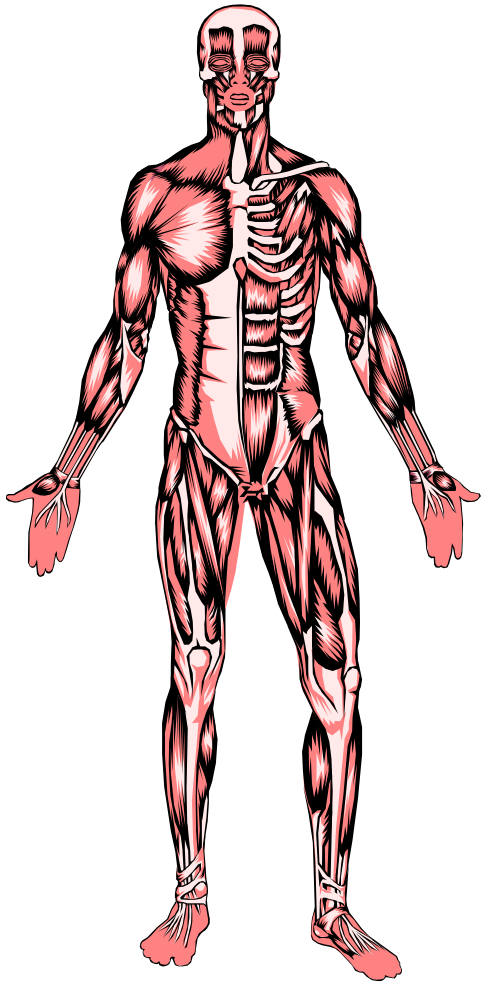
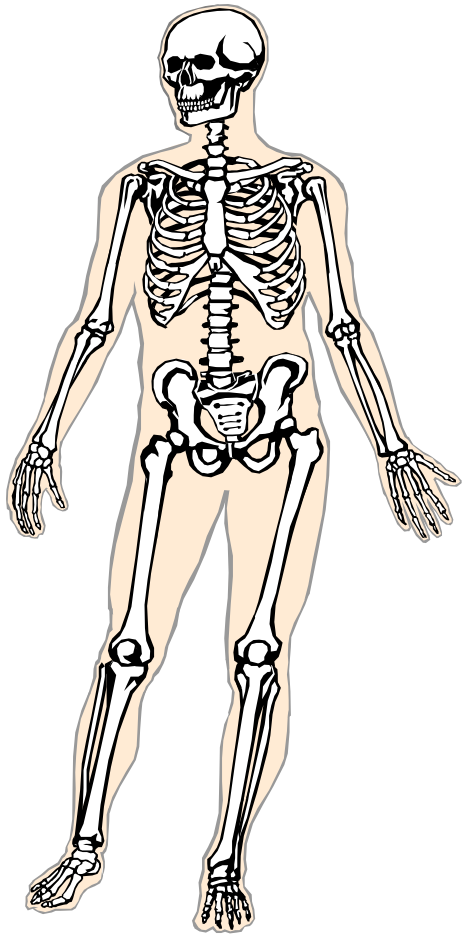
THE SKELETAL SYSTEM





Human Skeleton

- The human skeleton consists of 206 bones. We are actually born with more bones (about 300), but many fuse together as a child grows up.
- These bones support your body and allow you to move.
- Bones contain a lot of calcium (an element found in milk, broccoli, and other foods).
- Bones manufacture blood cells and store important minerals.

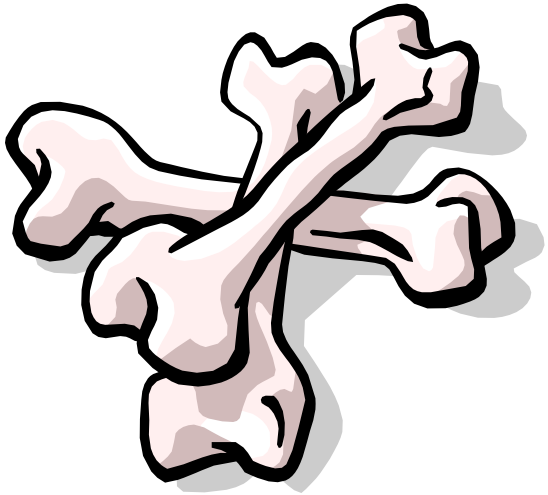
Human Skeleton

- The longest bone in our bodies is the femur (thigh bone).
- The smallest bone is the stirrup bone inside the ear.
- Each hand has 26 bones in it.
- Your nose and ears are not made of bone; they are made of cartilage, a flexible substance that is not as hard as bone.

Structure & Function

Forms the body framework

Enables the body to move



Protects and supports internal organs

Consists of bones, joints and muscles

Structure & Function

How does the Skeletal System help us?

Support

- **The main job of the skeleton is to provide support for our body.**
- **Without your skeleton your body would collapse into a heap.**
- **Your skeleton is strong but light.**
- **Without bones you'd be just a puddle of skin and guts on the floor**

Protection

- Your skeleton also helps protect your internal organs and fragile body tissues.
- The brain, eyes, heart, lungs and spinal cord are all protected by your skeleton.
- Your cranium (skull) protects your brain and eyes, the ribs protect your heart and lungs and your vertebrae (spine, backbones) protect your spinal cord

Movement

- Bones provide the structure for muscles to attach so that our bodies are able to move.
- Tendons are tough inelastic bands that hold attach muscle to bone.

Storage of Minerals

- The minerals like calcium and phosphorus are stored in the bones, till they need to be distributed in various parts of the body that need minerals to carry out various functions.

Chemical Energy Storage

- The yellow marrow in bones discussed above consist of adipose cells.
- These adipose cells are fat cells that are very important source of chemical energy.

Production of Red Blood Cells

- The red blood cells as well as the white blood cells are produced in the red marrow of the bones.
- After birth and in early childhood, the red blood morrow is red in color. Then, in adulthood, half of the bone marrow turns yellow, as it consists of fat cells.
- The long bones consist of yellow marrow and the red marrow is found in the flat bones of hip, skull and shoulder blades.
- You may also find red marrow in the vertebrae and the end of the long bone.
- In extreme conditions, the body can convert some of the yellow bone marrow to red bone marrow.

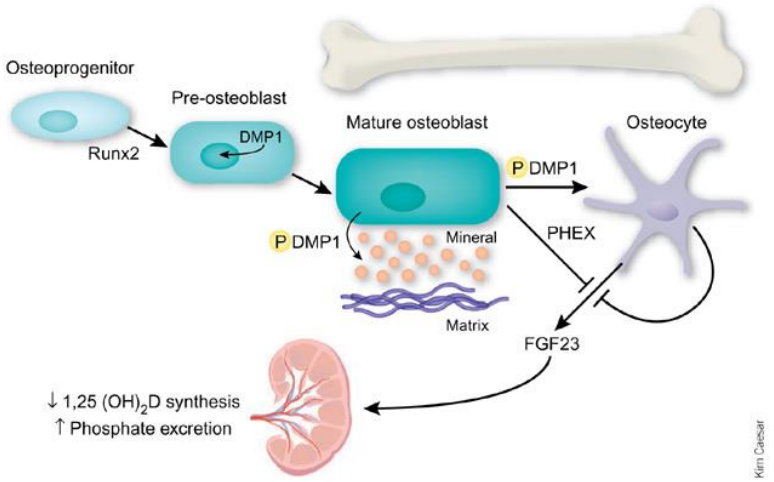
Structure & Function

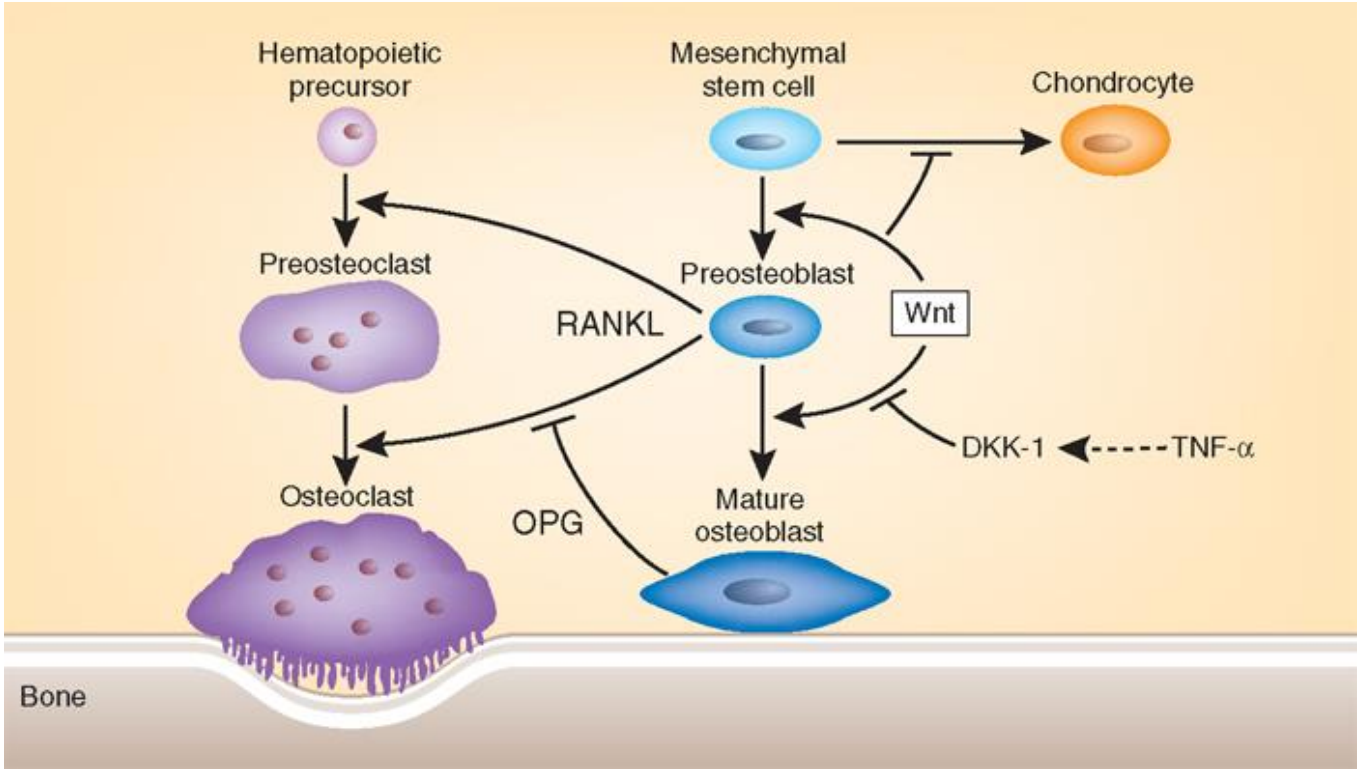
Bones

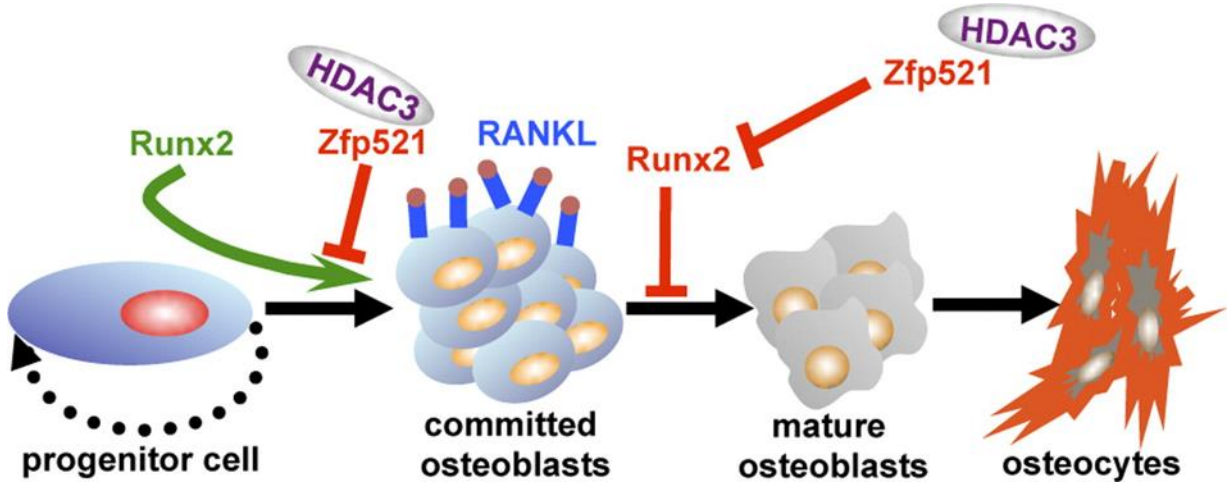
- Composed of osseous tissue
- Consists of a rich supply of blood vessels and nerves
- **Osteoblasts** are bone-forming cells
- **Osteoclasts** are responsible for reabsorbing dead bone tissue
- Bone cells are called **osteocytes**

Osteoblasts: 조골세포 [造骨細胞]

- arise from marrow mesenchymal cells;
- when active, are plump and present on bone surface;
- eventually are encased within the collagen they produce and get flattened (see osteocytes below
- Osteoblasts control osteoclast activity via parathyroid hormone (parathormone), PHRP (Parathyroid hormone related protein), IL-1, TNF alpha; digestion of bone by osteoclasts releases cytokines and growth factors for osteoblasts
- Express parathormone receptors (mediate the activation of osteoclasts)

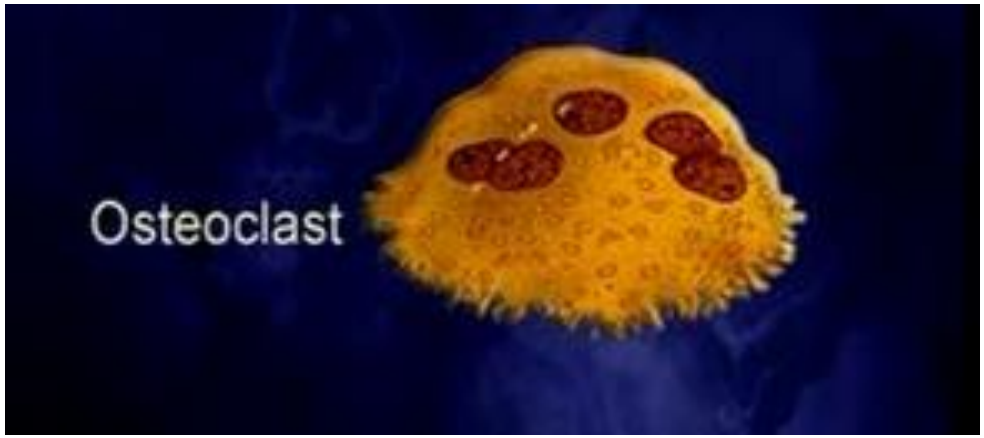



Hematopoietic precursor
Mesenchymal stem cell
Chondrocyte
Preosteoclast
Preosteoblast
RANKL
Wnt
DKK-1
TNF-α
Osteoclast
OPG
Mature osteoblast
Bone


HDAC3
Zfp521
HDAC3
Zfp521
Runx2
RANKL
Runx2
progenitor cell
committed osteoblasts
mature osteoblasts
osteocytes

Osteoclasts: 파골세포 [**osteoclast**, 破骨細胞]

- cause bone resorption due primarily to remodeling and not calcium homeostasis; derived from monocyte fusion;
- multinucleated (2-12 nuclei) giant cells, associated with bone surface; use their ruffled borders (with villous extensions) to bind to matrix adhesion proteins, produce resorption pits/bays (shallow concavities) called Howship's lacunae; plasma membrane forms a seal with bone;
- osteoclast acidifies extracellular area, which solubilizes the mineral and releases enzymes which dissolve the matrix; contains tartrate-resistant acid phosphatase



Osteocytes: 뼈세포 [**osteocyte**, ~細胞]
the mature form of osteoblasts after they are surrounded by matrix; most numerous cell in bone; communicate with each other via osteocytic cell processes with gap junctions that travel through canaliculi (bone tunnels); may maintain serum calcium and phosphorus levels; can translate mechanical forces into biologic activity

