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Musculoskeletal System

Anatomy & Physiology

Bones, joints, cartilage and muscles

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Musculoskeletal System - Applied Anatomy Notes for B.Sc. Nursing

1. Introduction

The musculoskeletal system is made up of bones, joints, cartilage, muscles, tendons and ligaments. It provides support, stability and movement to the human body.

The skeletal and muscular systems work together to maintain posture, protect internal organs and produce body movements.

Main Components

1. Bones
2. Joints
3. Cartilage
4. Skeletal muscles
5. Tendons
6. Ligaments

Functions of the Musculoskeletal System

- Provides support and shape to the body.
- Protects internal organs.
- Helps in body movement and locomotion.
- Maintains posture and balance.
- Produces blood cells in bone marrow.
- Stores minerals, especially calcium and phosphorus.
- Stores fat in yellow bone marrow.
- Helps generate body heat through muscle contraction.

2. Skeletal System

Definition

The skeletal system is the framework of the body consisting of bones, cartilage and associated connective tissues.

An adult human skeleton usually contains 206 bones.

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Divisions of the Skeleton

The skeleton is divided into two main parts:

A. Axial Skeleton

The axial skeleton forms the central axis of the body and consists of approximately 80 bones.

It includes:

1. Skull - 22 bones.
2. Auditory ossicles - 6 bones.
3. Hyoid bone - 1 bone.
4. Vertebral column - 26 bones in the adult.
5. Thoracic cage - 25 bones (24 ribs and 1 sternum).

Functions:

- Protects the brain and spinal cord.
- Protects the heart and lungs.
- Supports the head and trunk.

B. Appendicular Skeleton

The appendicular skeleton consists of approximately 126 bones.

It includes:

1. Pectoral girdle - 4 bones.
2. Upper limbs - 60 bones.
3. Pelvic girdle - 2 hip bones.
4. Lower limbs - 60 bones.

Functions:

- Supports the limbs.
- Helps in movement and locomotion.
- Connects the limbs to the axial skeleton.

3. Classification of Bones

Bones are classified according to their shape.

Type

Description

Examples

Long bones

Longer than they are wide

Femur, humerus, tibia

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Short bones

Approximately cube-shaped

Carpals, tarsals

Flat bones

Thin and flattened

Sternum, ribs, skull bones

Irregular bones

Have complex shapes

Vertebrae, hip bones

Sesamoid bones

Develop within tendons

Patella

Pneumatic bones

Contain air-filled spaces

Frontal, ethmoid, sphenoid and maxillary bones

4. Structure of a Long Bone

A typical long bone consists of the following parts:

1. Diaphysis

- Long central shaft of the bone.
- Mainly composed of compact bone.
- Contains the medullary cavity.

2. Epiphysis

- Expanded ends of a long bone.
- Mainly composed of spongy bone with a thin outer layer of compact bone.
- Forms part of a joint surface.

3. Metaphysis

- Region between the diaphysis and epiphysis.
- Contains the epiphyseal plate in growing bones.
- Responsible for longitudinal bone growth.

4. Periosteum

- Tough connective tissue covering the outer surface of bone, except at articular surfaces.
- Contains blood vessels and nerves.

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- Helps in bone growth, repair and nourishment.

5. Endosteum

- Thin membrane lining the medullary cavity and internal bone surfaces.
- Contains bone-forming and bone-resorbing cells.

6. Medullary Cavity

- Central cavity in the shaft of long bones.
- Contains bone marrow.

7. Articular Cartilage

- Hyaline cartilage covering the ends of bones at synovial joints.
- Reduces friction and absorbs shock.

5. Microscopic Structure of Bone

Bone is a specialised connective tissue consisting of cells and a mineralised extracellular matrix.

Bone Cells

Cell

Function

Osteoblasts

Form new bone

Osteocytes

Maintain bone tissue

Osteoclasts

Break down and resorb bone

Osteoprogenitor cells

Develop into osteoblasts

Types of Bone Tissue

1. Compact Bone
   - Dense and hard outer bone tissue.
   - Provides strength and support.
   - Organised into structural units called osteons (Haversian systems).
2. Spongy Bone
   - Also called cancellous or trabecular bone.
   - Contains a network of bony trabeculae.
   - Found mainly at the ends of long bones and inside flat and irregular bones.

