accelerates the process of bone loss



### THE SKELETON

- Composed of bones, cartilages, joints, ligaments

- 206 bones in the adult body (make up about 20% of body weight)
- Grouped into axial and appendicular skeletons
  - Axial (80 bones): bone of the skull, vertebral column and thoracic cage
  - Appendicular = bones of upper and lower limbs + pectoral/pelvic girdles (attach limbs to axial skeleton)

Table 6.2 Bone Markings		
NAME OF BONE MARKING	DESCRIPTION	ILLUSTRATIONS
<b>Projections That Are Sites of Muscle and Ligament Attachment</b>		
Tuberosity (too'bē-ros'ī-te)	Large rounded projection; may be roughened	
Crest	Narrow ridge of bone; usually prominent	
Trochanter (tro-kan'ter)	Very large, blunt, irregularly shaped process (the only examples are on the femur)	
Line	Narrow ridge of bone; less prominent than a crest	
Tubercle (too'ber-kl)	Small rounded projection or process	
Epicondyle (ep'ī-kon'dīl)	Raised area on or above a condyle	
Spine	Sharp, slender, often pointed projection	
Process	Any bony prominence	

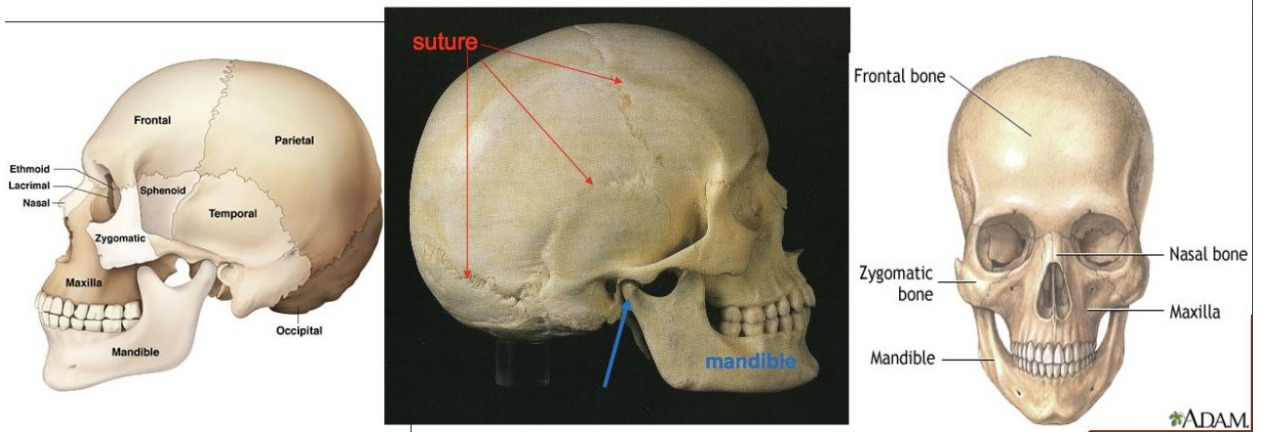
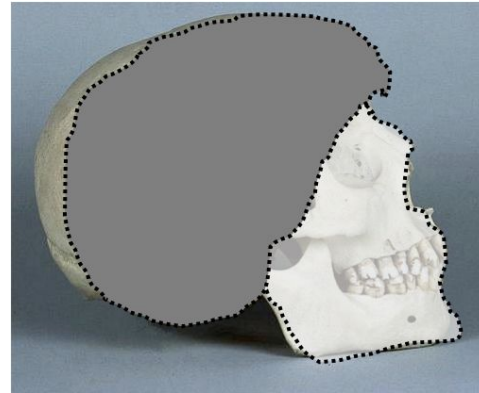
Throughout this section, refer to table 6.2: Bone Markings - you are responsible for being able to describe all of these bone markings



Table 6.2 Bone Markings		
NAME OF BONE MARKING	DESCRIPTION	ILLUSTRATIONS
<b>Surfaces That Help to Form Joints</b>		
Head	Bony expansion carried on a narrow neck	
Facet	Smooth, nearly flat articular (joint) surface	
Condyle (kon'dīl)	Rounded articular projection; often articulates with a corresponding fossa	
<b>Depressions and Openings</b>		
<b>For Passage of Blood Vessels and Nerves</b>		
Groove	Furrow	
Fissure	Narrow, slitlike opening	
Foramen (fo-ra'men)	Round or oval opening through a bone	
Notch	Indentation at the edge of a structure	
<b>Others</b>		
Meatus (me-a'tus)	Canal-like passageway	
Sinus	Cavity within a bone, filled with air and lined with mucous membrane	
Fossa (fos'ah)	Shallow, basinlike depression in a bone, often serving as an articular surface	

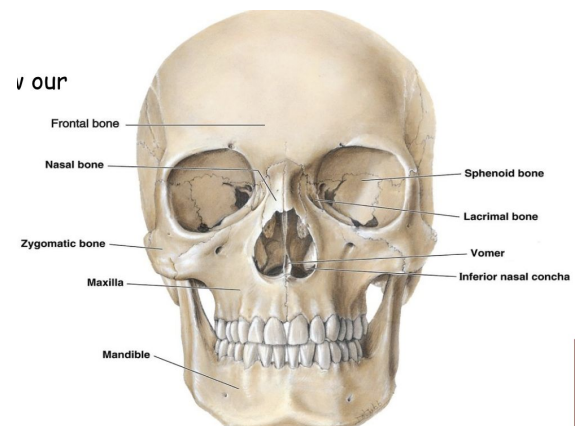
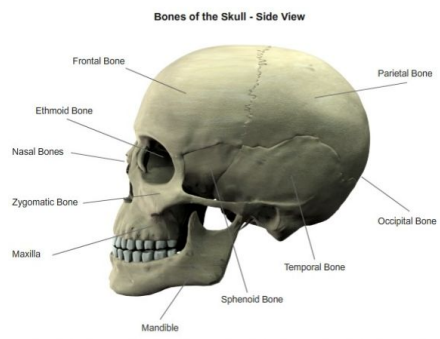
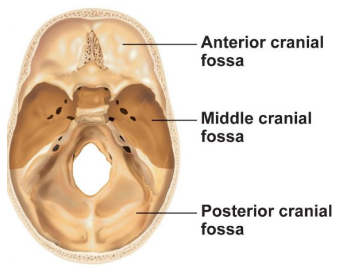
## SKULL

- 2 sets of bones: facial + cranial= 22 bones
- Facial bones from anterior part of skull and cranial bones from the rest
- The cranium encloses and protects the brain and organs of hearing and balance
- The facial bones hold the eyes in place and serve as attachment for the facial muscles
- The skull has 85 openings for nerves, blood vessels and spinal cord
- Most skull bones are flat bones and united by structures (immovable joints); except mandible



## CRANIUM

- Can be divided into a vault and a base
- vault : forms superior, lateral and posterior aspects of the skull and forehead
- Base: inferior aspect of skull
- Cranium surrounds and protects the brain and organs of hearing and balance
- Internally, 3 bony ridges divide the cranial base into 3 distinct areas: anterior (highest) fossa, middle fossa and posterior (lowest) fossa



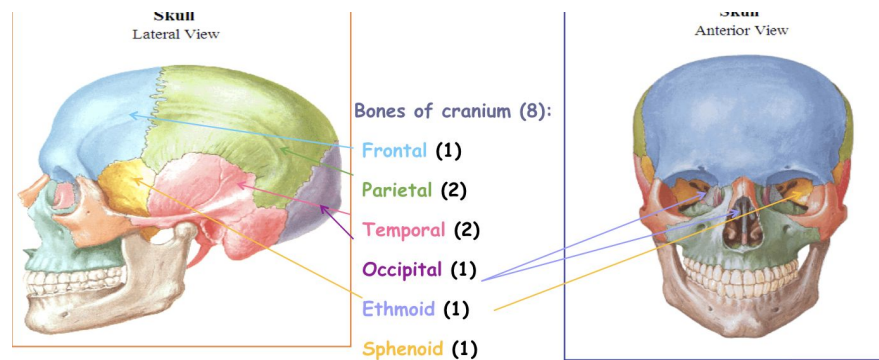
getbodysmart.com/skeletal-system-quizzes