Osteon: 골단위 [**osteon, Osteon**, 骨單位]
dense compact cylindrical unit underlying cortical bone; formed in childhood by ingrowth of periosteal vessels that follow a cutting cone of osteoclasts through the cortex; tunnel is haversian canal, is filled in partially with osteoblast created bone matrix

Osteoid: 유골 [**osteoid**, 類骨]

- non mineralized bone always present at the formative surface of bone, but usually a very thin layer; resembles hyalinized collagen;
- composed of type I collagen (90%), acid mucopolysaccharides, noncollagen proteins including bone morphogenetic protein (may initiate bone formation), adhesion proteins (fibronectin, osteopontin, thrombospondin), calcium binding proteins (osteonectin, bone sialoprotein), mineralization proteins (osteocalcin), enzymes (collagenase, alkaline phosphatase); increased if increased bone formation (fracture callus, Paget's disease, hyperparathyroidism), if inadequate mineralization or if toxic / inhibitory structures present in bone (aluminum, iron, fluoride)

- **Osteoprogenitor (골전구세포)**
  : mesenchymal stem cells near bony surfaces, can produce osteoblasts; 뼈막, 빼내막, 치말골의 중앙관에서 발견되는 미분화된 세포

- **Osteoblast : osteoprogenitor cell** 로 부터 생성, **Ca** 및 기타 미네랄을 분비

- **Osteocytes : osteoblast**가 성숙된 뼈세포

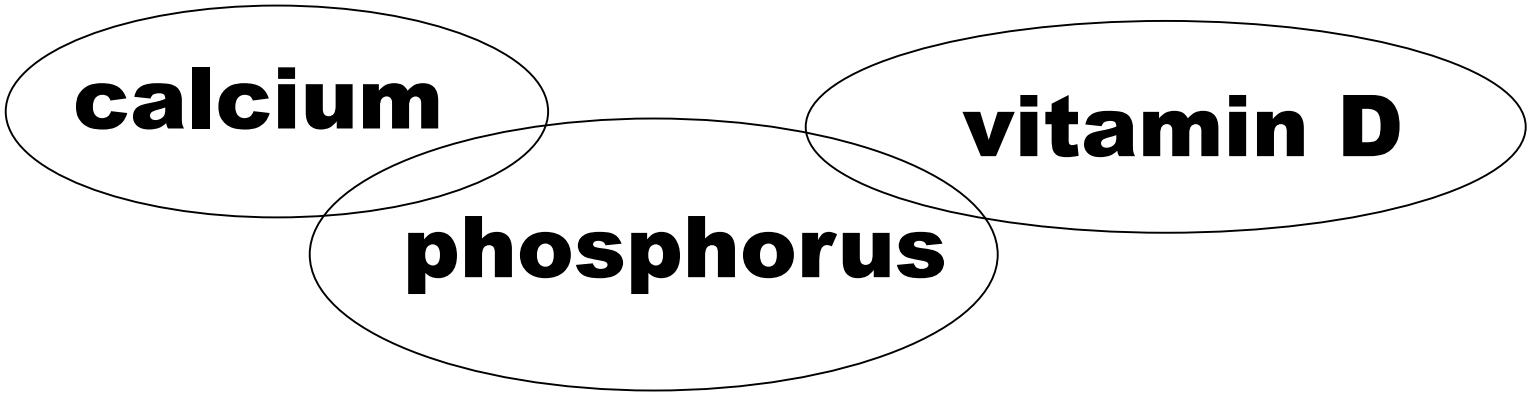
- **Osteoclast :** 뼈의 성장과 재생에 중요한 역할, 오래된 뼈를 파괴 시키는 역할, 뼈에 있는 **Ca, P** 분자를 혈액이나 조직으로 이동을 도와주는 역할

Structure & Function

Bones

The development of osteocytes and the hardening process is called ossification.

Ossification depends on:



Bone Tissue

- There are two types of bone tissue: compact and spongy.
- There are three types of cells that contribute to bone homeostasis.
  - ✓ Osteoblasts are bone-forming cell
  - ✓ Osteoclasts resorb or break down bone
  - ✓ Osteocytes are mature bone cells
- An equilibrium between osteoblasts and osteoclasts maintains bone tissue.

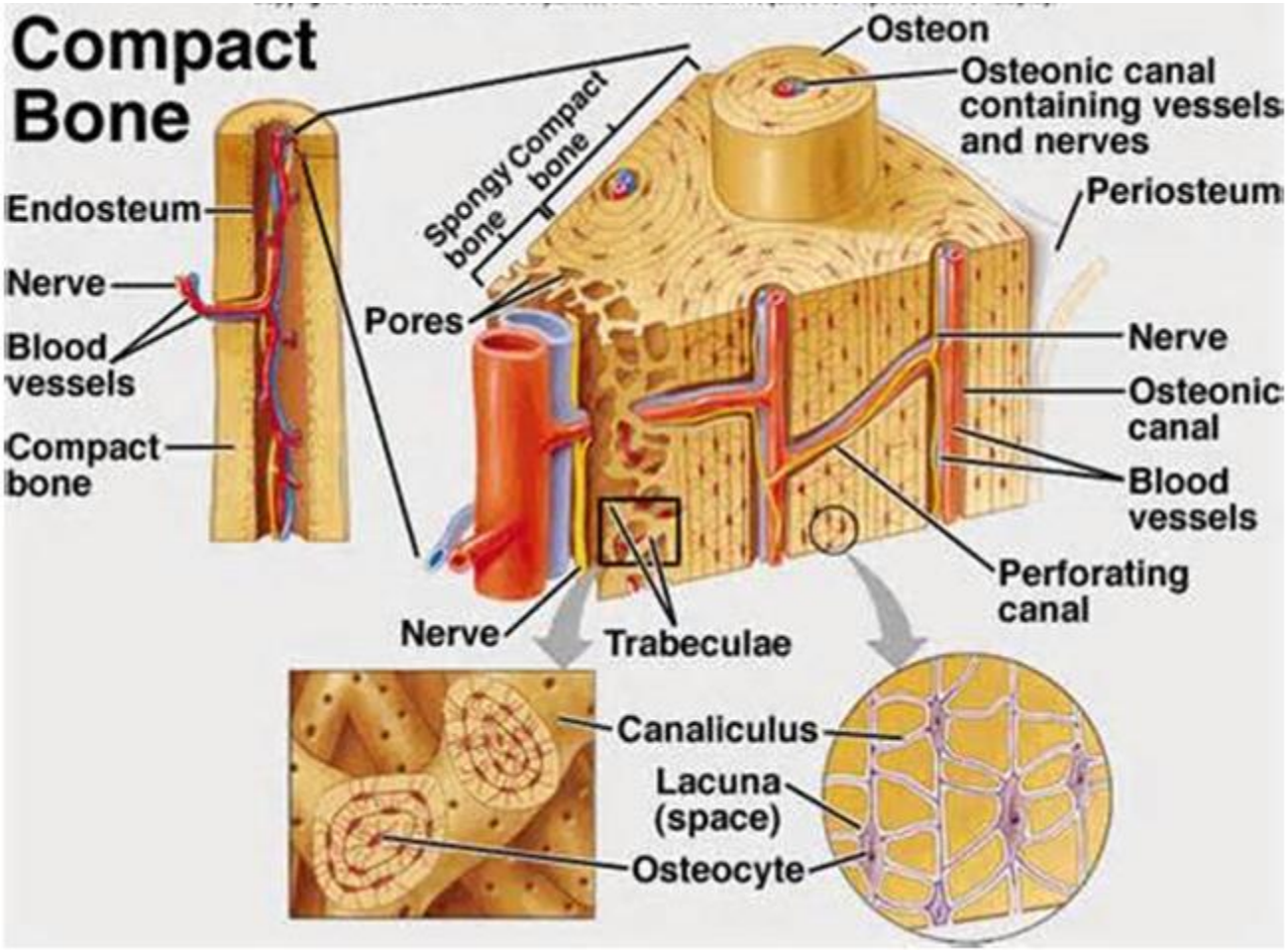
Compact Bone

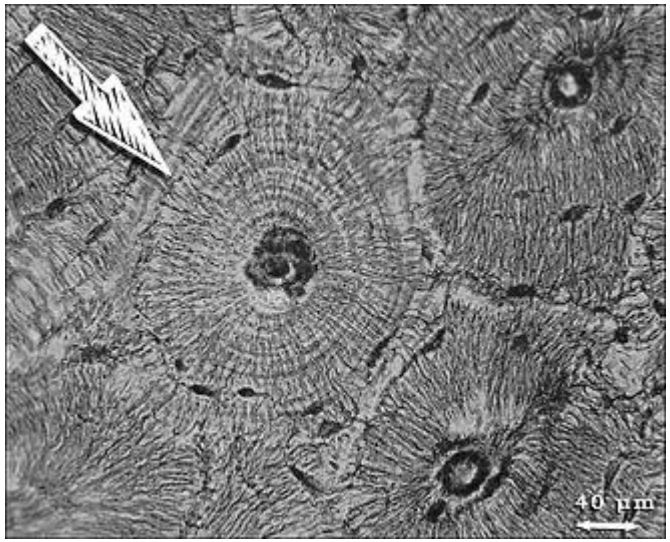
- Compact bone consists of closely packed osteons or haversian systems.
- The osteon consists of a central canal called the osteonic (Haversian) canal, which is surrounded by concentric rings (lamellae) of matrix.
- Between the rings of matrix, the bone cells (osteocytes) are located in spaces called lacunae.
- Small channels (canaliculi) radiate from the lacunae to the osteonic (Haversian) canal to provide passageways through the hard matrix.

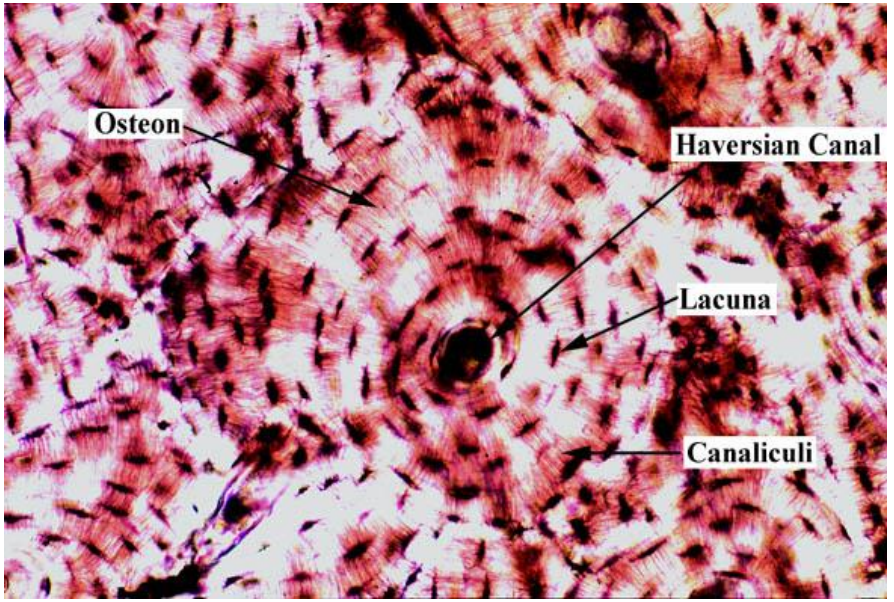
Compact Bone

- In compact bone, the Haversian systems are packed tightly together to form what appears to be a solid mass.
- The osteonic canals contain blood vessels that are parallel to the long axis of the bone.
- These blood vessels interconnect, by way of perforating canals, with vessels on the surface of the bone.

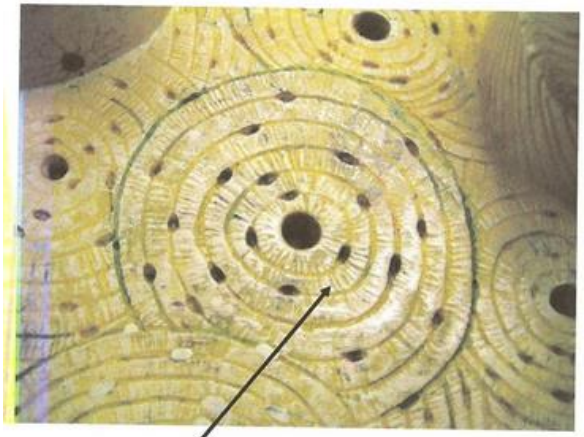
Compact Bone (치밀골) : 뼈의 밀집도가 높고 단단하다. Osteon (뼈단위) 혹은 Haversian system 으로 구성, 골세포 (osteocytes)를 가짐


Compact Bone
Endosteum
Nerve
Blood vessels
Compact bone
Spongy bone
Compact bone
Pores
Osteon
Osteonic canal containing vessels and nerves
Periosteum
Nerve
Osteonic canal
Blood vessels
Perforating canal
Nerve
Trabeculae
Canaliculus
Lacuna (space)
Osteocyte

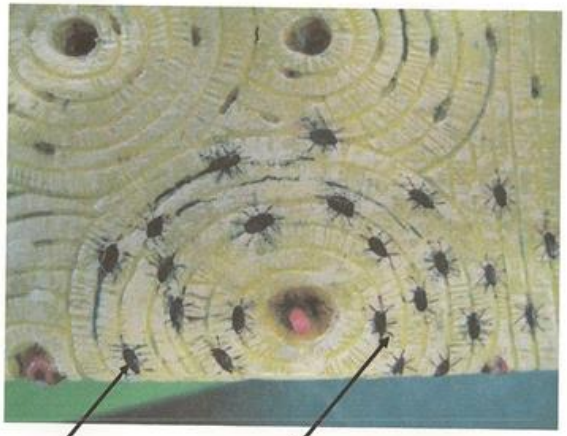




Osteon - Canaliculi



Canaliculi



Osteocyte (dark oval)

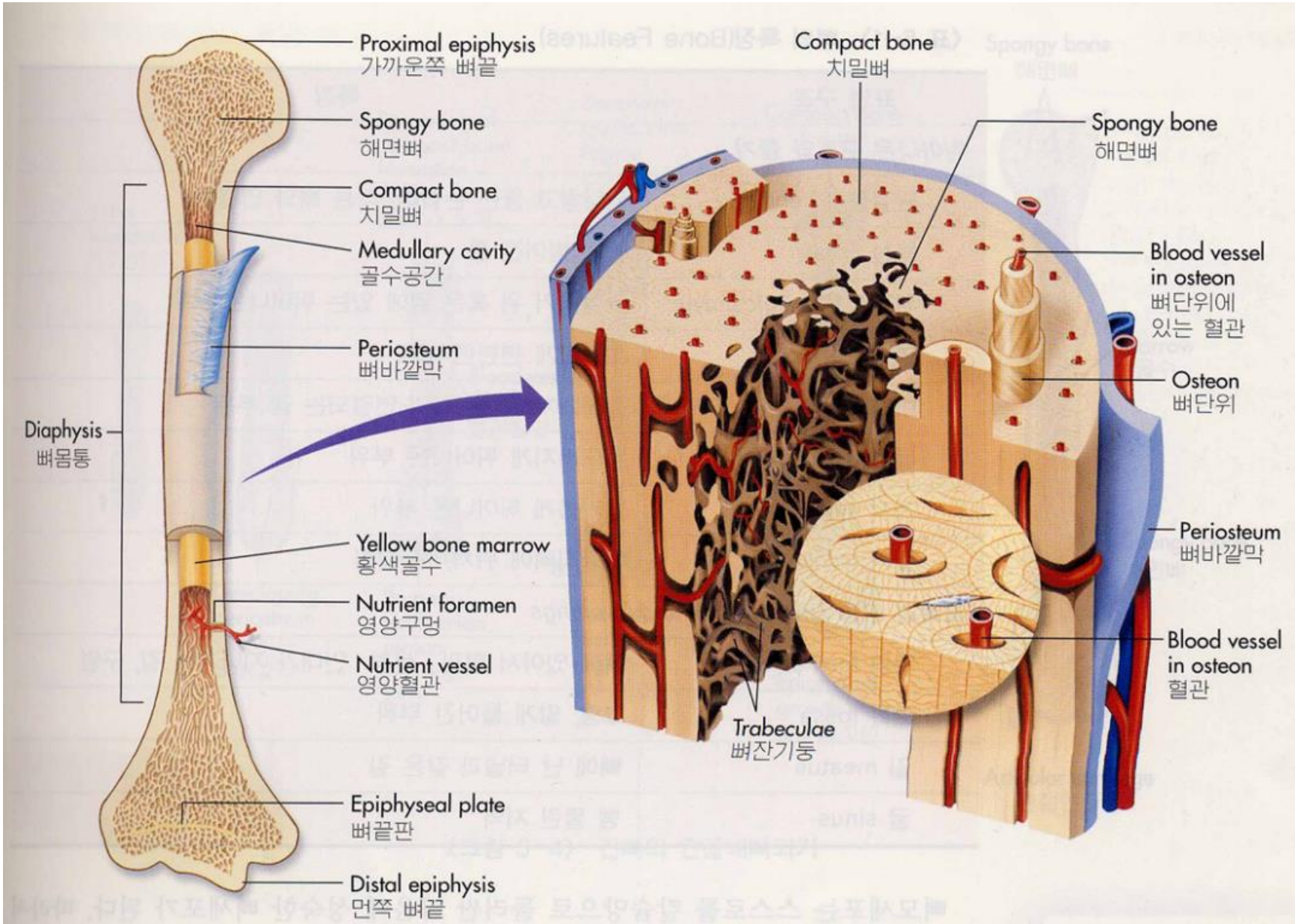
Canaliculi (extensions)

Spongy (Cancellous) Bone

- Spongy (cancellous) bone is lighter and less dense than compact bone.
- Spongy bone consists of plates (trabeculae) and bars of bone adjacent to small, irregular cavities that contain red bone marrow.
- The canaliculi connect to the adjacent cavities, instead of a central haversian canal, to receive their blood supply.