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- Contains marrow spaces.

6. Bone Marrow

Bone marrow is soft tissue found within bone cavities.

Types of Bone Marrow

1. Red Bone Marrow
   - Responsible for blood cell production (haematopoiesis).
   - Produces red blood cells, white blood cells and platelets.
   - Found mainly in the pelvis, sternum, ribs, vertebrae and other selected bones in adults.
2. Yellow Bone Marrow
   - Mainly consists of fat cells.
   - Stores energy in the form of fat.
   - May convert to red marrow under certain conditions of increased blood cell demand.

7. Functions of Bones

- Support the body.
- Protect vital organs.
- Provide attachment for muscles.
- Help in movement by acting as levers.
- Store calcium and phosphorus.
- Produce blood cells through red bone marrow.
- Store fat in yellow bone marrow.

8. Major Bones of the Human Body

A. Skull

The skull protects the brain and forms the framework of the face.

It consists of 22 bones:

Cranial Bones - 8

1. Frontal - 1
2. Parietal - 2
3. Temporal - 2
4. Occipital - 1
5. Sphenoid - 1
6. Ethmoid - 1

Facial Bones - 14

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1. Maxillae - 2
2. Zygomatic - 2
3. Nasal - 2
4. Lacrimal - 2
5. Palatine - 2
6. Inferior nasal conchae - 2
7. Vomer - 1
8. Mandible - 1

B. Vertebral Column

The vertebral column supports the head and trunk and protects the spinal cord.

It consists of 33 vertebrae during development, which form 26 bones in the adult because the sacral and coccygeal vertebrae fuse.

Region

Number of Vertebrae

Cervical

7

Thoracic

12

Lumbar

5

Sacral

5 fused

Coccygeal

Usually 4 fused

Functions:

- Supports the head and trunk.
- Protects the spinal cord.
- Provides attachment to ribs and muscles.
- Allows flexibility and movement.
- Transmits body weight to the pelvis.

C. Thoracic Cage

The thoracic cage protects the heart and lungs.

It consists of:

- Sternum - 1

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- Ribs - 12 pairs
- Thoracic vertebrae - 12

Types of Ribs

Type

Number

Description

True ribs

7 pairs

Attach directly to the sternum through their own costal cartilage

False ribs

3 pairs

Attach indirectly to the sternum through the cartilage above

Floating ribs

2 pairs

Have no anterior attachment to the sternum

D. Upper Limb Bones

Each upper limb contains 30 bones.

Bone Group

Bones

Arm

Humerus - 1

Forearm

Radius - 1, Ulna - 1

Wrist

8 carpal bones

Palm

5 metacarpals

Fingers

14 phalanges

E. Lower Limb Bones

Each lower limb contains 30 bones.

Bone Group

Bones

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Thigh

Femur - 1

Knee

Patella - 1

Leg

Tibia - 1, Fibula - 1

Ankle

7 tarsal bones

Foot

5 metatarsals

Toes

14 phalanges

Important: The femur is the longest and strongest bone in the human body.

9. Joints

Definition

A joint, also called an articulation, is the site where two or more bones meet or where a bone meets cartilage.

Joints provide stability and allow movement.

Classification of Joints

Joints are classified structurally into three main types.

A. Fibrous Joints

- Bones are connected by dense fibrous connective tissue.
- Usually allow little or no movement.
- Do not have a joint cavity.

Examples:

- Sutures of the skull.
- Syndesmosis between the tibia and fibula.
- Gomphosis between a tooth and its socket.

B. Cartilaginous Joints

- Bones are connected by cartilage.
- Allow limited movement or no movement.

Types:

1. Primary Cartilaginous Joints (Synchondroses)

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- Bones are joined by hyaline cartilage.
- Usually temporary and immovable.
- Example: Epiphyseal growth plate.