## FACIAL BONES (face)

- Framework of the face
- Contain the cavities for the sensory organs of sight, smell and taste
- Provide openings for passage of air and food
- Secure the teeth
- Anchor the facial muscles that we use to show our feelings

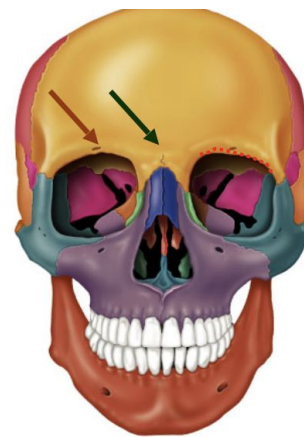
## CRANIUM

- 8 cranial bones are the paired parietal and temporal bones and the unpaired frontal, occipital, sphenoid and ethmoid bones
- Curvature allows them to be self-bracing; can be strong while being thin



## FRONTAL BONE

- Dome shaped bone; forms the roof of the orbit and anterior cranial fossa
- Articulates with paired parietal bones posteriorly
- Note **supraorbital margin**, **supraorbital foramen** and **glabella**
- Area lateral to glabella has left and right frontal sinus within bone

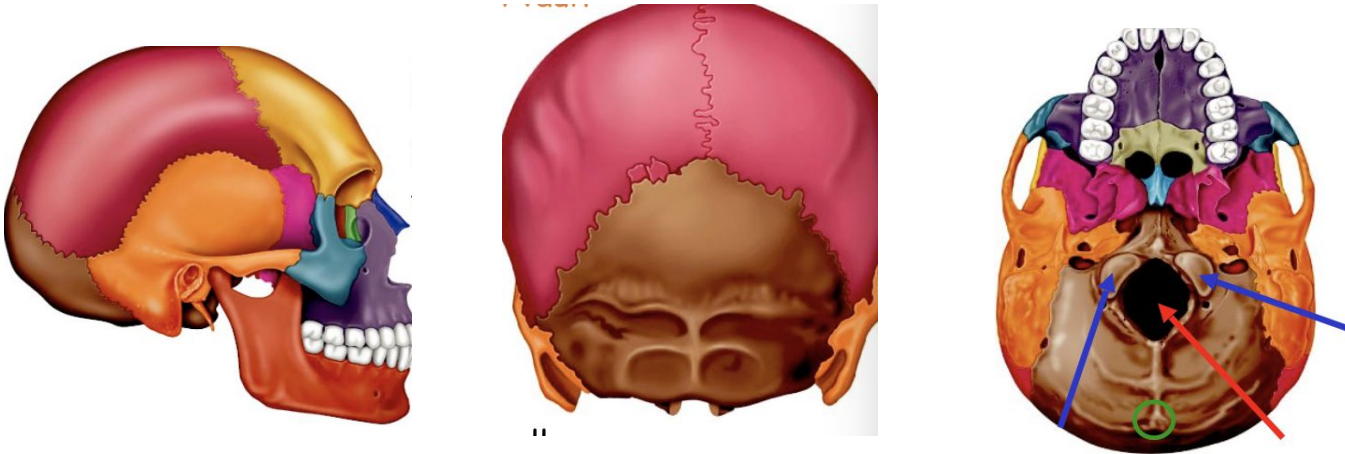


## Parietal bones

- Paired; from superior and lateral aspects of skull therefore form bulk of **cranial vault**

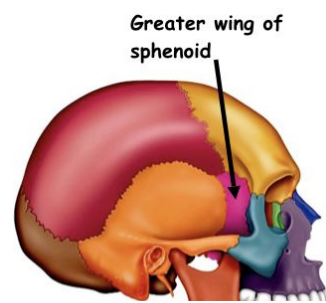
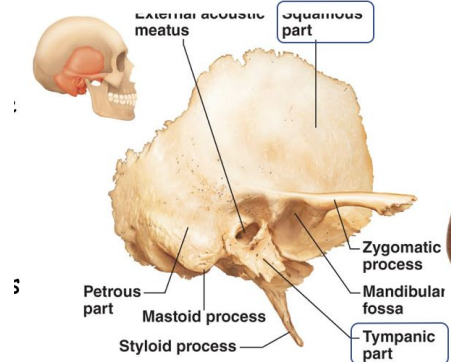
### Occipital bone

- Single bone at the base of skull; helps from post aspect of skull
- Attaches anteriorly to the 2 parietals and 2 temporals and attaches to sphenoid
- Also form walls of the past cranial fossa
- Large hole at the base - **foramen magnum**
- **Occipital condyles** on each side of foramen magnum = site or articulation with first cervical vertebra
- **External occipital protuberance** = projection at back of skull - more prominent in males



### Temporal bones

- Pared; form inferior and lateral aspects of skulls and parts of the cranial floor
- Located just below the 2 parietal bones; have 3 very different areas or regions
  1. **Squamous part**: flattened from **zygomatic process** to articulate with cheekbones (zygomatic bone) **Mandibular fossa** receives condyle of mandible
  2. **Tympanic part**: surrounds external acoustic meatus
  3. Petrous part is on the internal aspect of the temporal bone
    - a. Contributes to cranial base; houses middle and inner ear cavities
- 4. Mastoid process is attachment site for some neck muscles
- 5. Styloid process is attachment area of muscles of the tongue and some neck muscles
  - a. Several important foramina associated with this part of the temporal bone; jugular foramen, carotid canal, internal acoustic



## SPHENOID BONE

- Complex bone: difficult to visualize; articulates with all other cranial bones
  - forms the base of middle cranial fossa; contributes to base of anterior cranial fossa

### Central body

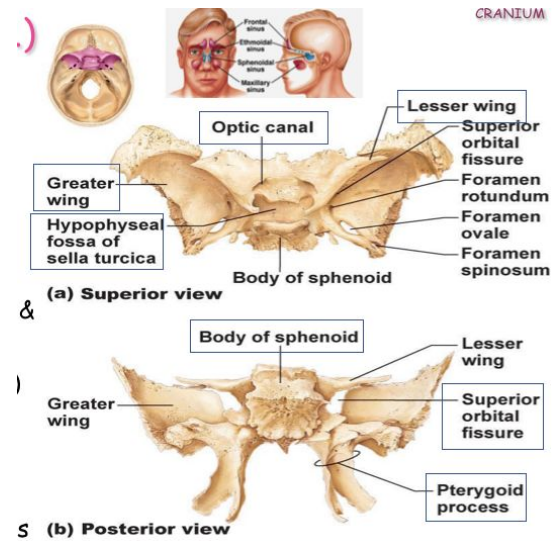
- Contains sphenoid sinuses
- Includes sella turcica (hypophyseal fossa) for pituitary gland

### 3 projections

Greater and lesser wings (orbits, MCF and ACF)

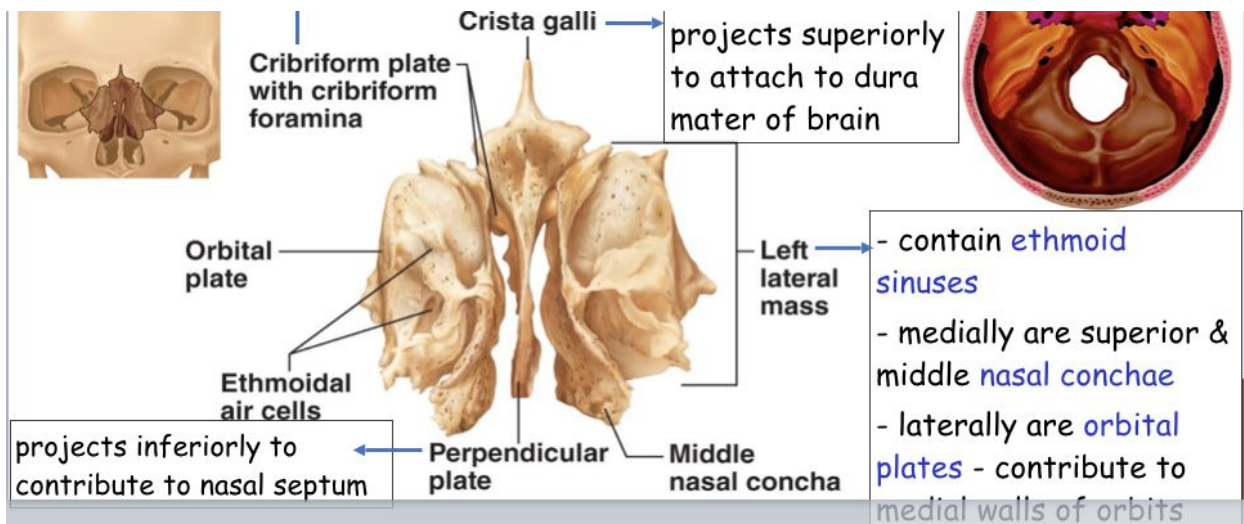
Pterygoid processes (muscles more movement of the jaw)