- It may appear that the trabeculae are arranged in a haphazard manner, but they are organized to provide maximum strength similar to braces that are used to support a building.
- The trabeculae of spongy bone follow the lines of stress and can realign if the direction of stress changes.

Sponge bone (해면골) : 뼈를 가볍게 해준다, 적혈세포를 생산하는 적골수에게 공간제공, cancellous bone이라고도 함



〈그림 5-3〉 치밀뼈와 해면뼈의 비교

Classification of Bones

Structure & Function

Bones

The adult skeleton has 206 bones.

Common Bone Categories

- **Long bones (Femur)**
- **Short bones (Wrist bones)**
- **Flat bones (Skull)**

- **Irregular bones (Vertebrae)**
- **Sesamoid bones (Kneecap)**

Long Bones

- Bones that are longer than they are wide are called long bones.
- They consist of a long shaft with two bulky ends or extremities.
- They are primarily compact bone but may have a large amount of spongy bone at the ends or extremities.
- Long bones include bones of the thigh, leg, arm, and forearm.

Short Bones

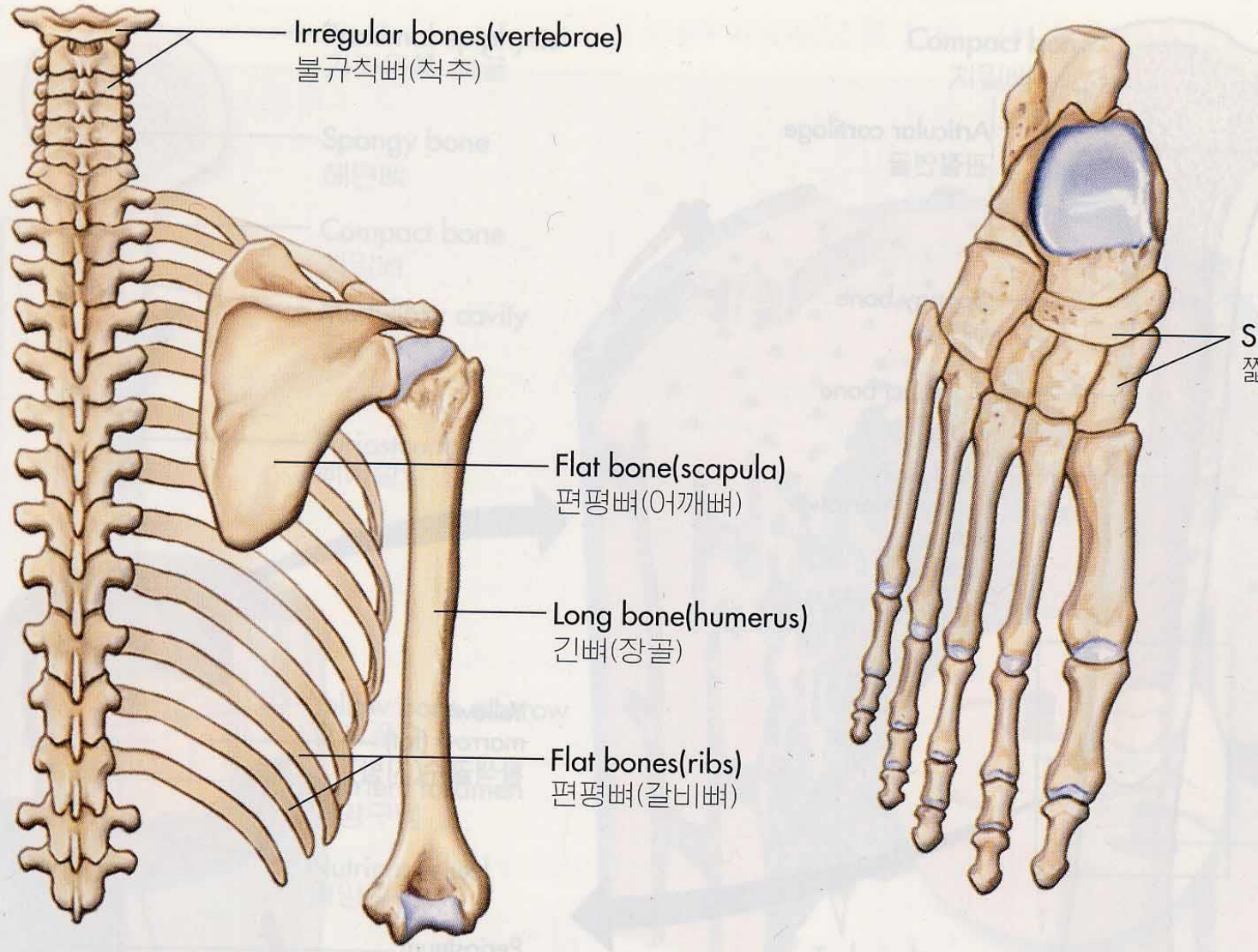
- Short bones are roughly cube shaped with vertical and horizontal dimensions approximately equal.
- They consist primarily of spongy bone, which is covered by a thin layer of compact bone.
- Short bones include the bones of the wrist and ankle.

Flat Bones

- Flat bones are thin, flattened, and usually curved.
- Most of the bones of the cranium are flat bones.

Irregular Bones

- Bones that are not in any of the above three categories are classified as irregular bones.
- They are primarily spongy bone that is covered with a thin layer of compact bone.
- The vertebrae and some of the bones in the skull are irregular bones.



〈그림 5-1〉 다양한 뼈의 형태

Structure & Function

Bones

Parts of long bones:

- **The shaft is the longest portion also called the diaphysis.**
- **The ends are called the epiphysis.**
- **Space between the epiphyses and the diaphysis is called the metaphysis.**

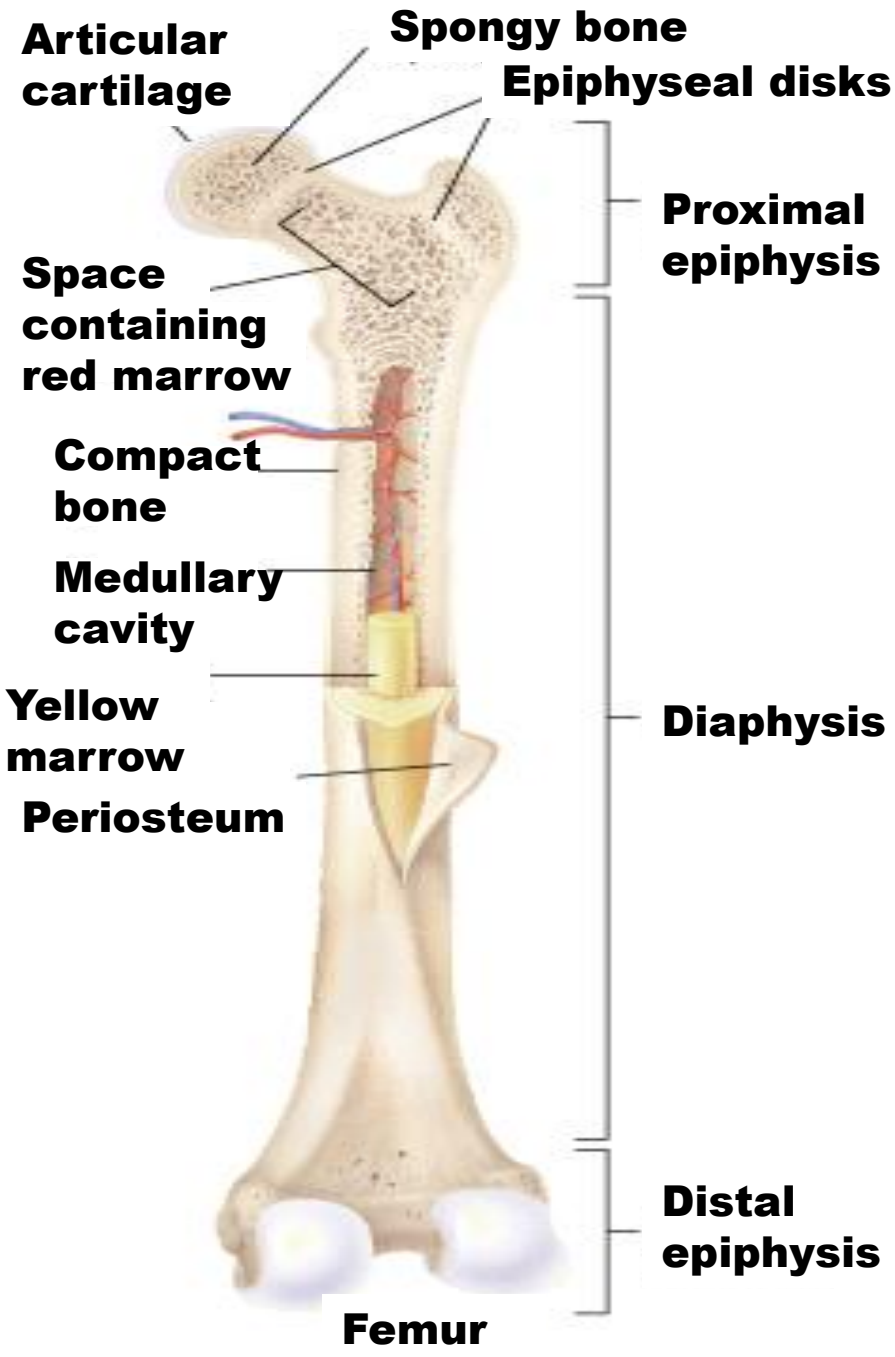
Structure & Function

Parts of a long bone

- **Articular cartilage** is a thin flexible substance that provides protection at movable points.

- **Medullary cavity** contains yellow bone marrow.

- Red bone marrow is found in infant bones and the flat bones of adults.



Blood supply:

- *diaphysis*: a nutrient artery enters medullary canal at center of diaphysis, divides and supplies entire diaphysis; also contributions from vessels within the Volkmann / Haversian system;
- *epiphyses*: supplied by medullary arteries; sometimes from the epiphysis along additional vessels that traverse the joint
- *metaphysis*: supplied by vessels within the medulla that loop back

Vascular channels:

- 2 types in compact bone, either haversian (longitudinal) canals or transverse/oblique (Volkmann's canals)

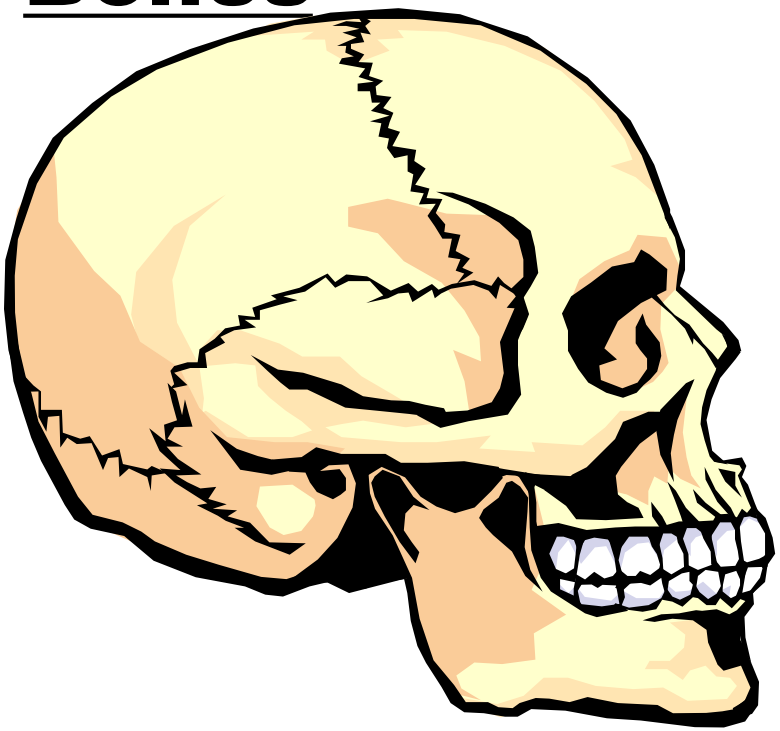
Bone composition:

- 35% organic (cells, proteins), 65% calcium hydroxyapatite (contains 99% of body's calcium, 85% of phosphorus, 65% of sodium, also magnesium)
- Hydroxyapatite crystal is formed via phase transition; 12 day lag between matrix deposition and mineralization
- Collagen resists tension
- Hydroxyapatite and proteoglycans in cartilage resist compression
- Thicker cortex in middle of long bones resists bending Cancellous bone at ends of long bones resists compression