2. Secondary Cartilaginous Joints (Symphyses)

- Bones are joined by fibrocartilage.
- Allow slight movement.
- Examples: Pubic symphysis and intervertebral discs.

C. Synovial Joints

- Freely movable joints.
- Have a joint cavity containing synovial fluid.
- Covered by an articular capsule.

Main Components:

1. Articular cartilage.
2. Joint cavity.
3. Synovial fluid.
4. Fibrous joint capsule.
5. Synovial membrane.
6. Supporting ligaments.

Types of Synovial Joints

Type

Movement

Example

Plane (gliding)

Sliding movement

Intercarpal joints

Hinge

Flexion and extension

Elbow, interphalangeal joints

Pivot

Rotation

Atlanto-axial joint

Condyloid (ellipsoid)

Flexion, extension, abduction and adduction

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Wrist joint

Saddle

Movement in two planes

First carpometacarpal joint

Ball-and-socket

Movement in multiple directions, including rotation

Shoulder and hip joints

Movements at Joints

Movement

Meaning

Flexion

Decreases the angle between bones

Extension

Increases the angle between bones

Abduction

Movement away from the midline

Adduction

Movement towards the midline

Rotation

Turning around an axis

Circumduction

Circular movement combining several movements

Pronation

Rotation of forearm so the palm faces posteriorly in anatomical position

Supination

Rotation of forearm so the palm faces anteriorly in anatomical position

Dorsiflexion

Movement of the foot upwards

Plantar flexion

Movement of the foot downwards

Functions of Joints

- Connect bones.
- Allow movement.

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- Provide stability.
- Support body weight.
- Help maintain posture.
- Reduce friction between articulating bones.

10. Cartilage

Definition

Cartilage is a specialised connective tissue that provides flexible support, cushioning and smooth surfaces at joints.

It is firm but more flexible than bone.

Characteristics of Cartilage

- Made of specialised cells called chondrocytes.
- Chondrocytes are present in spaces called lacunae.
- Has a firm extracellular matrix.
- Usually lacks blood vessels and nerves.
- Receives nutrients by diffusion.
- Repairs slowly because of its limited blood supply.

Types of Cartilage

A. Hyaline Cartilage

- Most common type of cartilage.
- Smooth and glass-like appearance.
- Provides support and reduces friction.

Locations:

- Articular surfaces of bones.
- Costal cartilages.
- Nose.
- Trachea and bronchi.
- Embryonic skeleton.

B. Fibrocartilage

- Strongest type of cartilage.
- Contains thick bundles of collagen fibres.
- Resists compression and tensile forces.

Locations:

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- Intervertebral discs.
- Pubic symphysis.
- Menisci of the knee.

C. Elastic Cartilage

- Contains numerous elastic fibres.
- Provides flexible support.
- Maintains shape after bending.

Locations:

- External ear (auricle).
- Epiglottis.
- Auditory tube.

Functions of Cartilage

- Provides smooth joint surfaces.
- Reduces friction during movement.
- Absorbs shock.
- Supports soft tissues.
- Maintains the shape of certain structures.
- Helps in skeletal development and bone growth.

11. Muscular System

Definition

The muscular system consists of specialised tissues capable of contraction and relaxation to produce movement, maintain posture and generate heat.

The human body has more than 600 skeletal muscles.

Functions of Muscles

- Produce body movement.
- Maintain posture and body position.
- Stabilise joints.
- Generate heat.
- Support breathing.
- Assist circulation through skeletal muscle contractions.
- Help in swallowing and digestion.
- Protect and support internal organs.

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Types of Muscles

There are three main types of muscle tissue.

A. Skeletal Muscle

- Attached mainly to bones by tendons.
- Voluntary in control.
- Striated in appearance.
- Responsible for body movement and posture.
- Usually multinucleated.

Examples: Biceps, triceps, quadriceps and gastrocnemius.

B. Smooth Muscle

- Non-striated.
- Involuntary in control.
- Found in the walls of hollow organs and blood vessels.
- Helps move substances through internal organs.