- Optic foramina (canals): for optic nerves
- Superior orbital fissure between greater and lesser wings (cranial nerves for eye movement)



## ETHMOID BONE

- Approximates a cube that lies deep between orbits and nasal cavities
- Forms the roof of the nasal cavity and floor of anterior cranial fossa; tiny holes (olfactory foramina) transmit olfactory nerves

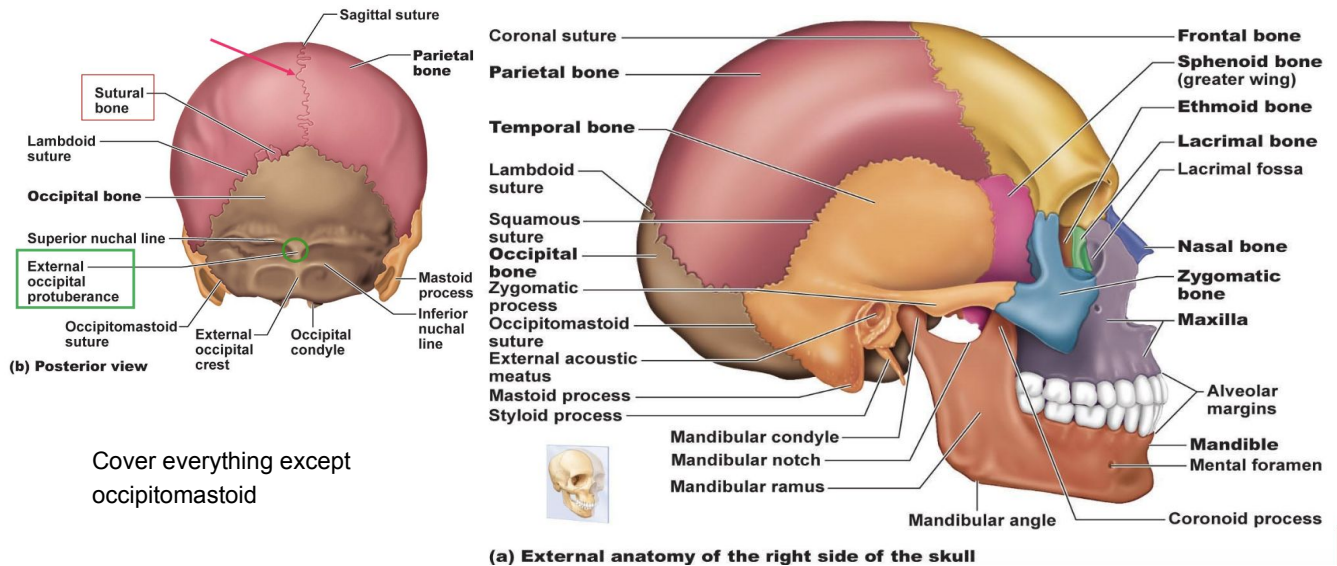


## Major cranial sutures

- Bones of the adult skull are firmly united by sutures
- 4 main sutures that connect the cranial bones
  1. **Coronal suture:** frontal bone and 2 parietal bones
  2. **Squamous suture:** parietal bone and temporal bone
  3. **Lambdoid structure:** occipital bone and 2 parietal bones
  4. **Sagittal suture:** 2 parietal bones

**Sutural bones:**

- tiny irregular bones; can occur within cranial suture
- Additional ossification centers that appeared rapidly during fetal development



Cover everything except occipitomastoid

**FACIAL BONES**

14 bones of which mandible and vomer and unpaired

Paired bones are: maxillae, zygomatic, nasal, lacrimal, palatine and inferior conchae

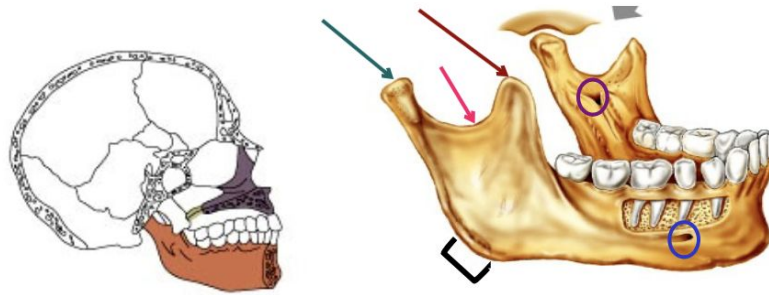
Bone of the face:

- Zygomatic
- Maxilla
- Nasal
- Lacrimal
- Vomer
- Palatine (not apparent)
- Inferior nasal conchae
- Mandible



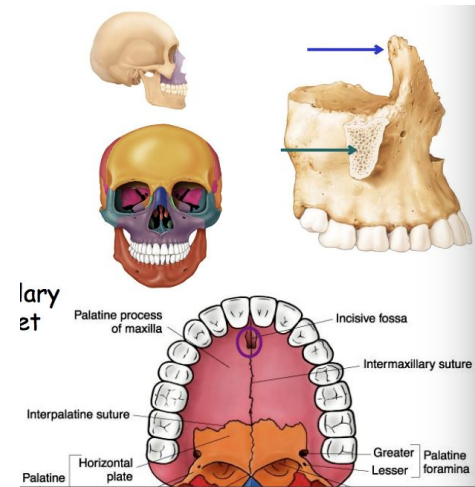
## Mandible

- Lower jaw bone; strongest bone of the face
- Formed of; body (chain) os horizontal part; and 2 rami (right and left) join body at mandibular angle
- note : **mandibular notch**, **coronoid process** (insertion of temporalis muscle), **mandibular condyle**, **alveolar margin** (contains tooth sockets), mandibular foramina (nerves to teeth in the lower jaw) and **mental foramina** (blood vessels and nerves to chain and lower lip)



## Maxillary bones

- Fused medially
- Alveolar margins hold teeth of upper jaw
- Palatine processes project posteriorly forming anterior  $\frac{2}{3}$  of hard palate
  - Note: **incisive fossa** (passage of blood vessels and nerves), **frontal process** and **zygomatic processes**
- Main portion of bone on each side has maxillary sinus; these are the sinuses that often get infected



## Zygomatic bones (cheekbones)

- Articulate with zygomatic process of maxilla, frontal and temporal bones
- Contribute to inferolateral margins of orbit