Structure & Function

Cranial Bones

- Temporal
- Frontal
- Sphenoid
- Occipital



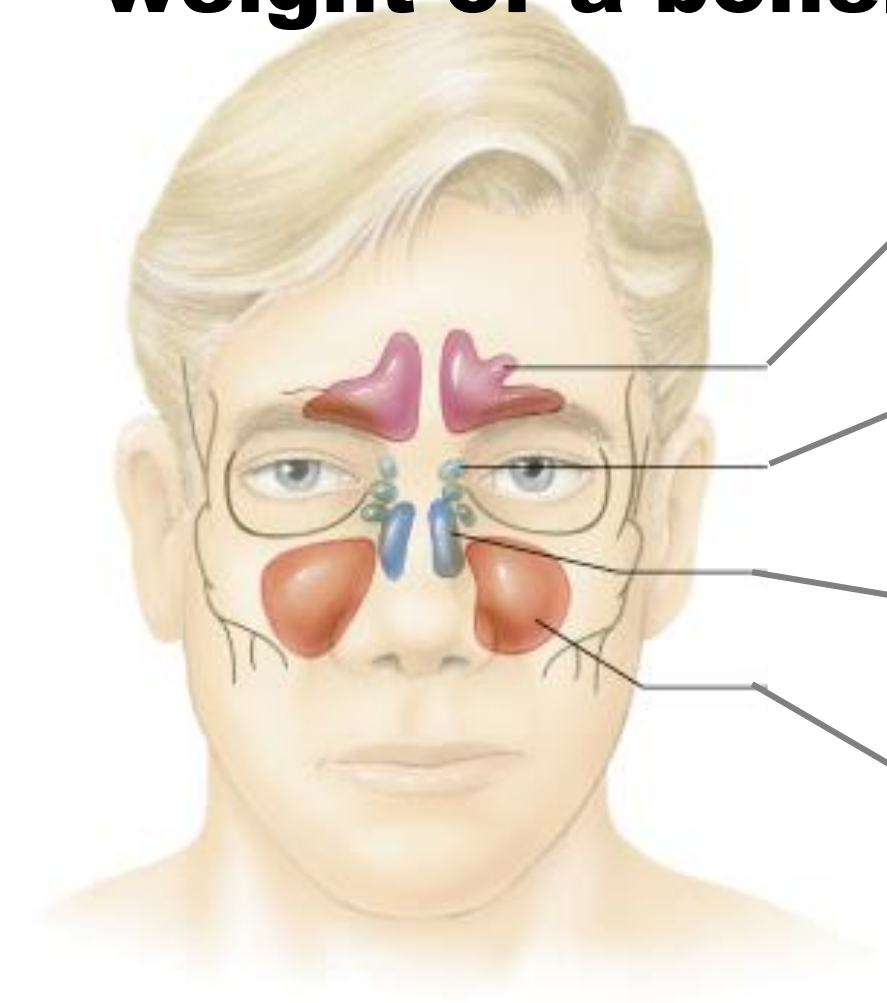
- Parietal
- Ethmoid

Human skull

Feature	Location	Description
ethmoid bone	eye cavity	a cranial bone forming part of the eye cavity
frontal bone	top of face (forehead) and front top of head	one of the major cranial bones that forms the forehead and front top of the head; roughly covers the frontal lobes of the brain
occipital bone	the lower rear of the head	a major cranial bone at the lower back of the head; covers occipital lobe of the brain
parietal bone	top and side of head	a major cranial bone that forms part of the top, back, and side of the head and roughly covers the parietal lobe of the brain
sphenoid bone	temple and eye orbit area	a cranial bone that forms part of the eye cavity
temporal bone	side of the head, above the ear	a cranial bone on the side of the head that roughly covers the temporal lobe of the brain; it extends down behind the ear towards the jaw

Structure & Function

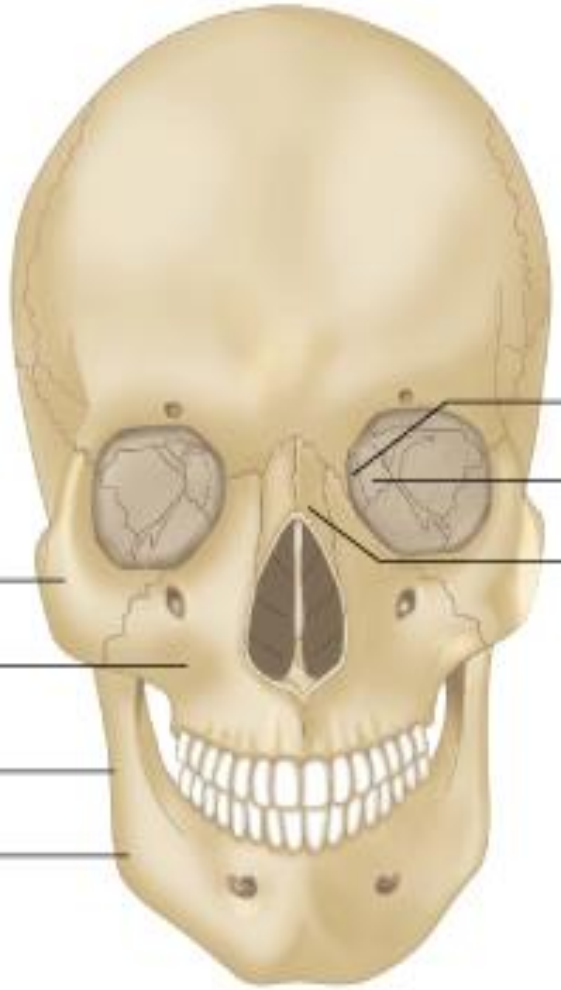
Sinuses are cavities that reduce the weight of a bone.



- **Frontal sinuses**
- **Ethmoid sinuses**
- **Maxillary sinuses**
- **Sphenoid sinuses**

Structure & Function

Facial Bones



- Lacrimal bone
- Ethmoid bone
- Nasal bones

Zygomatic bone

Maxillary bones

Mandible

Palatine bone

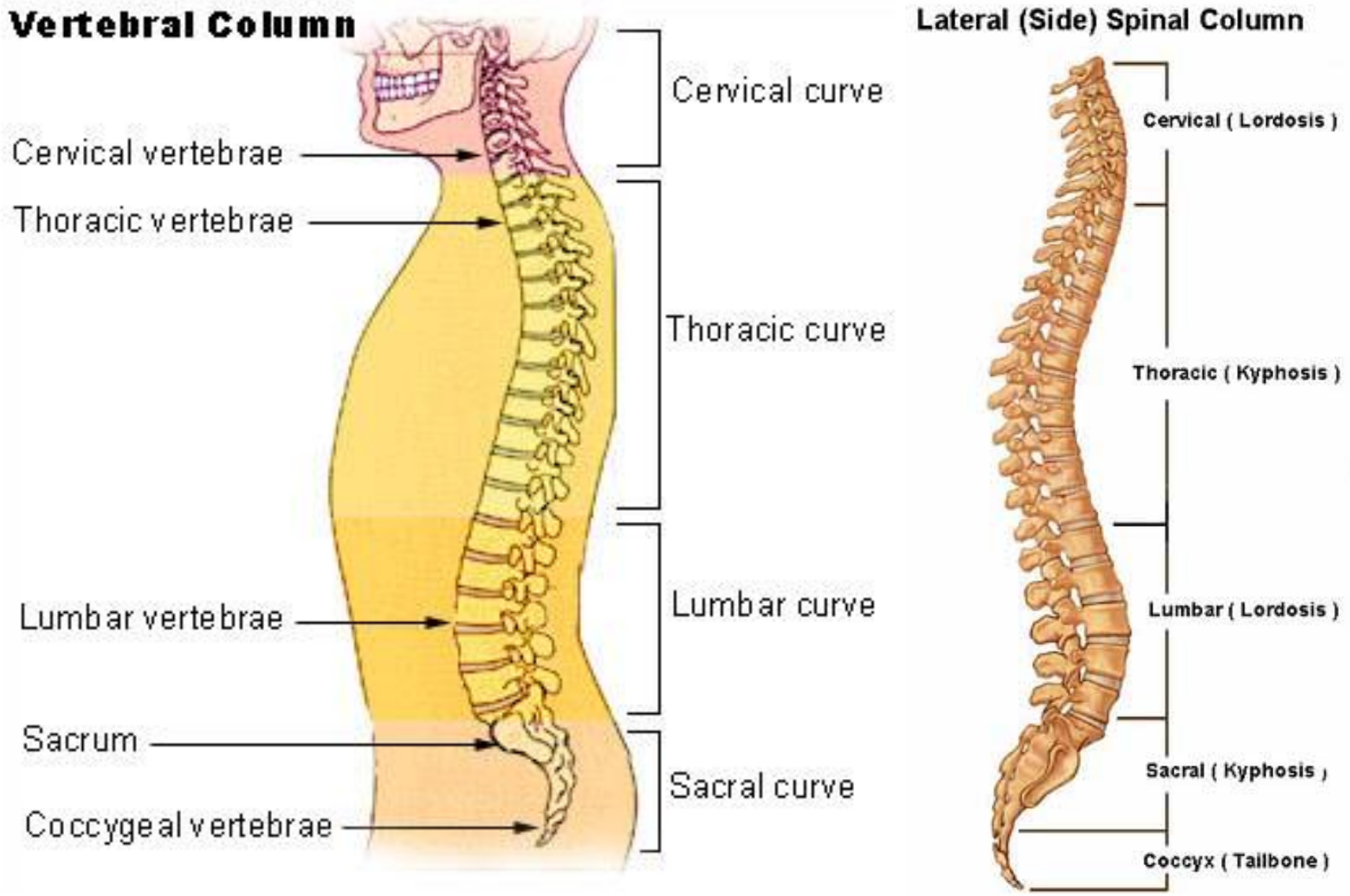
Structure & Function

Spinal Column

Consists of five sets of vertebrae

- **Cervical = 7**
- **Thoracic = 12**
- **Lumbar = 5**
- **Sacrum = 5**
- **Coccyx = 1**

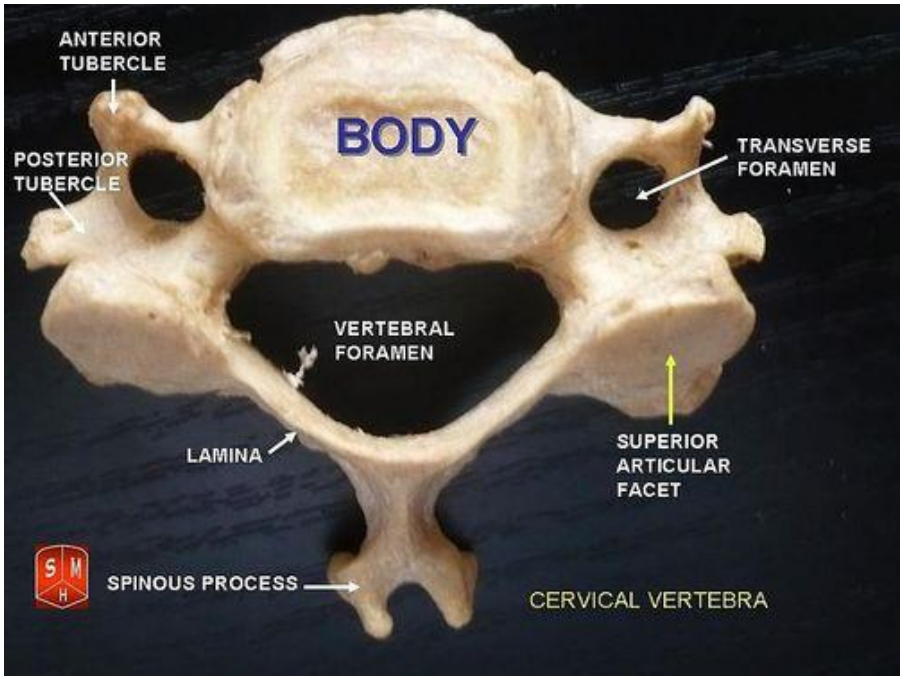
Human Vertebrates

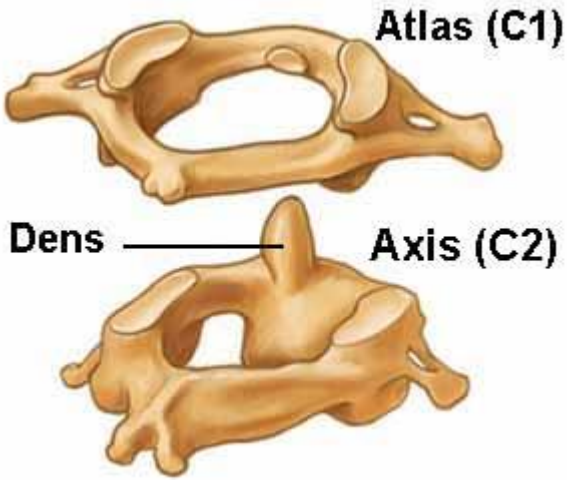


Cervical vertebrae

cervical vertebrae (singular: *vertebra*) are those vertebrae immediately inferior to the skull. ,

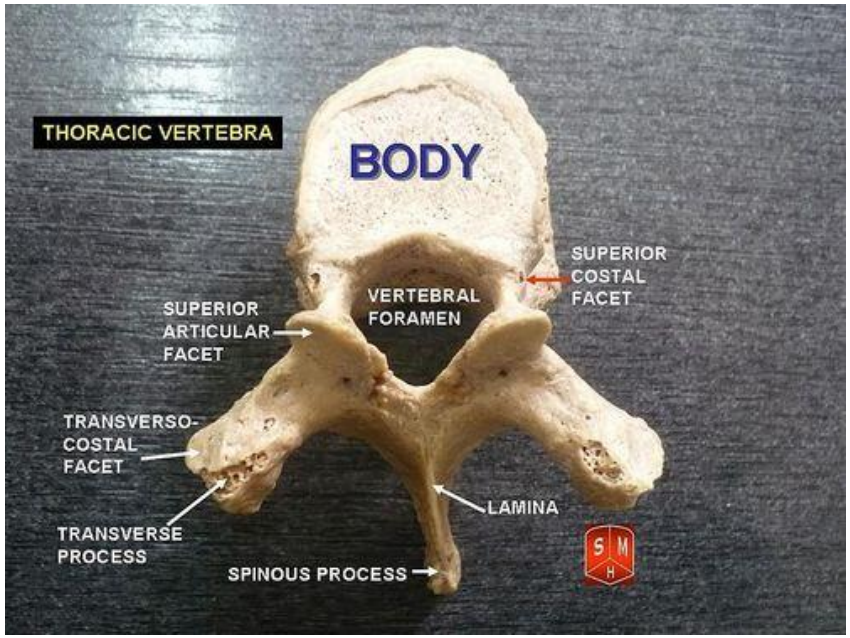
cervical vertebrae are the smallest of the true vertebrae, and can be readily distinguished from those of the thoracic or lumbar regions by the presence of a foramen (hole) in each transverse process, through which passes the vertebral artery.

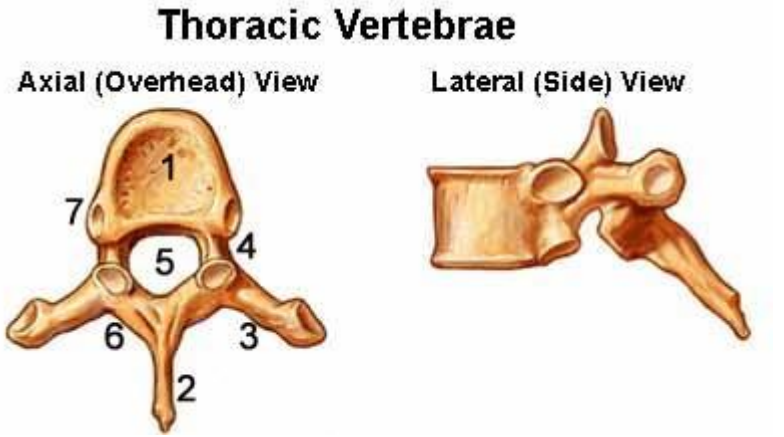




Thoracic vertebrae

- Twelve **thoracic vertebrae** compose the middle segment of the vertebral column, between the cervical vertebrae and the lumbar vertebrae.
- They are intermediate in size; they increase in size as one proceeds down the spine, the upper vertebrae being much smaller than those in the lower part of the region.
- They are distinguished by the presence of facets on the sides of the bodies for articulation with the heads of the ribs, and facets on the transverse processes of all, except the eleventh and twelfth, for articulation with the tubercles of the ribs.