Examples:

- Intestinal walls.
- Urinary bladder.
- Uterus.
- Blood vessels.

C. Cardiac Muscle

- Found only in the heart.
- Striated and involuntary.
- Contains branched muscle cells.
- Cells are connected by intercalated discs.
- Responsible for pumping blood.

Comparison of Three Types of Muscles

Feature

Skeletal

Smooth

Cardiac

Control

Voluntary

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Involuntary

Involuntary

Appearance

Striated

Non-striated

Striated

Location

Attached mainly to bones

Walls of hollow organs

Heart

Cell shape

Long, cylindrical

Spindle-shaped

Branched

Nuclei

Multiple

One

Usually one

Function

Body movement

Movement of substances

Pumps blood

12. Structure of Skeletal Muscle

A skeletal muscle is organised into several levels.

1. Whole muscle: Covered by connective tissue called epimysium.
2. Fascicles: Bundles of muscle fibres surrounded by perimysium.
3. Muscle fibres: Individual muscle cells surrounded by endomysium.
4. Myofibrils: Contractile structures within muscle fibres.
5. Sarcomeres: Repeating functional contractile units of myofibrils.
6. Myofilaments: Mainly actin (thin) and myosin (thick) filaments.

Important Muscle Structures

- Sarcolemma: Cell membrane of a muscle fibre.
- Sarcoplasm: Cytoplasm of a muscle fibre.

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- Sarcoplasmic reticulum: Stores and releases calcium ions needed for contraction.
- T-tubules: Carry electrical impulses into the muscle fibre.

13. Classification of Skeletal Muscles

Muscles may be classified according to shape, location and action.

According to Shape

- Fusiform - spindle-shaped; example: biceps brachii.
- Circular - arranged around openings; example: orbicularis oculi.
- Flat - broad and thin; example: external oblique.
- Convergent - broad origin with fibres converging towards a tendon; example: pectoralis major.
- Pennate - fibres arranged obliquely to the tendon; examples: rectus femoris and deltoid.

According to Action

- Flexors - produce flexion.
- Extensors - produce extension.
- Abductors - move a part away from the midline.
- Adductors - move a part towards the midline.
- Rotators - produce rotation.
- Levators - raise a body part.
- Depressors - lower a body part.

14. Major Muscles of the Human Body

A. Muscles of the Head and Neck

Muscle

Main Function

Frontalis

Raises eyebrows

Orbicularis oculi

Closes eyelids

Orbicularis oris

Closes and protrudes lips

Masseter

Elevates mandible during chewing

Temporalis

Elevates and retracts mandible

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Sternocleidomastoid

Flexes neck and rotates head

Trapezius

Moves and stabilises scapula; helps extend neck

B. Muscles of the Trunk

Muscle

Main Function

Pectoralis major

Adducts and medially rotates arm

Intercostal muscles

Assist breathing

Diaphragm

Main muscle of inspiration

Rectus abdominis

Flexes trunk

External oblique

Rotates and flexes trunk

Latissimus dorsi

Extends, adducts and medially rotates arm

Erector spinae

Extends and supports vertebral column

C. Muscles of the Upper Limb

Muscle

Main Function

Deltoid

Abducts arm

Biceps brachii

Flexes elbow and supinates forearm

Triceps brachii

Extends elbow

Brachialis

Flexes elbow

Flexor carpi radialis

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Flexes and abducts wrist

Extensor carpi radialis

Extends and abducts wrist

D. Muscles of the Lower Limb

Muscle

Main Function

Gluteus maximus

Extends and laterally rotates hip

Gluteus medius

Abducts hip and stabilises pelvis

Iliopsoas

Flexes hip

Quadriceps femoris

Extends knee

Hamstrings

Flex knee and extend hip

Gastrocnemius

Plantar flexes foot and assists knee flexion

Soleus

Plantar flexes foot

Tibialis anterior

Dorsiflexes and inverts foot

15. Tendons and Ligaments

Tendons

Tendons are strong bands of dense connective tissue that connect muscles to bones.

Functions:

- Transfer the force of muscle contraction to bones.
- Help produce movement.
- Stabilise certain joints.