## Nasal Bones

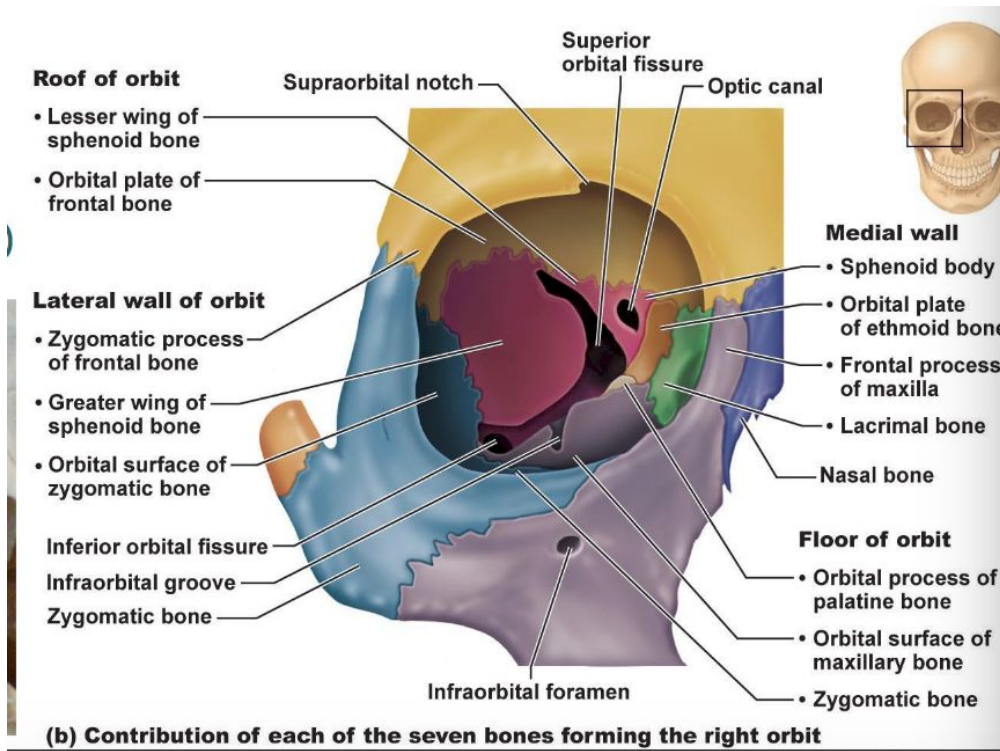
- 2 tiny, rectangular bones that fuse medially to form bridge of nose
- Articulate with frontal bones superiorly and maxillary bones laterally

## Lacrimal bones

- 2 fingernail-shaped bones in anterior, medial portion of orbit
- Articulate with: frontal bone, ethmoid bone, maxillae
- Each has a depression (lacrimal fossa) for lacrimal sac

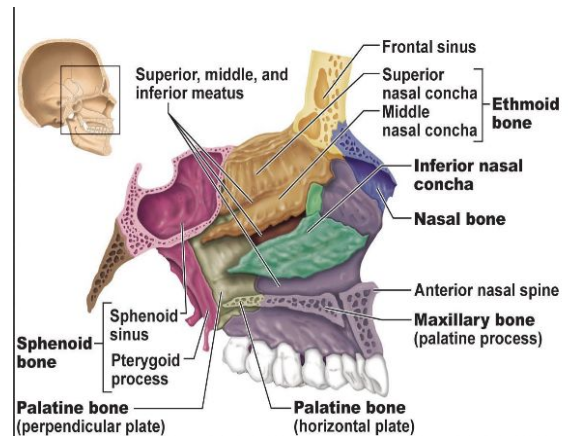
## Orbits

- The bone surrounding the eye (socket)



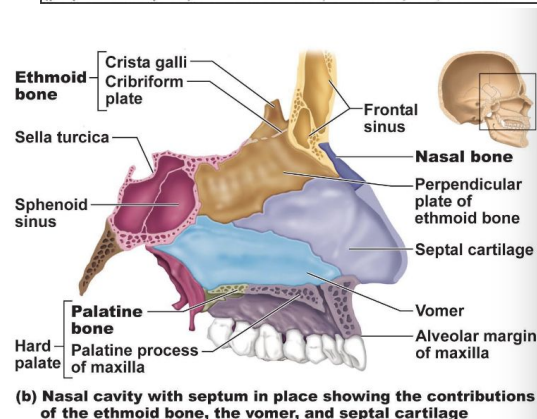
### Palatine bones

- 2 I-shaped bones
- Horizontal plates form part of the hard palate
- Vertical plates- nasal cavity and orbit



### Vomer

- Single thin bone forms nasal septum



### Inferior nasal conchae

getbodysmart.com/skeletal-system-quizzes

- Thin, curved bones- project medially
- Largest of 3 pairs of conchae
- \*\*the superior and middle nasal conchae are part of the ethmoid bone

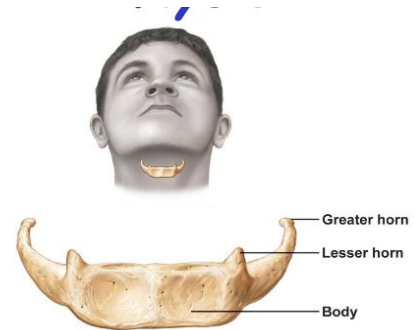
### Paranasal sinuses

- mucosa -lines, air-filled cavities lighten skull and enhance resonance of voice
- Connect to nasal cavity so also help warm air and humidify incoming air
- 4 sinuses: frontal, maxillary, sphenoid, ethmoid



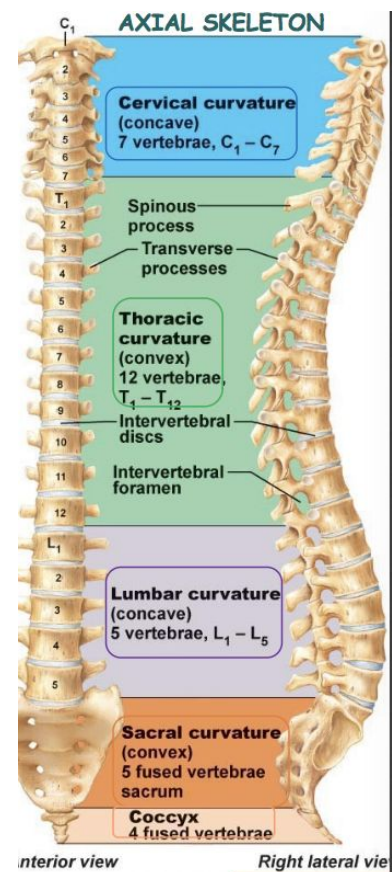
### Hyoid

- Only bone of the body that does not articulate with any other bones
- Supports tongue and gives attachment to muscles for swallowing and speech
- Horseshoe-shaped with a body + 2 pairs of horns



### VERTEBRAL COLUMN

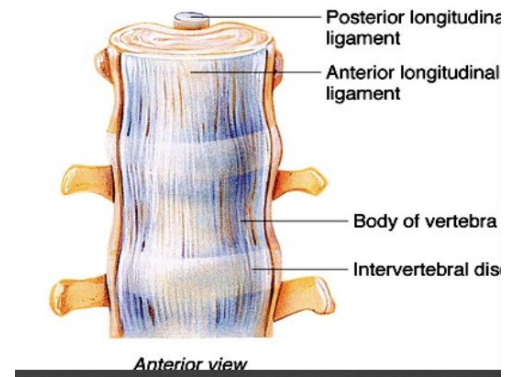
- Extends from the skull to pelvis - 70cm long
- Formed 33 vertebrae of which 24 remain separate, connected and reinforced by ligaments (flexibility) and the remaining 9 fuses to form 2 composite bones (sacrum and coccyx)
- 33 vs 26 (24 vertebra that are separate and the rest are fused into 2)
- Not a straight line- curvy, developed by time
- 3 main functions
  - 1. Weight bearing
  - 2. Anchor for muscles and ligaments
  - 3. Protection of spinal cord
- Normal curvatures
  - Resilience and flexibility
  - 2yr: cervical and lumbar: concave
  - 1yr: thoracic and sacral: convex



## SUPPORTING ELEMENTS OF VERTEBRAL COLUMN

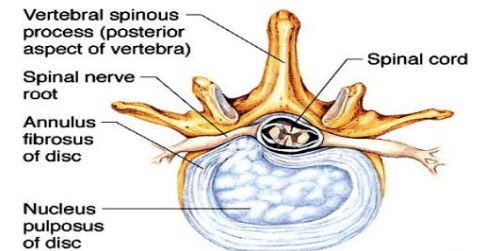
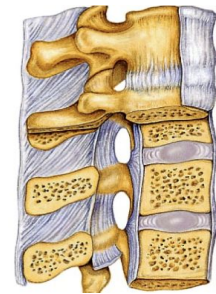
### 1. Ligaments