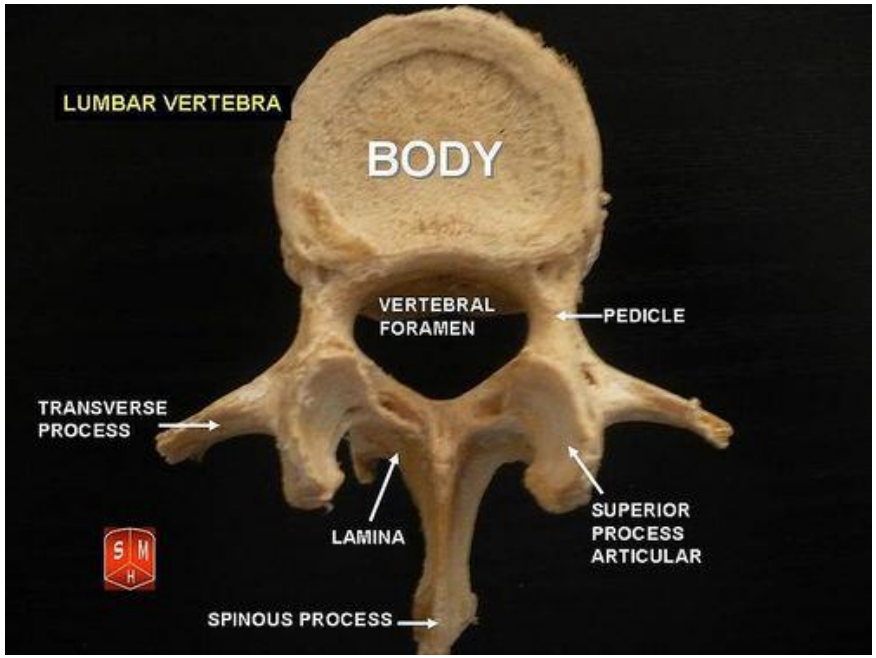


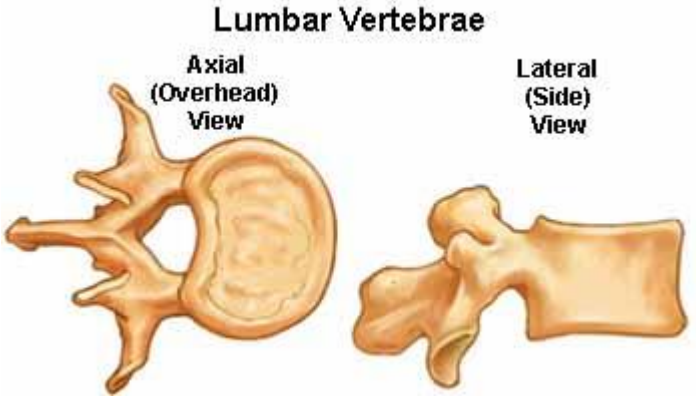


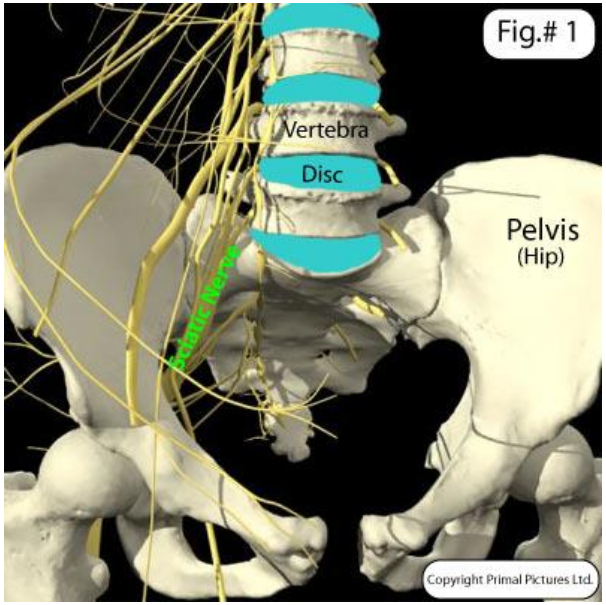
1-Vertebral Body **2**-Spinous Process **3**-Transverse Facet **4**-Pedicle **5**-Foramen **6**-Lamina **7**-Superior Facet

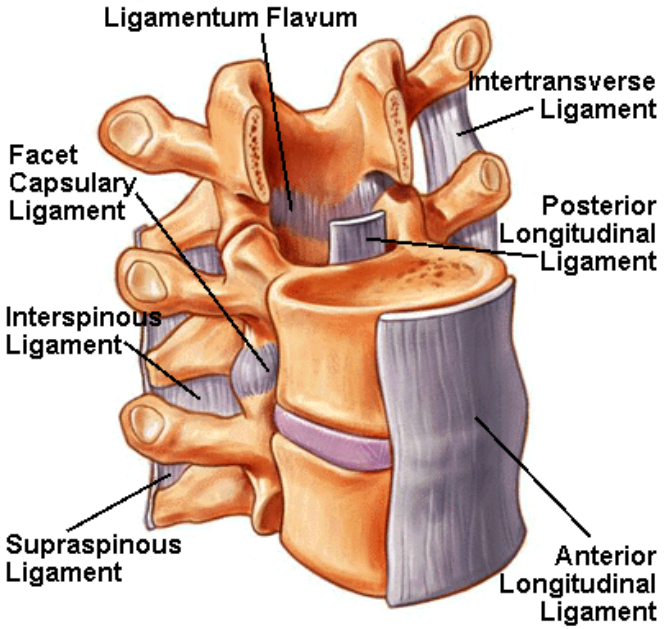
Lumbar vertebrae

The **lumbar vertebrae** are the largest segments of the movable part of the vertebral column, and are characterized by the absence of the foramen transversarium within the transverse process, and by the absence of facets on the sides of the body. They are designated L1 to L5, starting at the top.

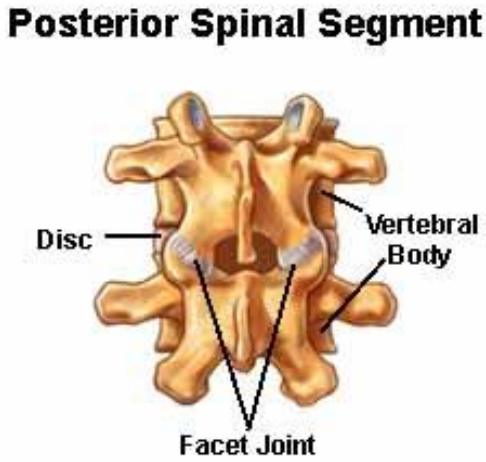


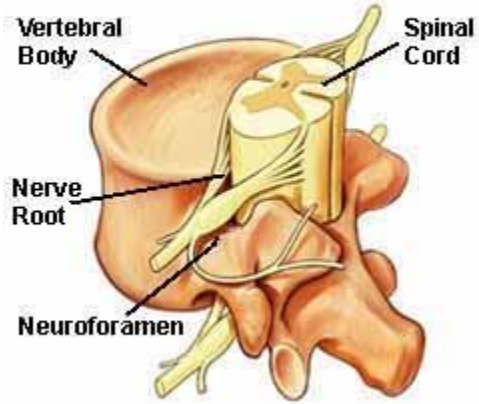






Spinal Ligaments





Spinal Nerve Structures

Functions of the Vertebral or Spinal Column Include:

Protection

- Spinal Cord and Nerve Roots
- Many internal organs

Base for Attachment

- Ligaments
- Tendons
- Muscles

Structural Support

- Head, shoulders, chest
- Connects upper and lower body
- Balance and weight distribution

Functions of the Vertebral or Spinal Column Include:

Flexibility and Mobility

- Flexion (forward bending)
- Extension (backward bending)
- Side bending (left and right)
- Rotation (left and right)
- Combination of above

Other

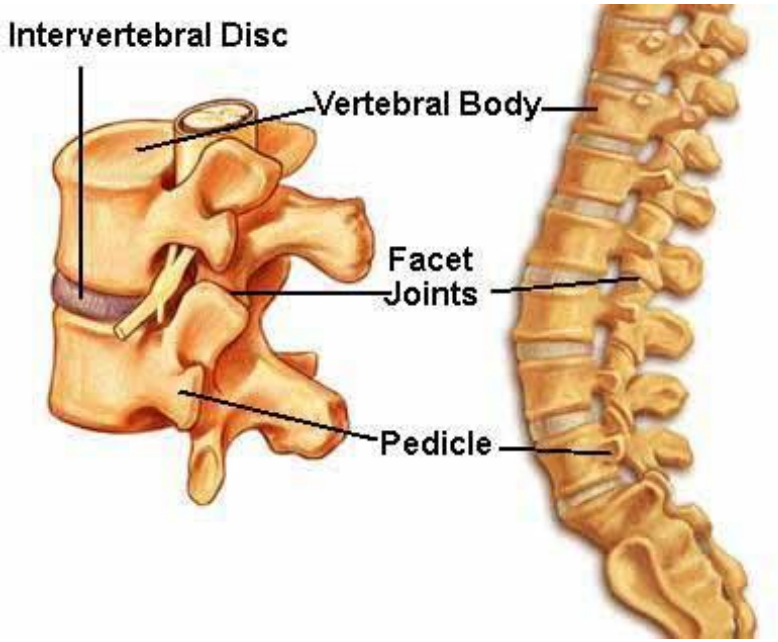
- Bones produce red blood cells
- Mineral storage

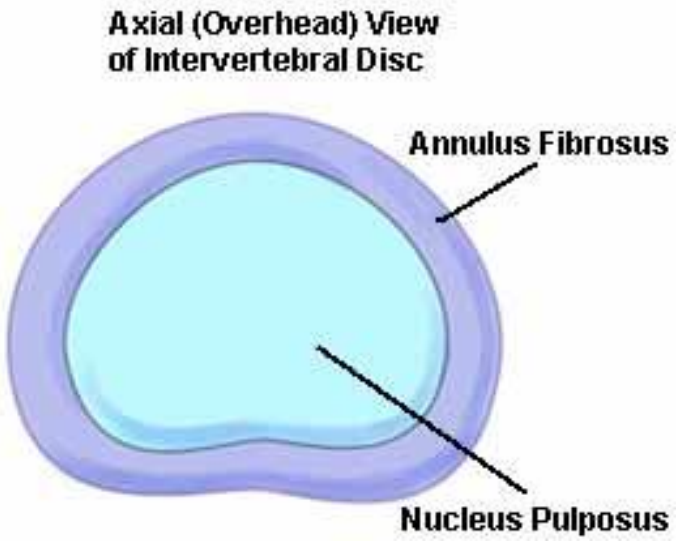
Sacral Spine

- The Sacrum is located behind the pelvis.
- Five bones (abbreviated S1 through S5) fused into a triangular shape, form the sacrum.
- The sacrum fits between the two hipbones connecting the spine to the pelvis.
- The last lumbar vertebra (L5) articulates (moves) with the sacrum.
- Immediately below the sacrum are five additional bones, fused together to form the Coccyx (tailbone).

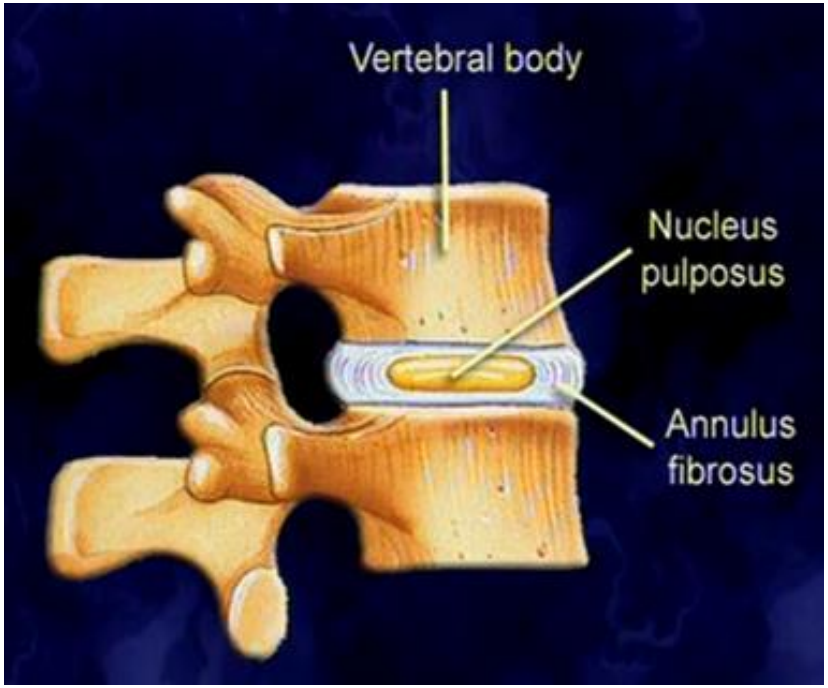
Intervertebral Discs

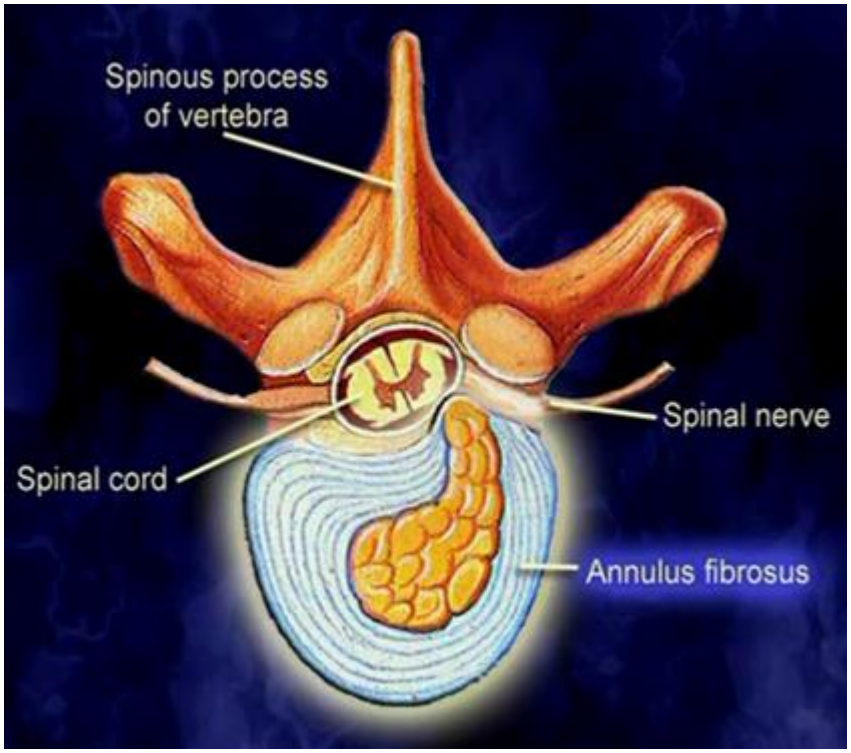
The intervertebral discs make up one fourth of the spinal column's length. There are no discs between the Atlas (C1), Axis (C2), and Coccyx. Discs are not vascular and therefore depend on the end plates to diffuse needed nutrients. The cartilaginous layers of the end plates anchor the discs in place.