Ligaments

Ligaments are strong bands of connective tissue that connect bone to bone.

Functions:

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- Stabilise joints.
- Limit excessive movement.
- Help prevent joint dislocation.

Difference Between Tendons and Ligaments

Feature

Tendons

Ligaments

Connection

Muscle to bone

Bone to bone

Main function

Transmit muscle force

Stabilise joints

Tissue

Dense connective tissue

Dense connective tissue

Role in movement

Produce movement through muscle force

Guide and limit joint movement

16. Common Musculoskeletal Disorders

Disorder

Description

Fracture

Break or disruption in the continuity of a bone

Osteoporosis

Reduced bone strength with increased fracture risk

Osteoarthritis

Degenerative joint disease

Rheumatoid arthritis

Chronic autoimmune inflammatory joint disease

Gout

Inflammatory arthritis due to monosodium urate crystal deposition

Scoliosis

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Abnormal lateral curvature of the spine

Kyphosis

Excessive posterior curvature of the thoracic spine

Lordosis

Excessive inward curvature of the lumbar spine

Sprain

Injury to a ligament

Strain

Injury to a muscle or tendon

Muscular dystrophy

Group of inherited disorders causing progressive muscle weakness

Tendinitis

Inflammation or irritation of a tendon

17. Nursing Importance of the Musculoskeletal System

Knowledge of the musculoskeletal system helps nurses to:

- Assess mobility, posture and gait.
- Assess joint range of motion.
- Identify swelling, deformity and tenderness.
- Monitor patients with fractures and joint injuries.
- Provide safe positioning and body alignment.
- Prevent pressure injuries and contractures.
- Assist patients with mobility and rehabilitation.
- Provide care to patients with casts, splints and traction.
- Encourage prescribed exercises and early mobilisation.
- Educate patients about bone health, nutrition and fall prevention.
- Observe for complications such as neurovascular impairment after fractures or casting.

Important nursing assessment: Check the six Ps of acute limb neurovascular compromise:

- Pain
- Pallor
- Pulselessness
- Paraesthesia
- Paralysis
- Poikilothermia (abnormal coldness)

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18. Important Examination Questions

Long Answer Questions

1. Describe the structure and functions of the human skeleton.
2. Explain the classification and structure of bones.
3. Describe the types of joints with suitable examples.
4. Explain the structure and functions of skeletal muscles.
5. Describe the classification of muscles with examples.
6. Explain the structure and functions of cartilage.

Short Answer Questions

1. Differentiate between axial and appendicular skeleton.
2. Write the classification of bones.
3. Describe the structure of a long bone.
4. Explain the functions of bone marrow.
5. Differentiate between compact and spongy bone.
6. Classify joints with examples.
7. Write the types of synovial joints.
8. Differentiate between tendons and ligaments.
9. Describe the three types of muscle tissue.
10. Write the functions of cartilage.

Very Short Answer Questions

1. How many bones are present in an adult human skeleton? - Usually 206.
2. Which is the longest bone in the body? - Femur.
3. Which is the smallest bone in the body? - Stapes.
4. Which bone forms the kneecap? - Patella.
5. How many cervical vertebrae are present? - Seven.
6. Which cells form bone? - Osteoblasts.
7. Which cells break down bone? - Osteoclasts.
8. Which joint is present at the shoulder? - Ball-and-socket joint.
9. Which cartilage is found in the external ear? - Elastic cartilage.
10. Which cartilage is found in intervertebral discs? - Fibrocartilage.
11. Which muscle is responsible for inspiration? - Diaphragm.
12. Which muscle tissue is found in the heart? - Cardiac muscle.