- Strap-like; support column of bones to stay upright
- Major supporting ligaments are anterior and posterior longitudinal
- Continuous bands down front and back of the vertebral bodies from neck to sacrum
- Broad anterior is strongly attached to bony vertebrae and the discs; prevents hyperextension of spine
- Posterior is narrow, weaker and attached only to discs; prevents hyperflexion of spine



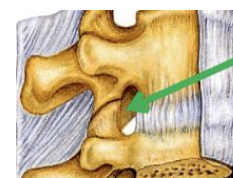
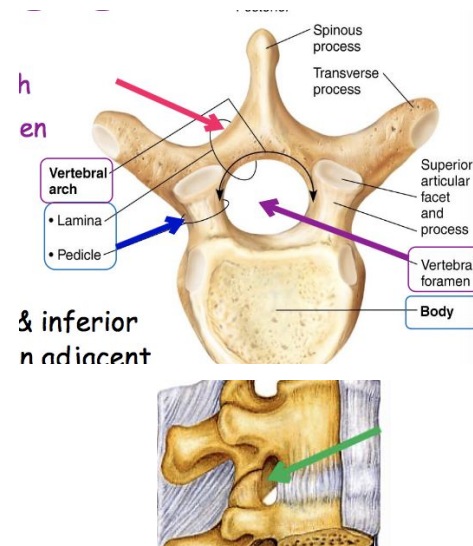
### 2. Intervertebral discs

- Cushioning between bony vertebral bodies - shock absorbers - 25% length of vertebral column
- Each is circular with nucleus pulposus in center and annulus fibrosus around periphery
- Nucleus pulposus is inner gelatinous like a rubber ball >>>> elasticity and compressibility
- Annulus fibrosus outer collar, holds together successive vertebrae and resists tension in spine, limits expansion of nucleus pulposus when compresses
- Sits tight in lumbar/cervical regions >>> flexibility
- A herniated disc when the annulus fibrosus is torn and the nucleus pulposus touches the spinal cord and causes extreme pain



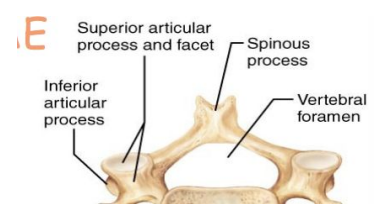
### A TYPICAL VERTEBRA

- gets larger as one descends column
- Weight-bearing **body + vertebral arch**
- Arch + body enclose vertebral foramen
- 2 **pedicles** + 2 **laminae** make up each vertebral arch
- Pedicles have notches on superior and inferior surfaces >>> lateral openings between adjacent vertebrae called the **intervertebral foramina** (nerves pass through)



### 7 processes from each vertebral arch

- **1 spinous process**; muscles attachment



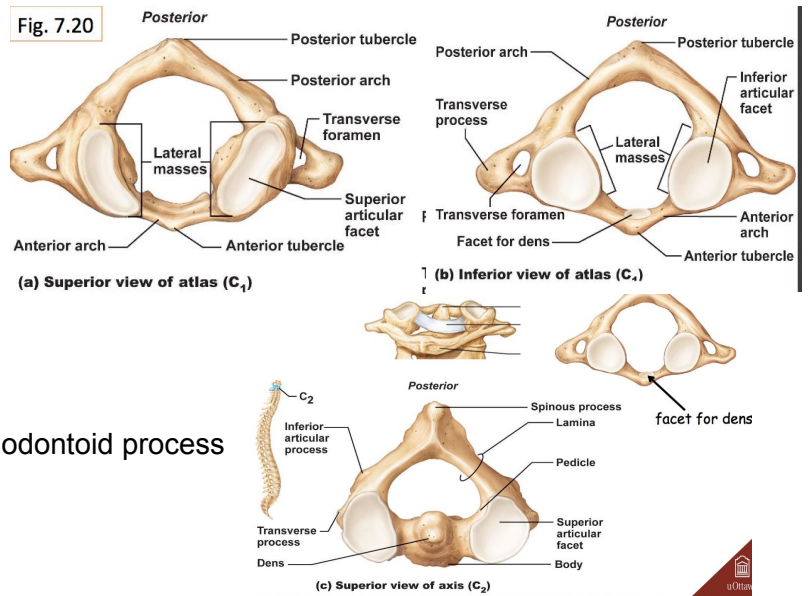
- 2 transverse processes; 1 per side for muscle attachment
- Paired superior and inferior articular processes; link vertebrae above and below; smooth, collagen-coated facets for articulation

### CERVICAL VERTEBRAE (7 total)

- 1 and 2 have unusual structure and no intervertebral discs
  - 3-7 considered typical
1. Body oval, broader side-to-side than front-to-back
  2. Spinous process short and split at end except 3 & sticks out/not split
  3. Vertebral foramen large
  4. Each transverse process contains transverse foramen for passage of vertebral artery to brain

### ATLAS

- No body and no spinous process
- Posterior and anterior neural arches
- Lateral and anterior neural arches
- Lateral masses with superior and inferior articular facets- articulate with occipital bone and with C2

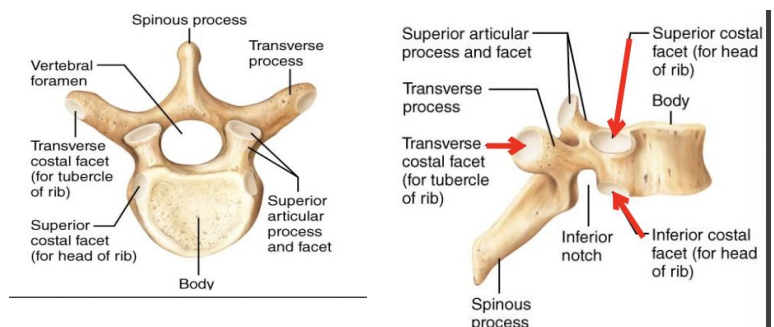


### AXIS

- More like others except for dens or odontoid process = pivot

### THORACIC VERTEBRAE

- 12 in all
- All have ribs attached
- Increased in size from first to last

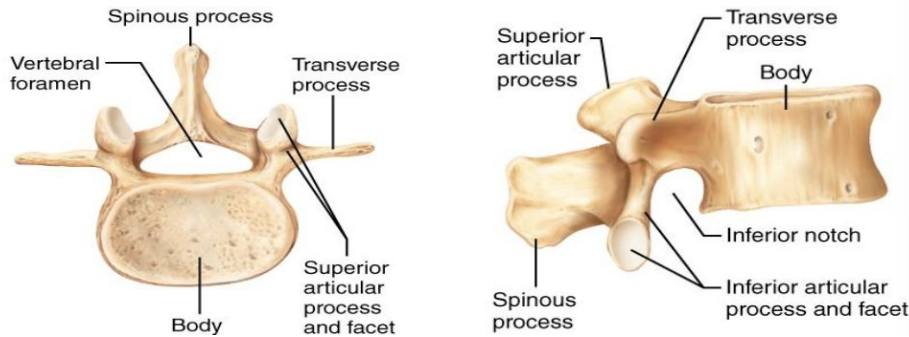


getbodysmart.com/skeletal-system-quizzes

1. Body roughly heart-shaped and bears facets for ribs (paired demi-facets)
2. Vertebral foramen in circular
3. Spinous process long, points decrease
4. Transverse processes have facets for articulation with tubercles of ribs (except numbers 11 and 12)

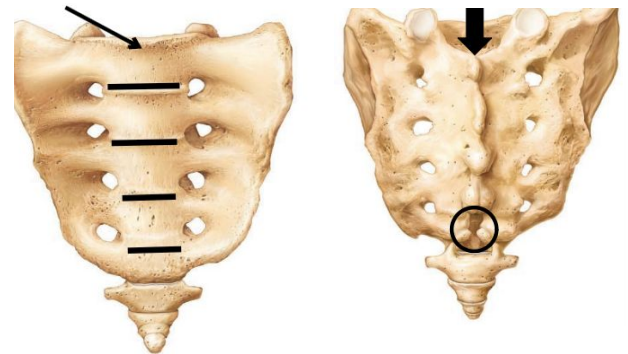
### LUMBAR VERTEBRAE

- Lower back >> major weight-bearing function
- Bodies are kidney-shaped and increase in size from top to bottom
  1. Pedicles and laminae shorter and thicker than those of other vertebrae
  2. Spinous process are flat and short- project directly back
  3. Vertebral foramen is triangular
  4. Orientation of inferior and superior facets unique - curved: sup faces in and inf faces out