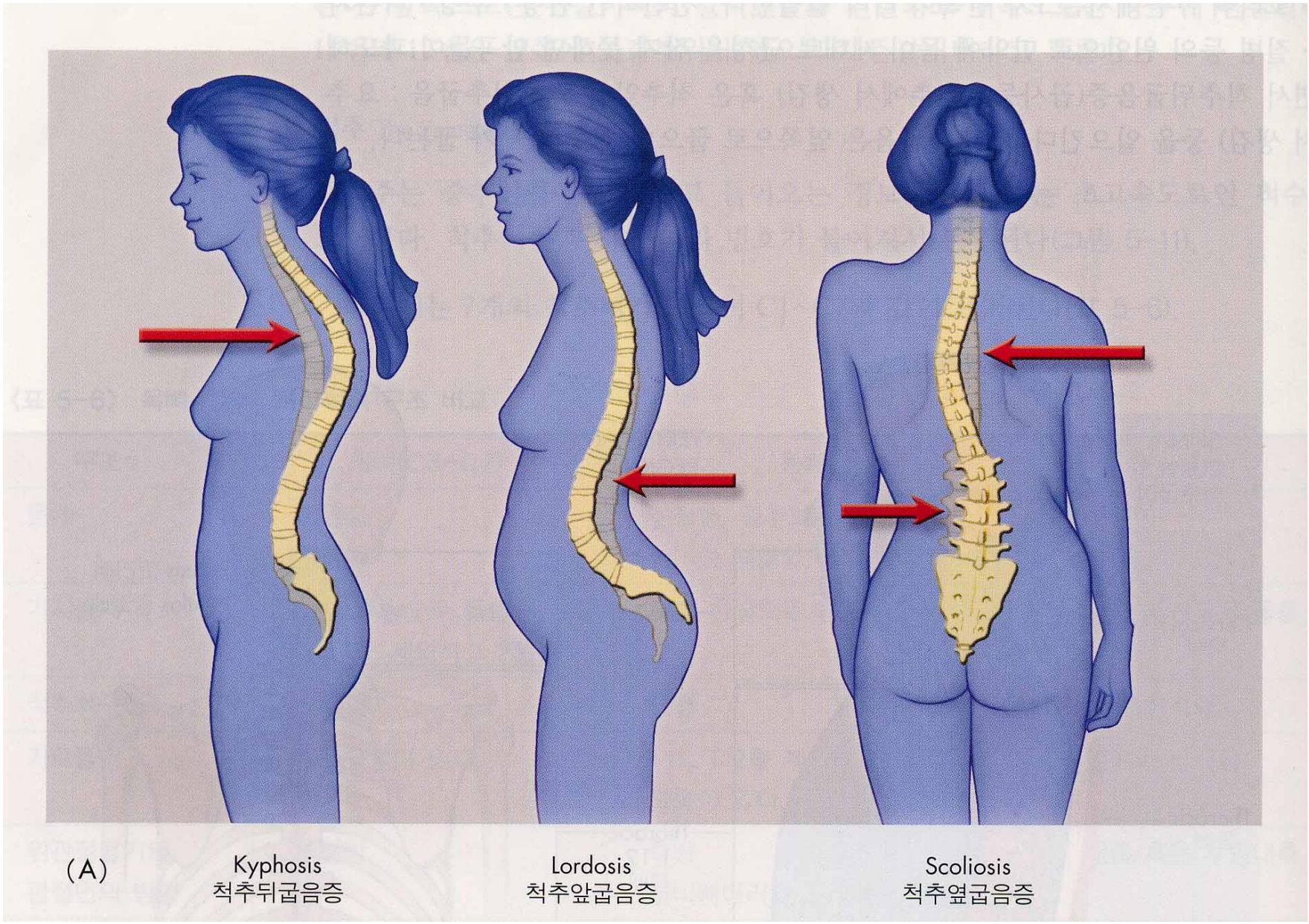




HNP : Herniated Nucleus Pulposus



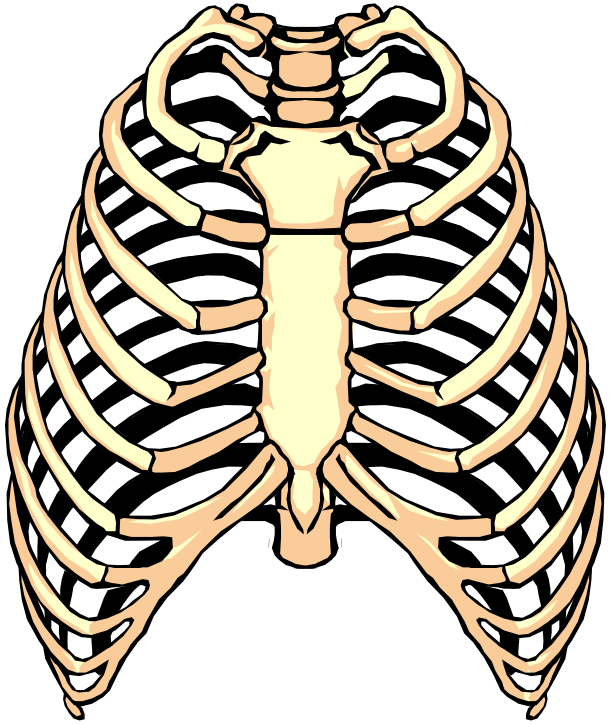



(A)
Kyphosis
척추뒤굽음증
Lordosis
척추앞굽음증
Scoliosis
척추옆굽음증

Structure & Function

Bones of the Chest

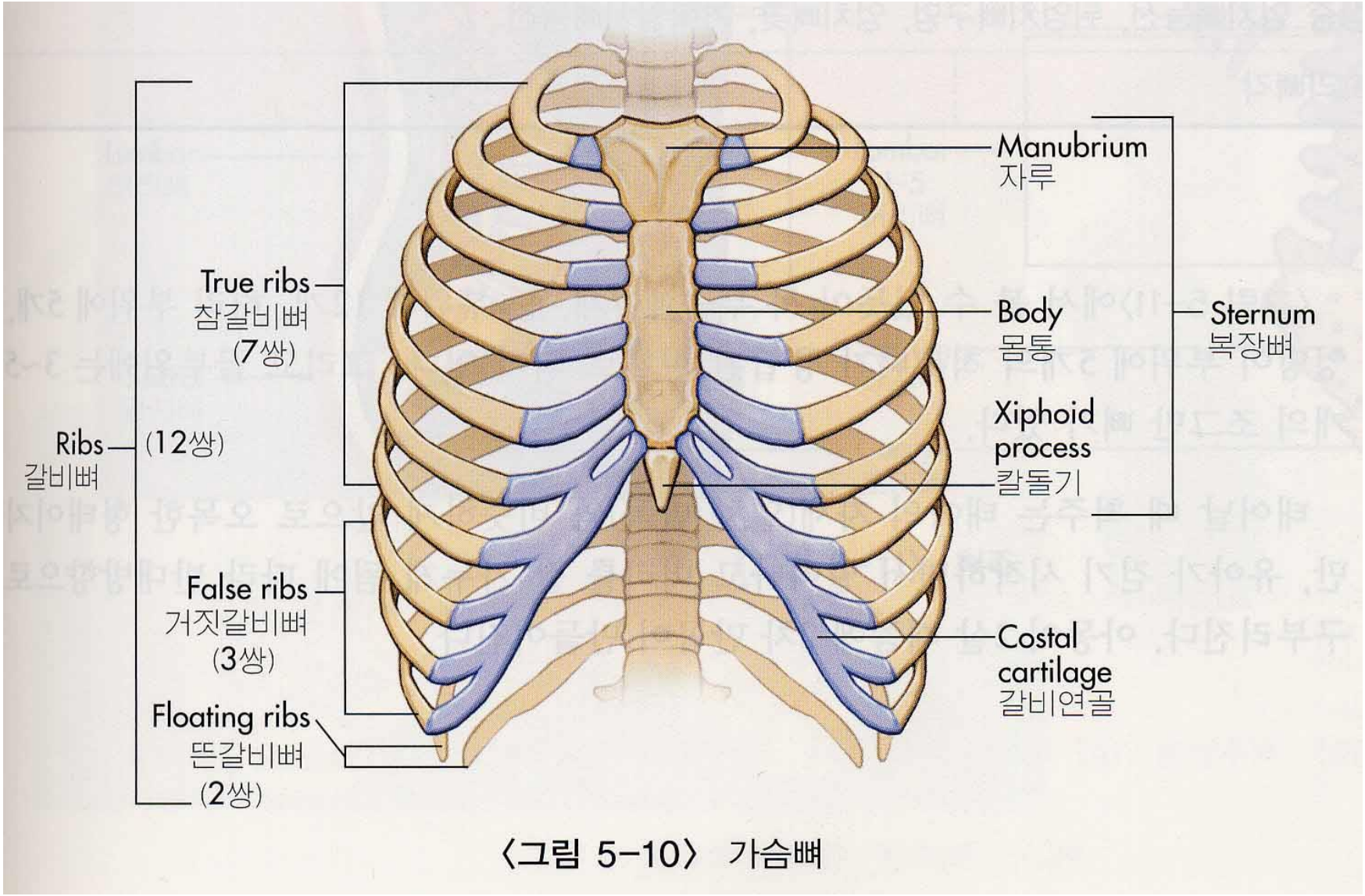
- Clavicle
- Scapula
- Sternum



- True ribs
- False ribs
- Floating ribs

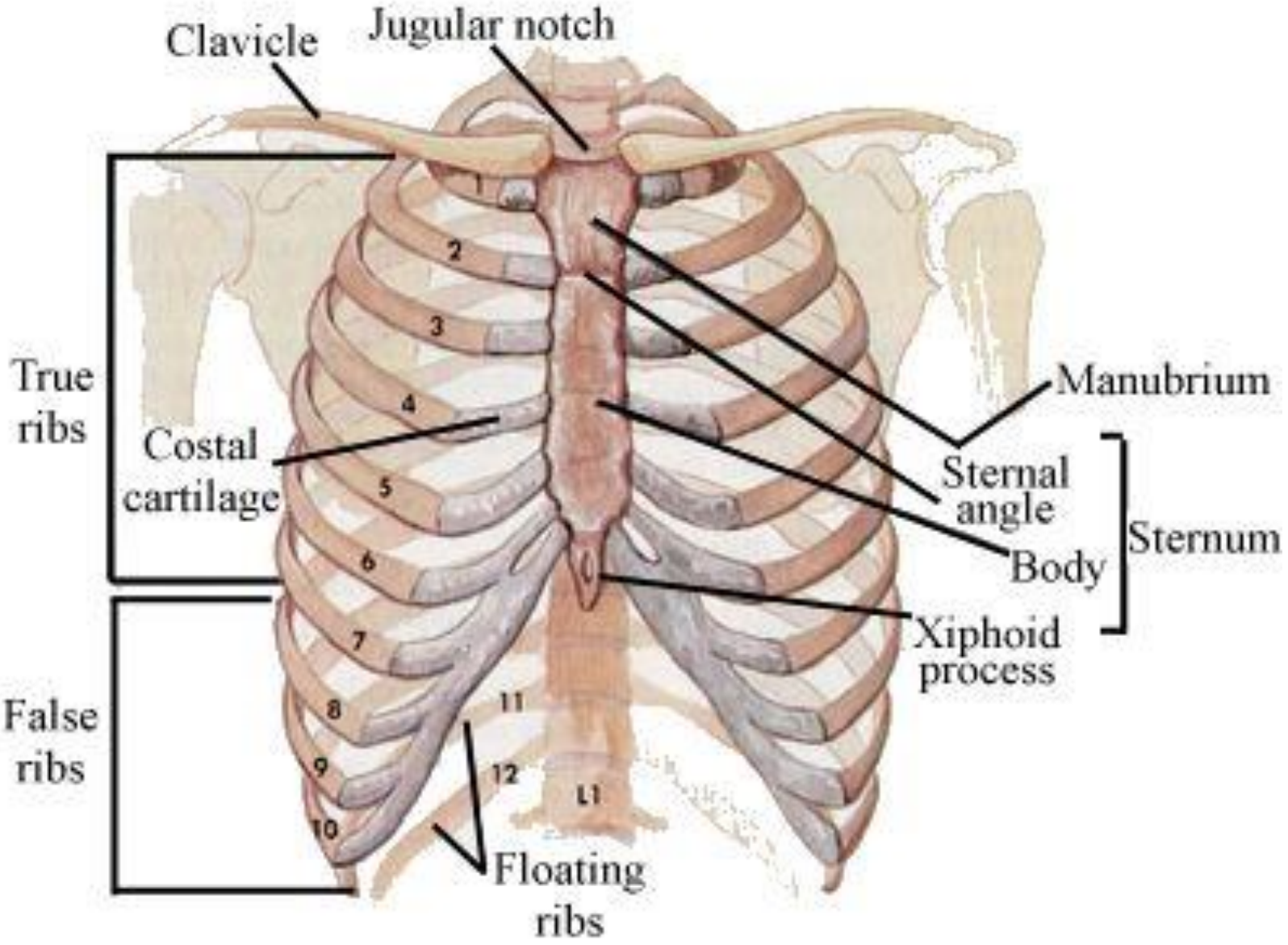
The chest cavity is also referred to as the thoracic cavity.

Human Rib Cage



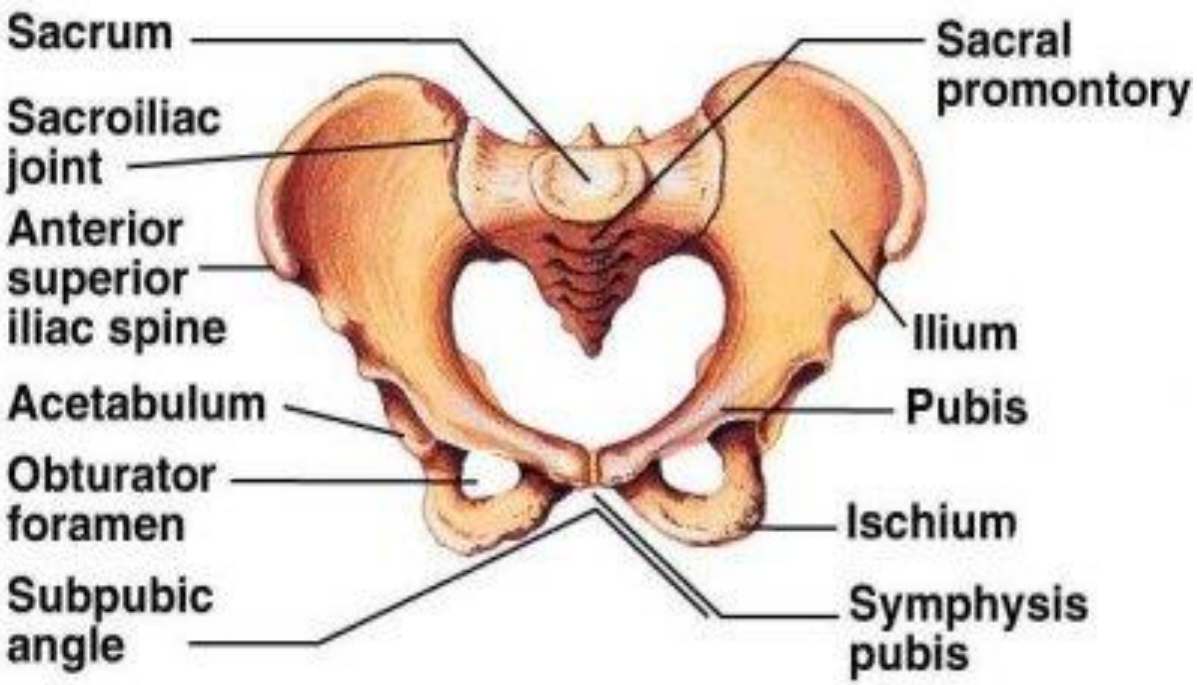
〈그림 5-10〉 가슴뼈

Human Rib Cage



Structure & Function

Bones of the Pelvis



- ilium
- ischium
- pubes
- pelvic cavity

The pubic symphysis is where both pubic bones join.