13. What connects muscle to bone? - Tendon.

14. What connects bone to bone? - Ligament.

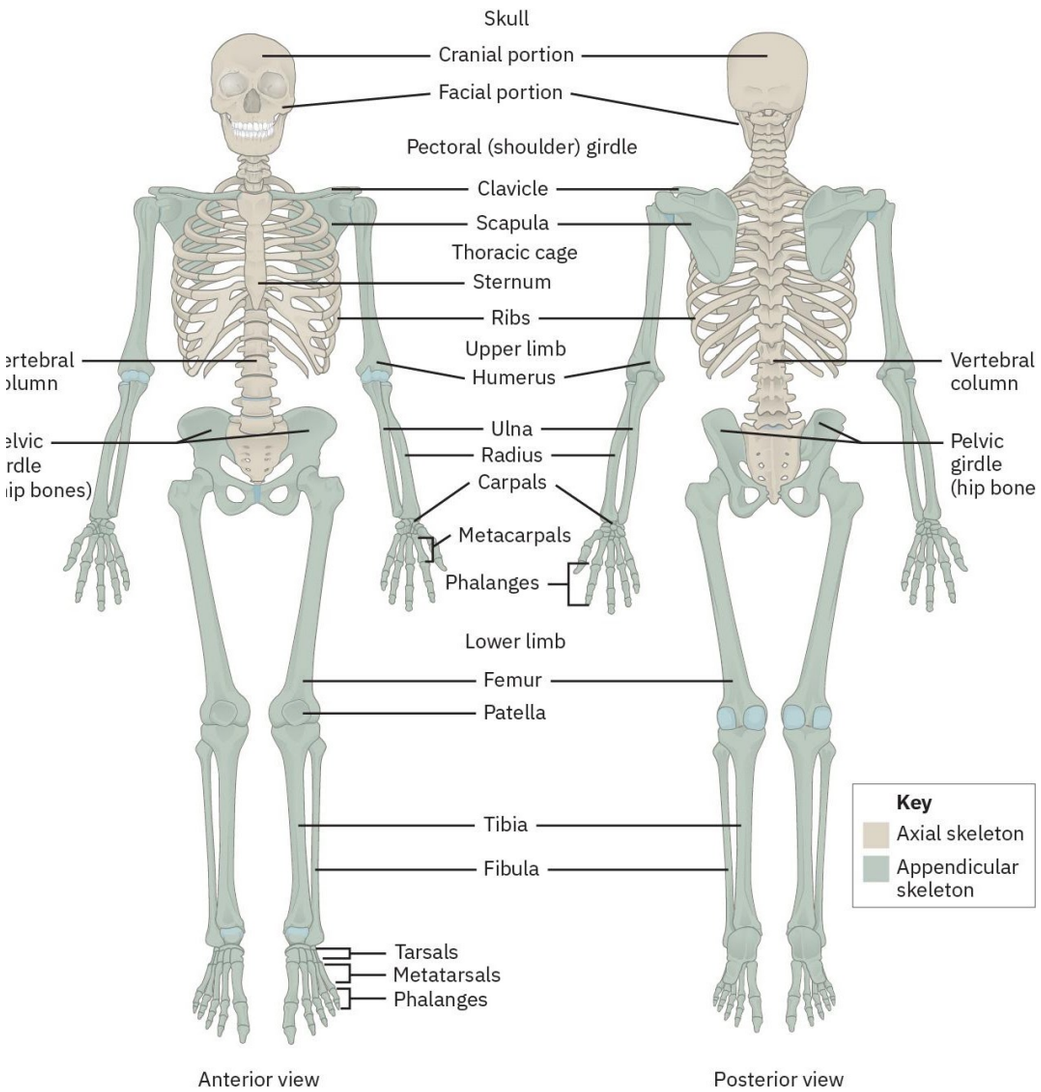
19. Quick Revision

- Adult human skeleton usually contains 206 bones.
- Skeleton is divided into axial and appendicular parts.
- Axial skeleton contains approximately 80 bones.
- Appendicular skeleton contains approximately 126 bones.
- Femur is the longest bone.
- Stapes is the smallest bone.
- Osteoblasts form bone.
- Osteoclasts resorb bone.
- Osteocytes maintain bone tissue.
- Red bone marrow produces blood cells.
- Yellow bone marrow stores fat.
- Joints connect bones.
- Synovial joints are freely movable.
- Hyaline cartilage is the most common type.
- Fibrocartilage is found in intervertebral discs.
- Elastic cartilage is found in the external ear.
- Skeletal muscle is voluntary and striated.
- Smooth muscle is involuntary and non-striated.
- Cardiac muscle is involuntary and striated.
- Tendons connect muscle to bone.
- Ligaments connect bone to bone.
- The diaphragm is the main muscle of inspiration.