### SACRAL VERTEBRAE

- Starts as 5 separate vertebrae >> fuse in adolescents = sacrum
- Articulates with 5th lumbar and laterally with hip bones (sacroiliac joint)
- Note: sacral promontory, transverse lines and sacral foramina
- Note: median sacral crest, sacral canal, sacral hiatus



### Coccygeal vertebrae

- tailbone= 3 or 4 fused coccygeal vertebrae
- Attachment are for some pelvic ligaments, but otherwise quite useless

### BONY THORAX

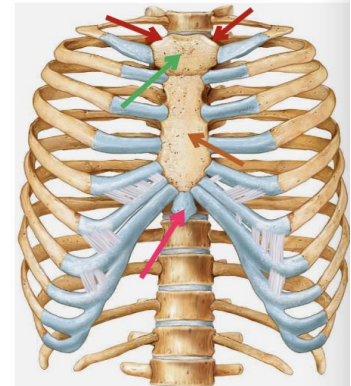
- Thoracic vertebrae + ribs + costal cartilage + sternum

getbodysmart.com/skeletal-system-quizzes

- Protective cage around heart, lungs and major blood vessels
- Supports shoulder girdle and upper limbs
- Provides area of muscle attachment for back, chest and shoulder

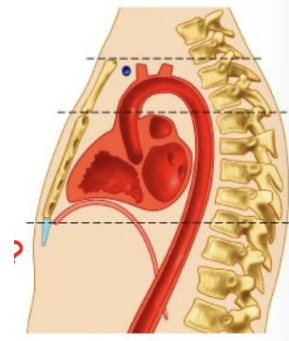
### STERNUM

- Anterior midline of thorax
- Fusion of 3 bones: **manubrium**, **body**, **xiphoid process**
- Manubrium articulates with clavicles via **clavicular notches**; also with 1st pr of ribs
- Body has notches for articulation with 2nd to 7th ribs
- Attachment of some abdominal muscles to xiphoid process



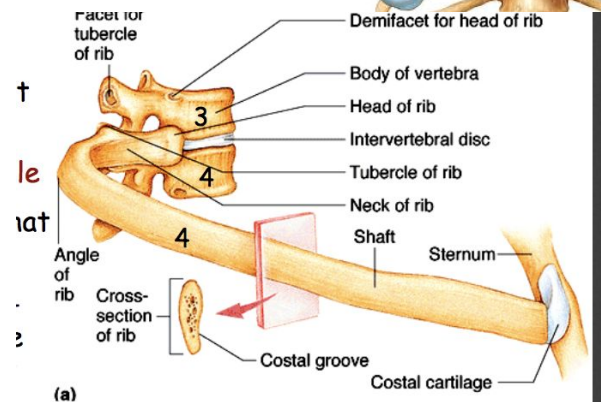
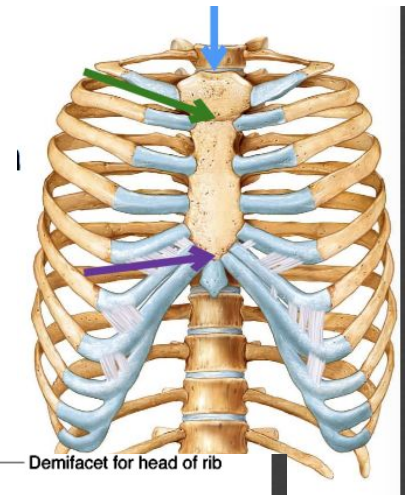
### 3 IMPORTANT ANATOMICAL LANDMARKS

1. **Jugular notch**: indentation you can palpate; in line with disc between T2 and T3; level of common carotid artery from aorta
2. **Sternal angle**: cartilaginous hinge joint between manubrium and body of sternum; level of exit of the aorta from the heart
  - a. Denotes the second rib
3. **Xiphisternal joint**: fusion of sternal body and xiphoid process - opposite T9

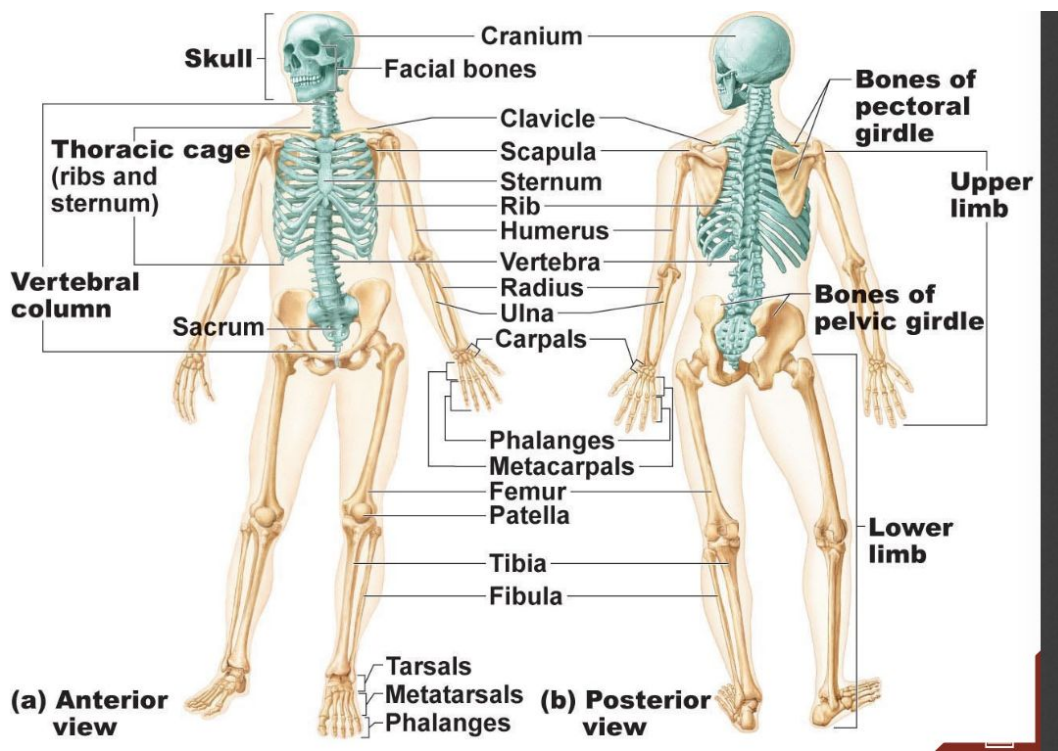


### RIBS

- 12/side; all attach at back to vertebral column
- Curve inferiorly and anteriorly
- 1st 7 are **true ribs** attach to the sternum directly; remaining 5 are **false ribs** (not attached to the sternum)
  - >>> ribs 8-10 attach to sternum indirectly via costal cartilages and rib 7 (rib above)
  - >>> ribs 11 and 12 are not attached anteriorly = floating ribs
- Typical rib is bowed, flat bone
- shaft, head, neck, tubercle
- Main portion is shaft; has an angle
- Between a ridge on the internal surface of the rib and the inferior border is a groove, the **costal groove**, for the intercostal vessels and nerves from trauma
- Note head with 2 facets - one articulates with the demi-facet on the body of the same-numbered thoracic vertebra, other with that on the body of superior vertebra



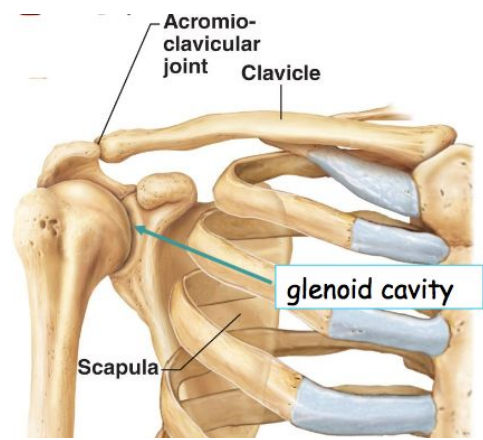
- Tubercle articulates with transverse process of same-numbered thoracic vertebra