Structure & Function

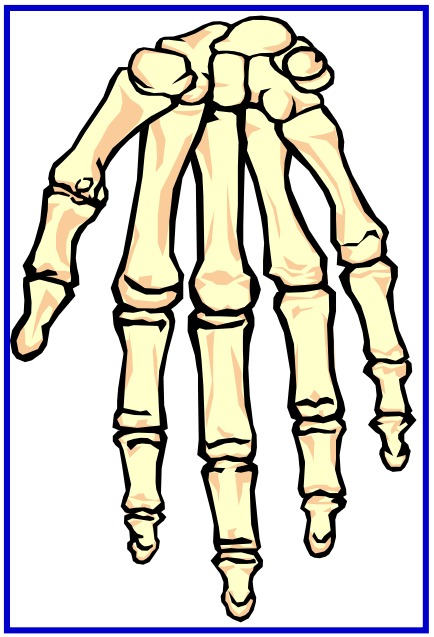
Bones of the Extremities

Upper Arm

- Humerus

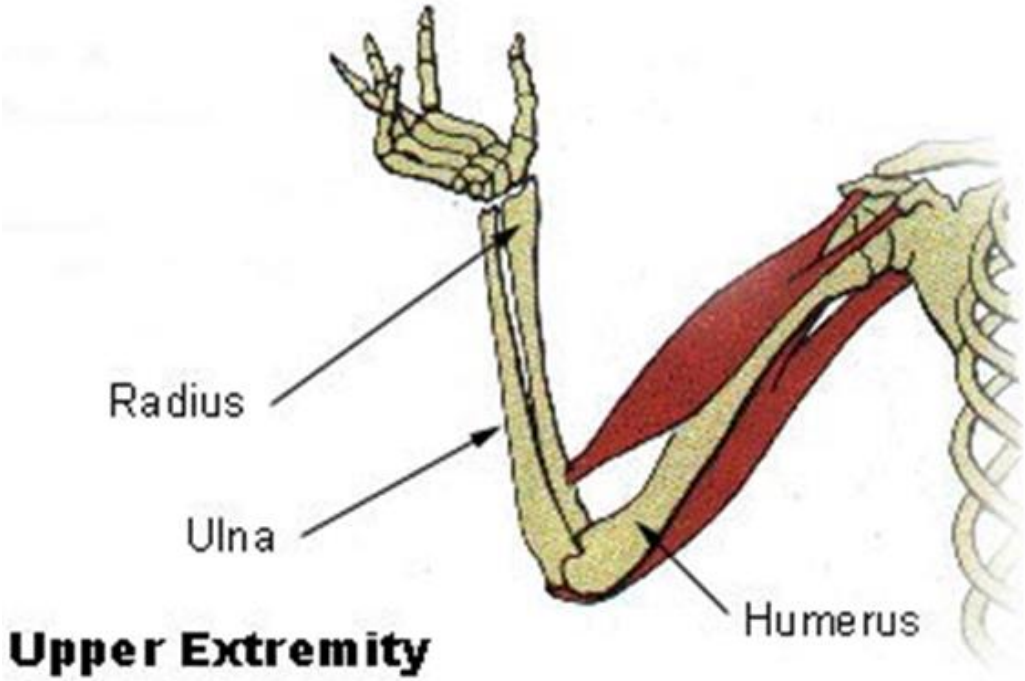
Lower Arm

- Ulna
- Radius



Hand and Fingers

- Carpals (wrist)
- Metacarpals (palm)
- Phalanges (fingers)



Upper Extremity

Structure & Function

Bones of the Extremities (Cont'd)

Upper Leg

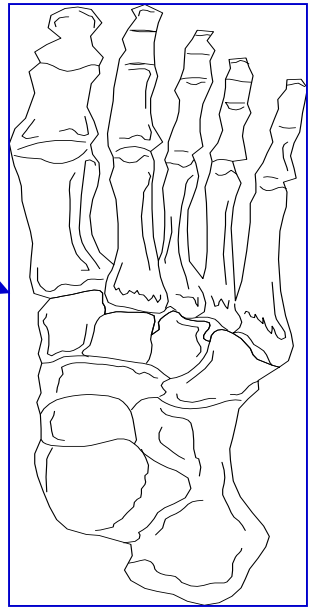
- Femur

Lower leg

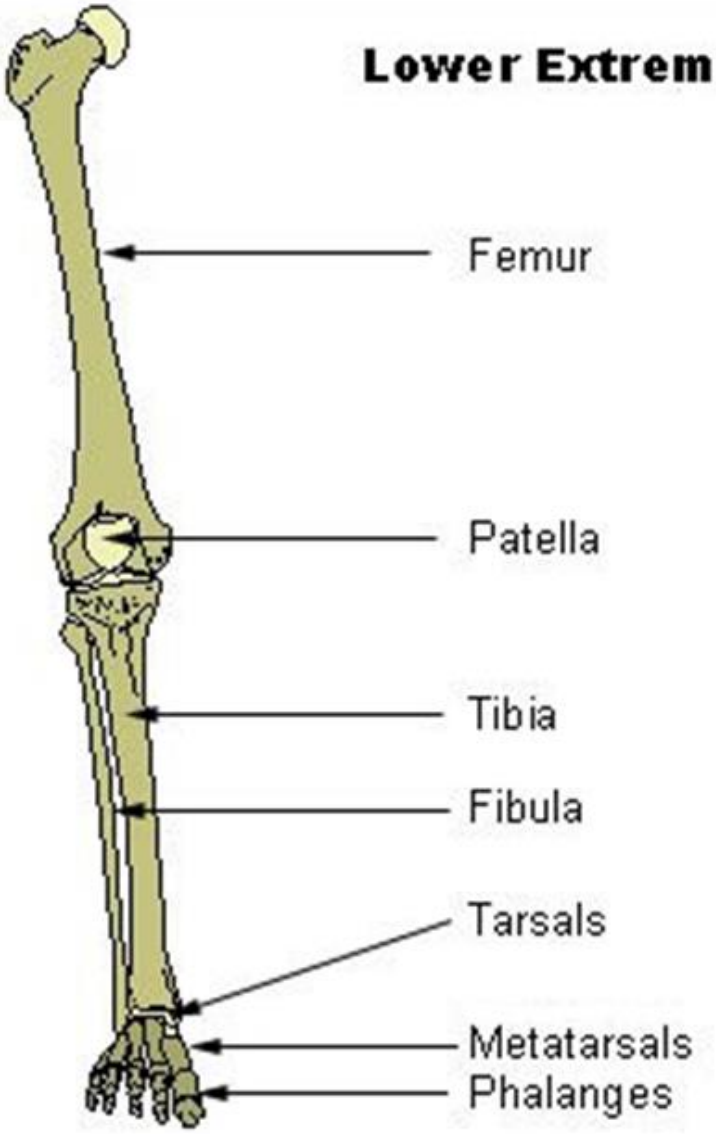
- Tibia (shin)
- Fibula
- Patella (kneecap)

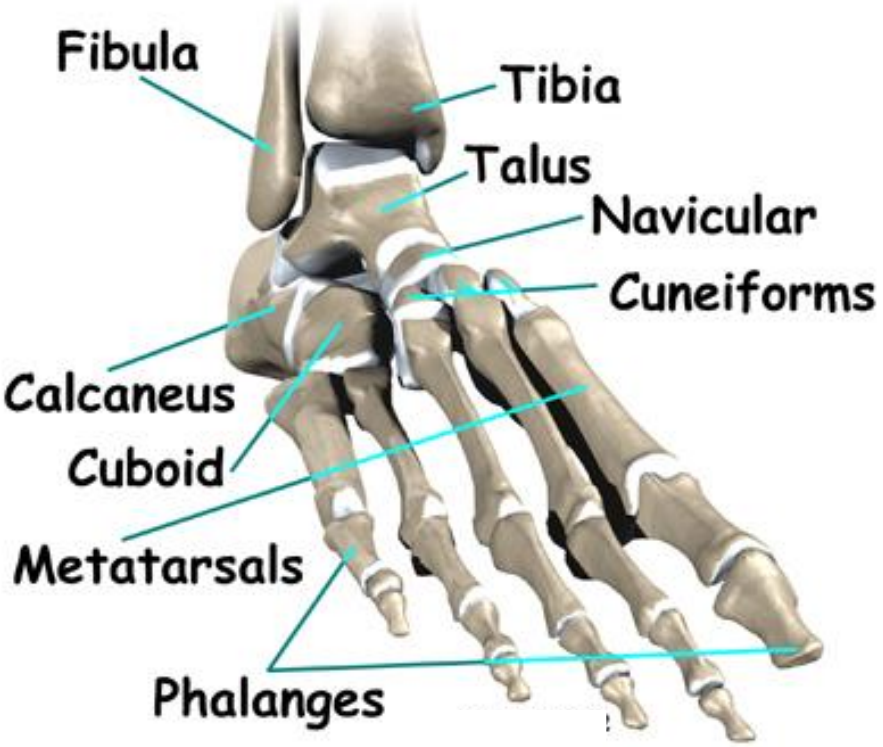
Feet and Toes

- Tarsals
- Calcaneus (heel)
- Metatarsals
- Phalanges



Lower Extremity





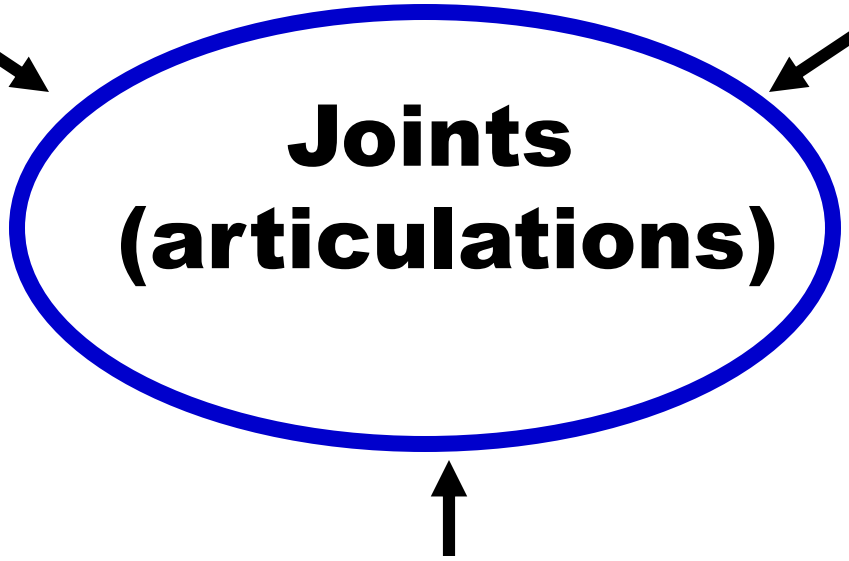
Structure & Function

Amphiarthroses

- Moves slightly

Diarthroses

- Moves freely



Synarthroses

- No movement

Structure & Function

Tendons and Ligaments

Tendons are bands of fibrous tissue that connect muscles to bone.

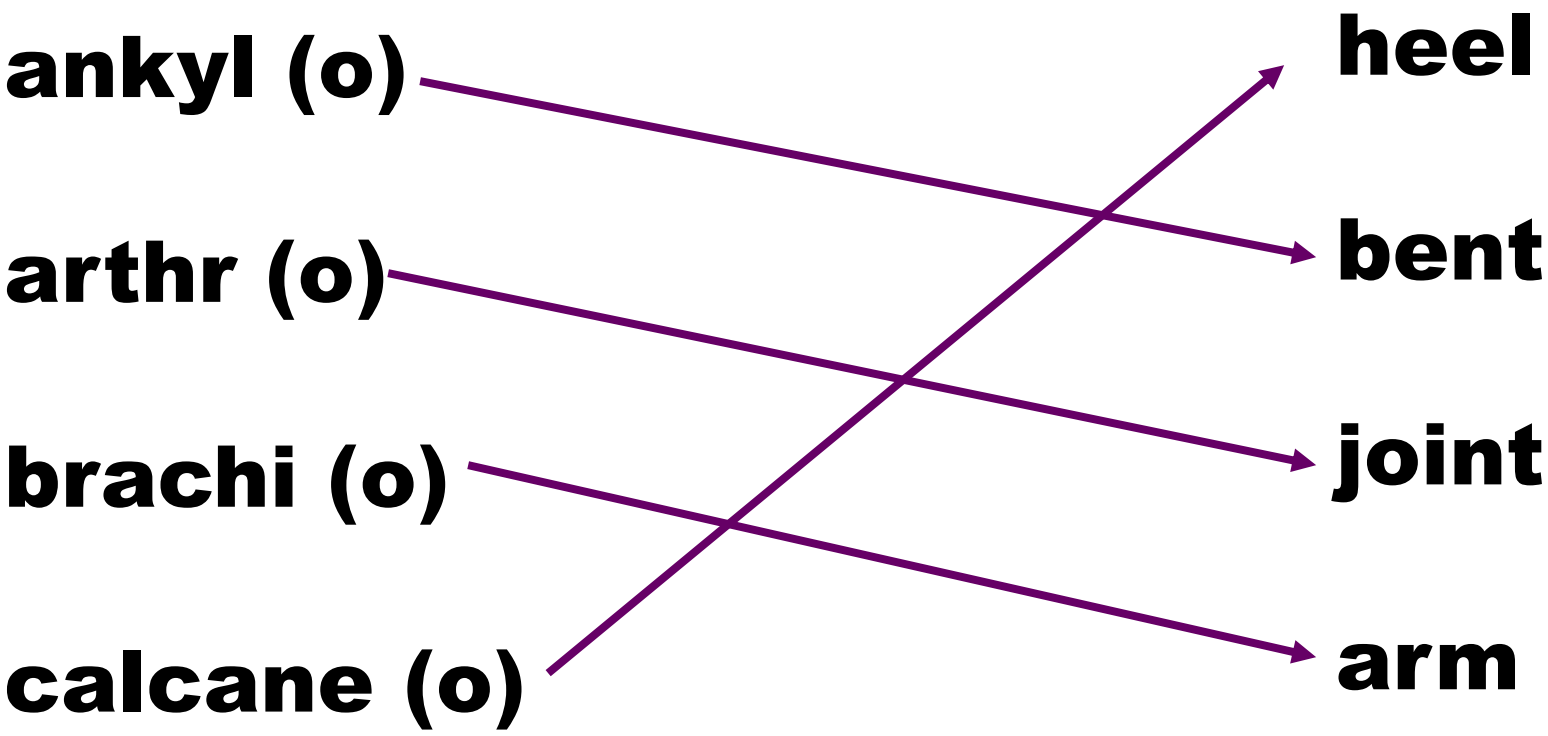
Ligaments connect bones to other bones.

A joint lubricator (**synovial fluid**) helps synovial joints move easier.

Movement occurs at joints with the assistance of **muscles**, tendons and ligaments.

Combining Forms

Match the following combining forms and meanings.



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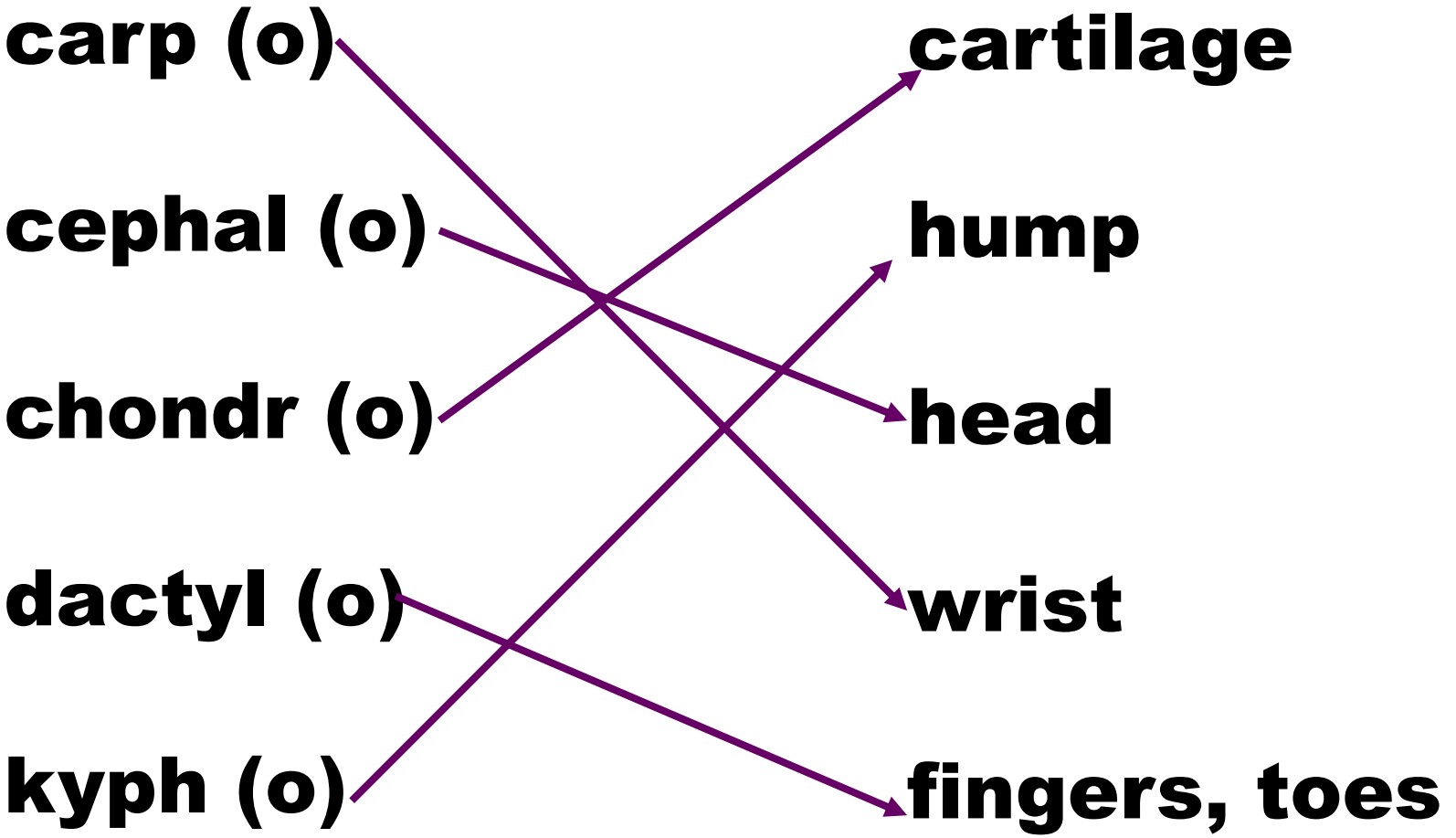