## APPENDICULAR SKELETON

### PECTORAL GIRDLE

- 2 pairs of bones: clavicles and scapulae-almost a complete circle around upper trunk to make shoulders:
  - Anteriorly:
  - Laterally:
  - Posteriorly:



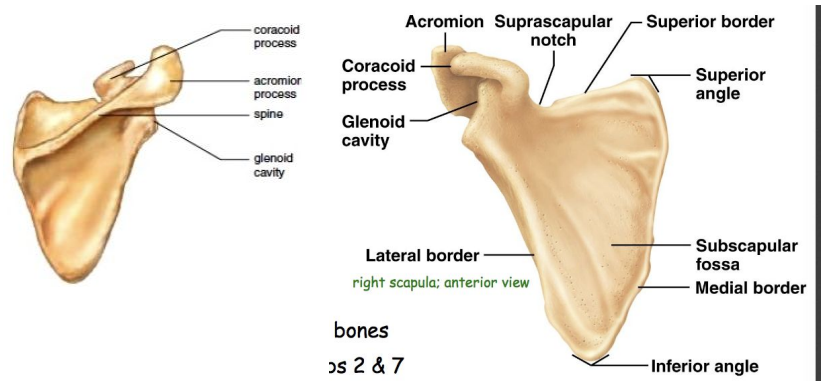
- Bones are light and very movable- attachment points of muscles to move upper limbs
  1. Scapulae only attached laterally
  2. Socket of shoulder joint (glenoid cavity) is shallow and poorly reinforced: supported by muscles (rotator cuff)

Clavicle (long bone)

- S-shaped to allow for a range of movement
- Insertion points for muscles, also brace to push arms laterally
- Curvature ensures outward fracture away from subclavian artery

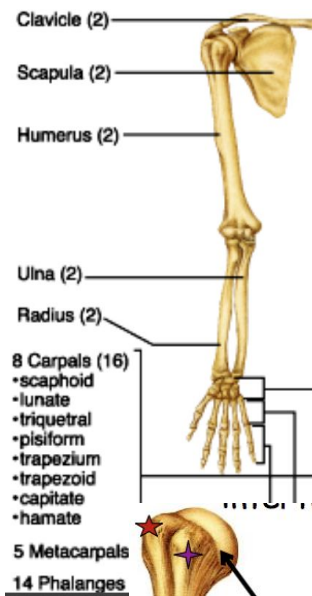
SCAPULAE (shoulder bones)

- Thin, triangular, flat bones
- Dorsally, between ribs 2 and 7
- Note superior, medial and lateral borders
- Note spine, acromion (articulates with acromial end of clavicle), coracoid process (biceps muscles)



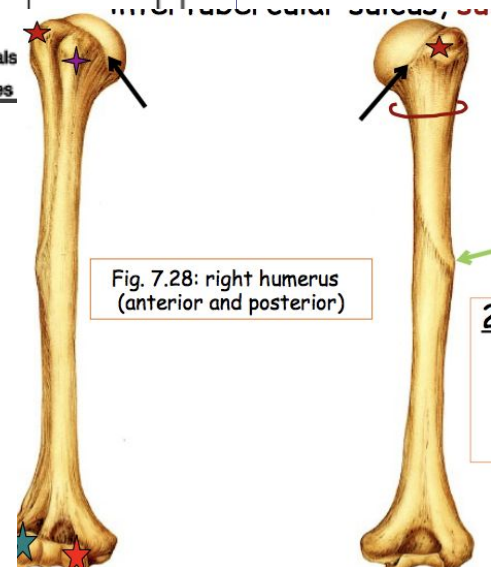
UPPER LIMB

- 30 separate bones: arm, forearm, hand



HUMERUS:

- Longest bone of upper limb/only bone of the "arm"
- Articulates with **scapula** and **radius + ulna**
- NOTE: head (inserts into glenoid cavity - .....), anatomical neck, **greater tubercle**, **lesser tubercle** (what attach here?), intertubercular sulcus, **surgical neck** (what happens here?)
- 2 condyles:
  - **Trochlea**: articulates with ulna
  - **Capitulum**: articulates with radius
  - **Ulnar nerve** behind medial epicondyle



Forearm:

- 2 parallel long bones: radius and ulna
- Articulates with the humerus and wrist bones; also articulates with each other at proximal and distal radio-ulnar joints
- What is the interosseous membrane?

Ulna: (elbow joint)

- Medial; slightly longer than radius **olecranon** and **coronoid** processes
- Locking of olecranon process prevents elbow hyperextension
- **Radial notch** on coronoid process
- **Styloid process** ligament attachment to wrist

Radius (wrist joint)

- Lateral; **head** at proximal end; **distal end** is the wider end
- Distal end has medial **ulnar notch** and lateral **styloid process** (anchors ligaments)

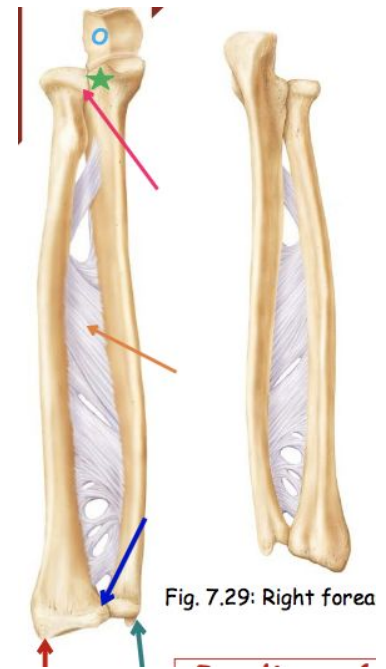
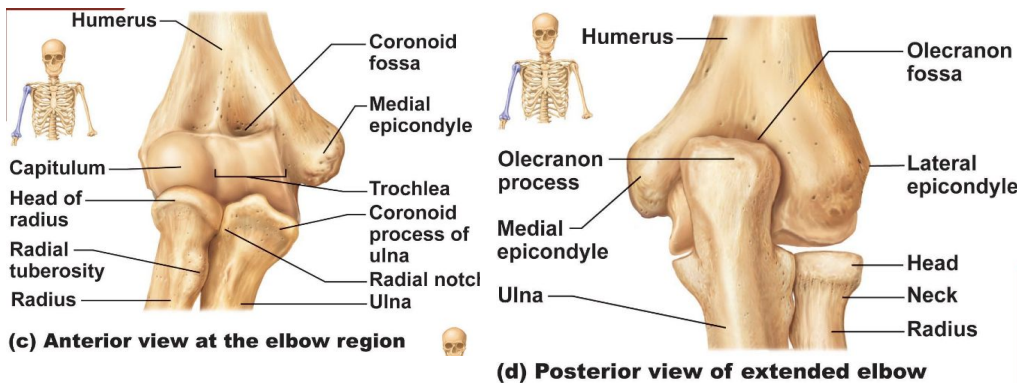