Combining Forms

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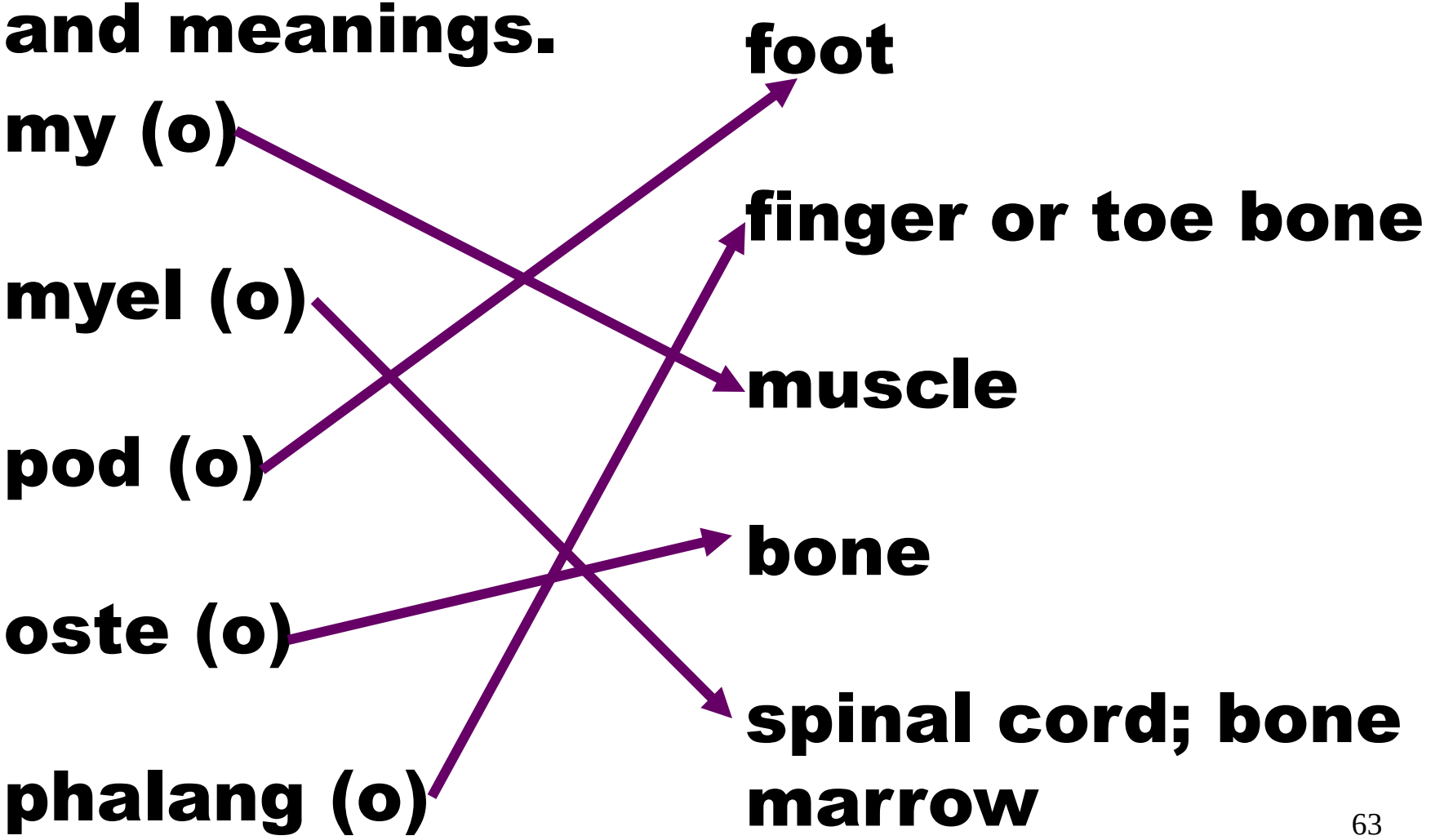

Combining Forms

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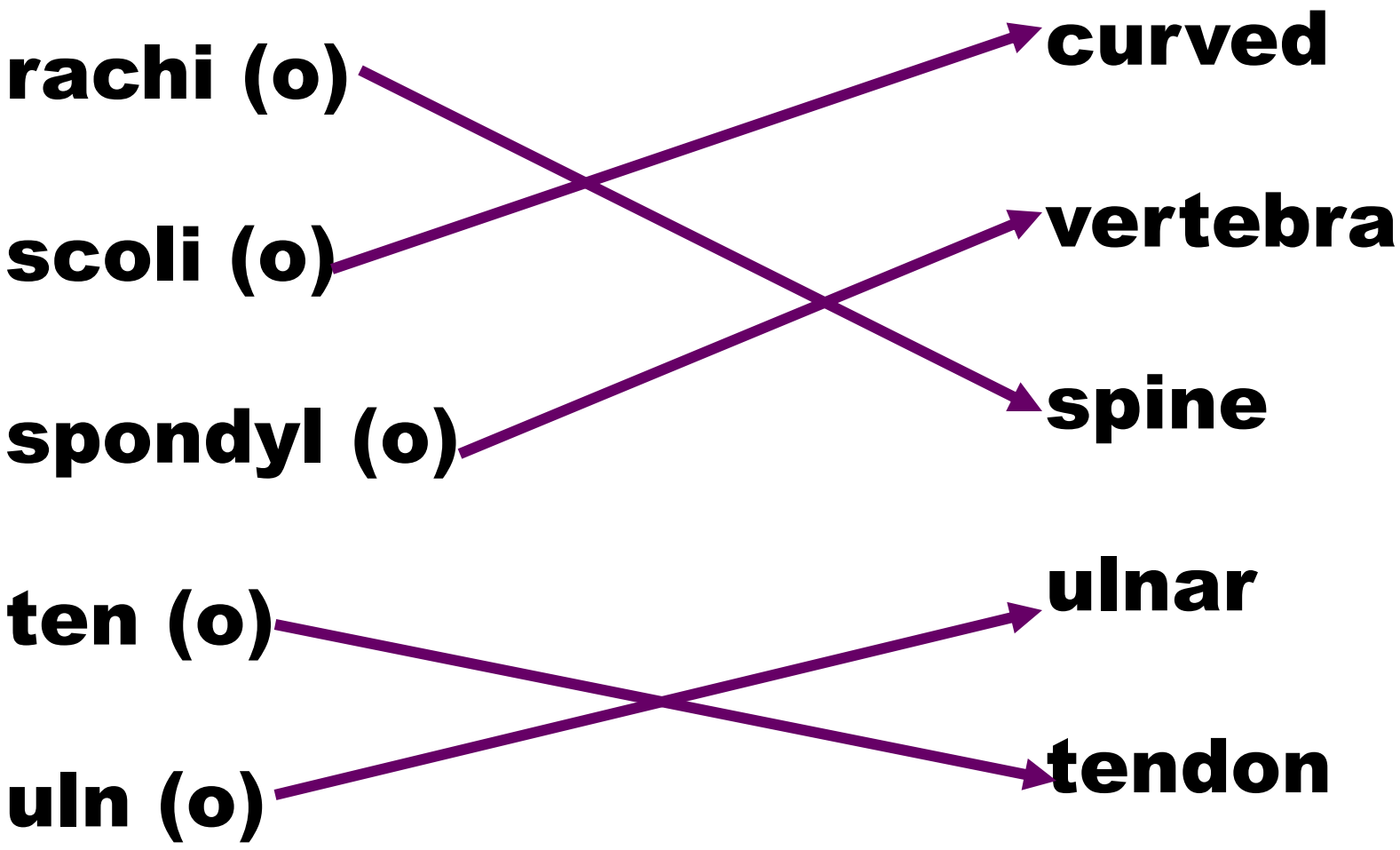


Diagnostic, Procedural, and Laboratory Tests

Performing internal examinations or the use of x-rays, scans, and radiographs are often required to diagnose bone and muscle ailments.

Diagnostic, Procedural, and Laboratory Tests

- Arthrography
- Arthroscopy
- Diskography
- Computed tomography (CT)
- Myelography
- Electromyogram
- Magnetic resonance imaging (MRI)

Diagnostic, Procedural, and Laboratory Tests

Laboratory tests measure the levels of substances found in some musculoskeletal disorders.

Common laboratory tests

- **Rheumatoid factor test**
- **Creatine phosphokinase (CPK)**
- **Calcium**
- **Phosphorus**
- **Uric acid**

Diagnostic, Procedural, and Laboratory Tests

Other Tests

Goniometer
-Tests for ROM

Densitometer
-Measures bone density

Goniometer

Pathology

Causes of musculoskeletal disorders

- Birth defects
- Injury
- Degenerative disease
- Systemic disorders

Pathology

Types of fractures

Complex

Incomplete

Comminuted

Greenstick

Simple (closed)

Compound (open)

Colles'

Impacted

Pathology

- Injury or trauma to the joints or muscle may cause a sprain.
- Overuse of a muscle may cause a strain.

Other conditions:

- Tendinitis
- Dislocation
- Subluxation
- Osteoporosis

Surgical Terms

Reduction is the return of a part to its normal position.

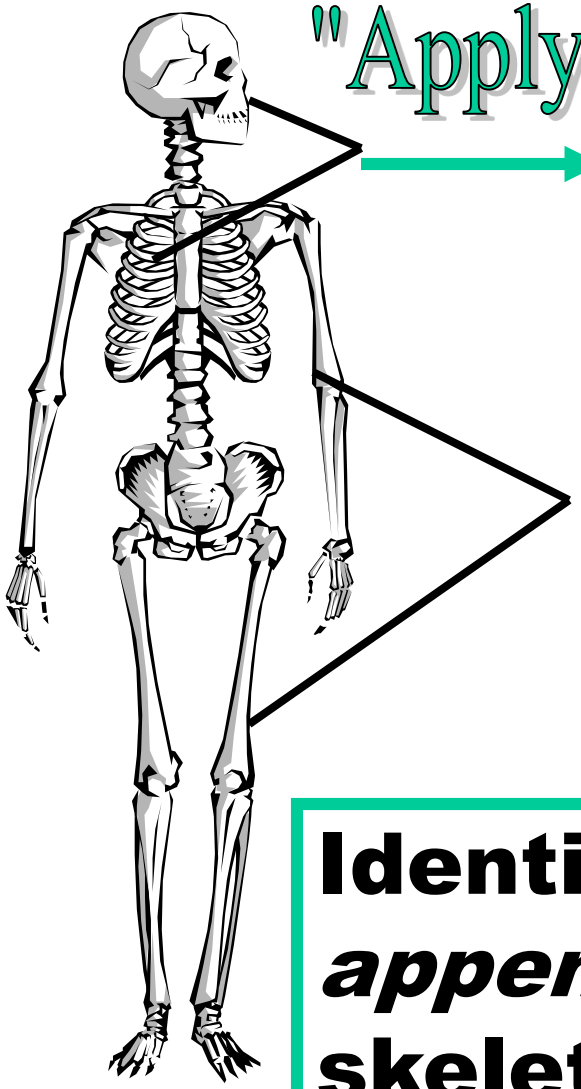
Osteoplasty is repair of a bone.

Tenotomy is the cutting into a tendon to repair a muscle (**myoplasty**).

Arthroplasty is repair of a joint.

Laminectomy is removal of part of a spinal disk.

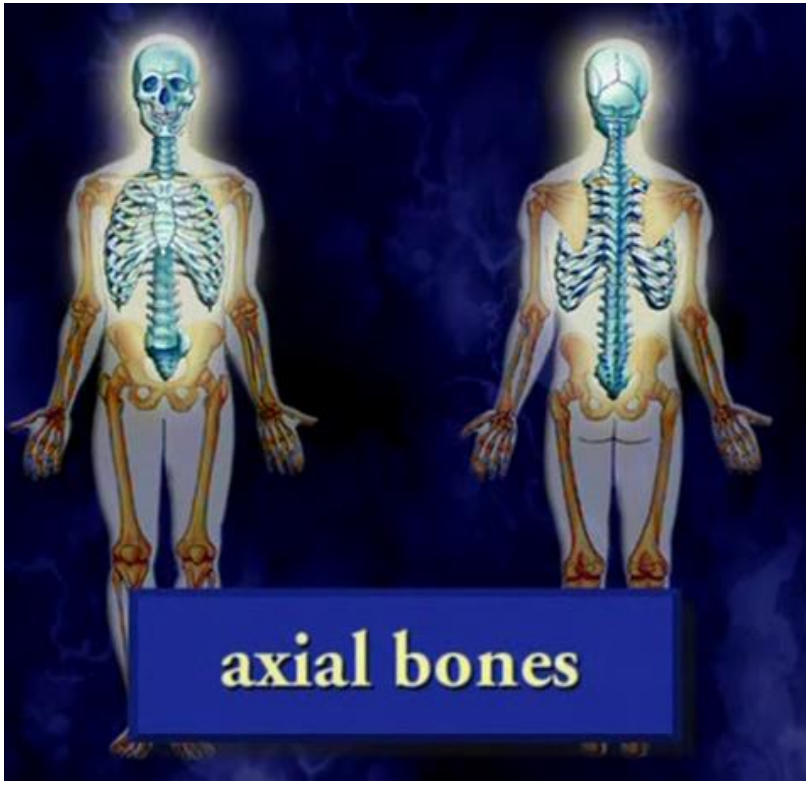
"Apply Your Knowledge"

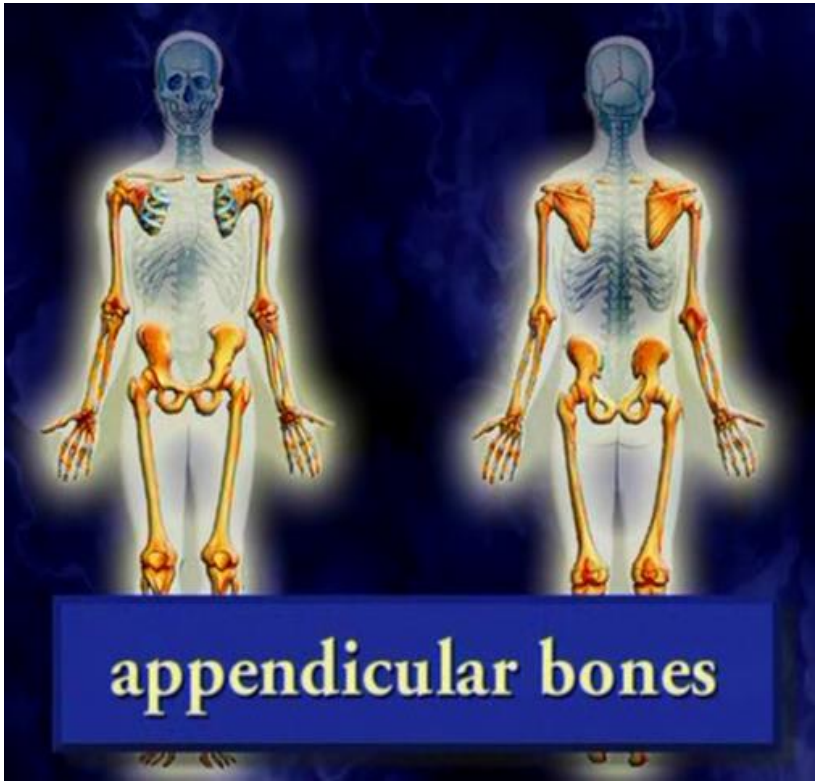


Head & Trunk

Arms & Legs

Identify the *axial* and *appendicular* portions of the skeleton.


axial bones


appendicular bones

"Apply Your Knowledge"

Relieves pain

Reduces swelling

Relieves stiffness

A. steroids

B. analgesics

C. muscle relaxants

Match the correct medication with its action.