Fig. 7.29: Right forea

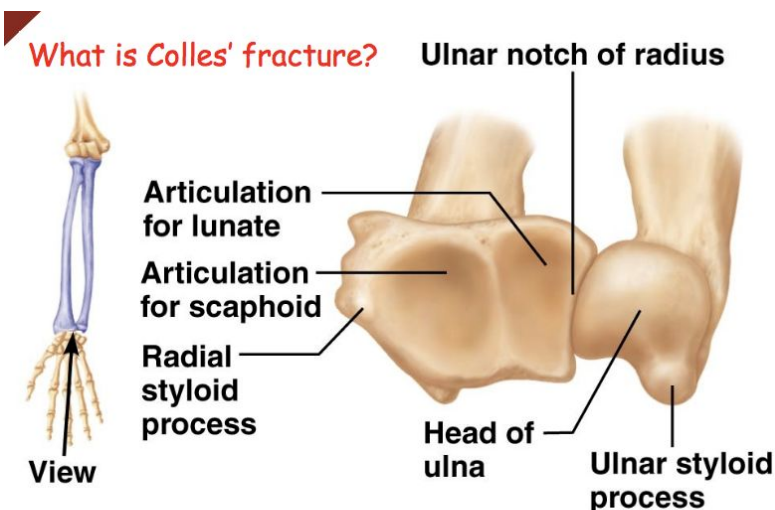


(c) Anterior view at the elbow region

(d) Posterior view of extended elbow

Colles' fracture

- The distal and radial gets broken



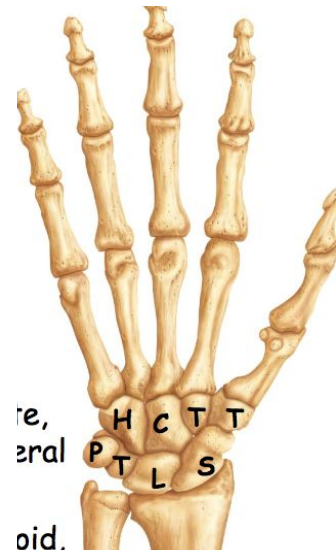
(e) Distal ends of the radius and ulna at the wrist

## HAND

- 27 bones in total
- Includes bones of carpus, metacarpus and phalanges

### Carpus (wrist) (short bone)

- 8 carpals
- Only scaphoid and lunate articulates with radius
- ‘So Long To Pittsburgh’ (**scaphoid, lunate, triquetrum, pisiform**) (proximal row; lateral to medial)
- ‘Time To Call Home’ (**trapezium, trapezoid, capitate, hamate**) (distal row: lateral to medial)
- ‘Sally left the party to take Cathy home’

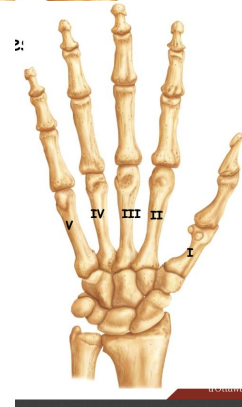


### Metacarpus: (long bones)

- 5 long bones - distal ends are knuckles
- Numbered 1-5 from thumb to little finger
- Proximal ends are articulated with wrist bones

### Phalanges: (long bone)

- 3/finger and 2/thumbs = miniature long bones
- thumb=pollex**
- Numbered 1-5 from thumb to little finger
- Proximal, middle, and distal except for thumb which has only proximal and distal



## Pelvic Girdle

- Attaches lower limbs, transmits weight of upper body to lower limbs, supports visceral organs of pelvis
- Forms a complete circle
- Left and right hip bones (coxal bones) unite anteriorly and within sacrum posteriorly
- Each os coxae consists of 3 bones that fuses at puberty:
- Ilium, ischium, pubis

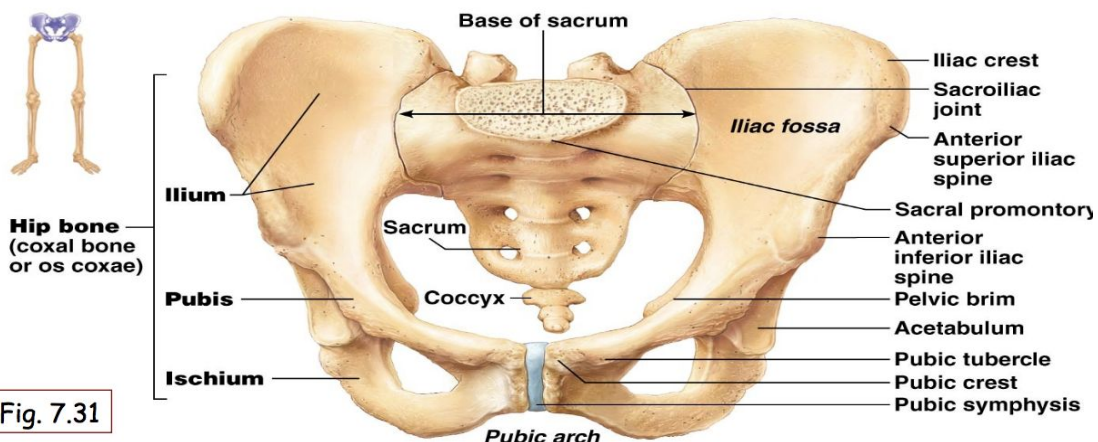


Fig. 7.31

TABLE 7.4 Comparison of the Male and Female Pelves		
CHARACTERISTIC	FEMALE	MALE
General structure and functional modifications	Tilted forward; adapted for childbearing; true pelvis defines the birth canal; cavity of the true pelvis is broad, shallow, and has a greater capacity	Tilted less far forward; adapted for support of a male's heavier build and stronger muscles; cavity of the true pelvis is narrow and deep
Bone thickness	Less; bones lighter, thinner, and smoother	Greater; bones heavier and thicker, and markings are more prominent
Acetabula	Smaller; farther apart	Larger; closer
Pubic angle/arch	Broader (80° to 90°); more rounded	Angle is more acute (50° to 60°)
Anterior view		

Ilium:

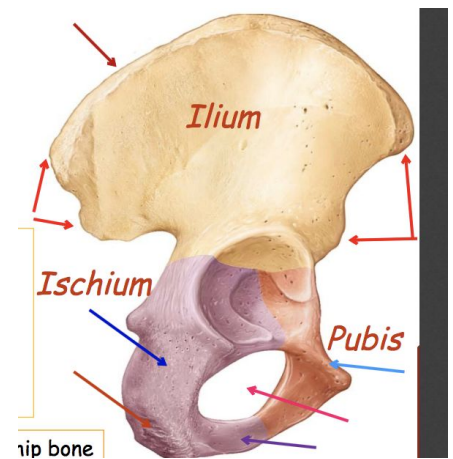
- Large flaring bone that forms most of os coxa
- Iliac crest (superior border); iliac spines (attachment of muscles)
- Pelvic brim is superior margin of true pelvis
- Anteriorly, the body of the ilium joins the ischium and pubis

Ischium:

- Postero-inferior part of hip bone
- Superior body joining ilium and thinner inferior ramus
- Ischial tuberosity

Pubis

- Anterior part of os coxa



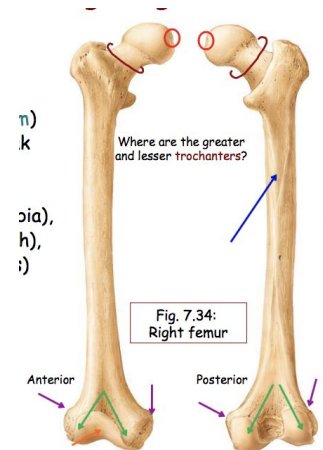
getbodysmart.com/skeletal-system-quizzes

- 2 pubic bones unite at pubis symphysis
- Pubic crest, obturator foramen (blood vessels and nerves)

LOWER LIMB: thigh, leg and foot

Thigh:

- Femur = largest, longest and strongest bone
- head, fovea capitis (ligament to acetabulum), neck (angles laterally to shaft; weak calcium deficiency), linea aspera, lat and med condyles (articulate with tibia), lat and med epicondyles (muscles attach),



Leg:

- 2 parallel bones: tibia and fibula
- Interosseus membrane + proximal and distal tibiofibular joints (rigid)
- Fibula not contributor to knee joint

Tibia: transfers weight from femur to foot; next largest and strongest bone

- NB: med and lat condyles, anterior border tibial tuberosity (patellar ligament), medial malleolus

Fibula: head and lateral malleolus

FOOT

- Total of 26 bones: tarsus (ankle bone), metatarsus and phalanges

Tarsus:

- 7 tarsal bones: largest is the calcaneus (heel bone) and second largest is the talus (part of ankle joint)

Metatarsus:

- 5 miniature long bones numbered 1-5
- Phalanges:
  - Big toe (hallus) has 2 and remaining toes have 3 each - proximal, middle and distal