Conclusion

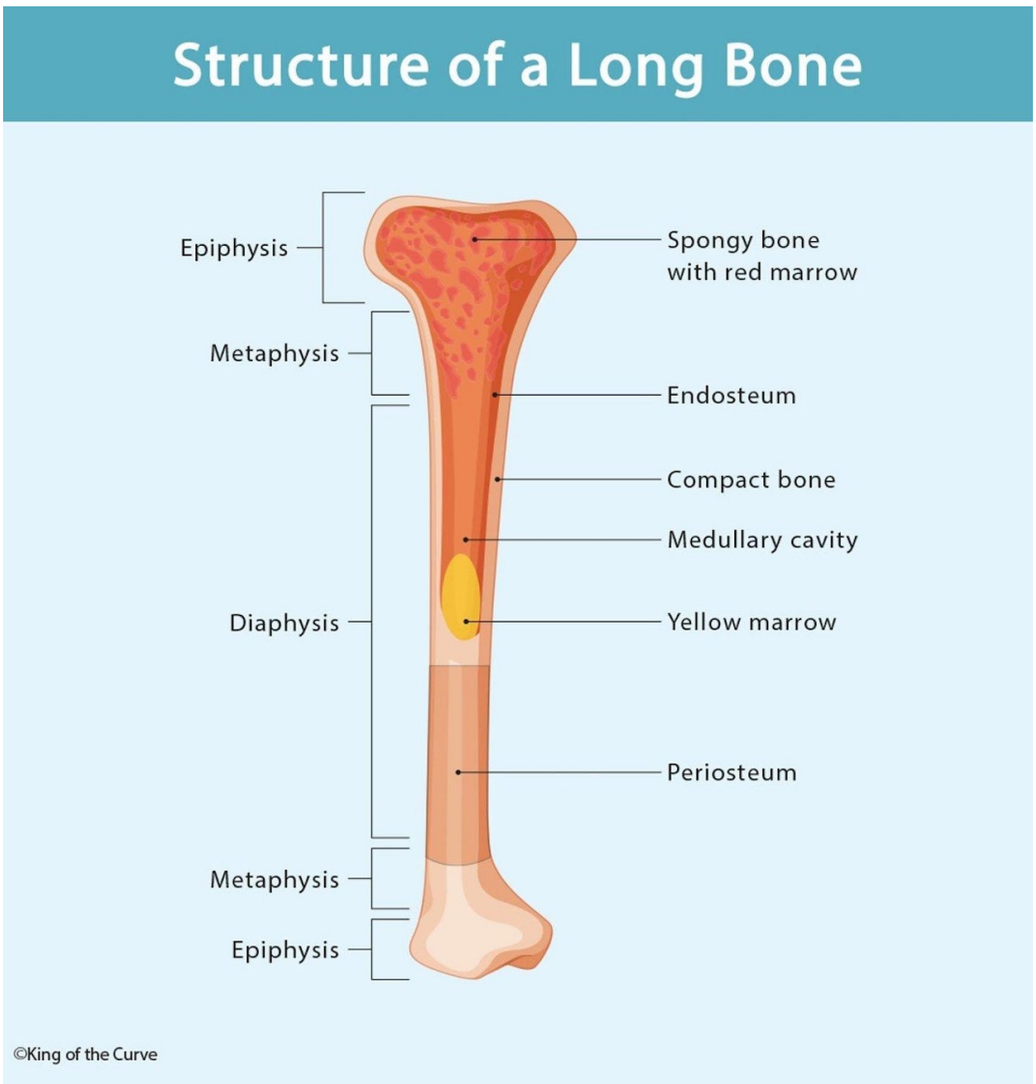
The musculoskeletal system provides support, protection, movement and stability to the body. Bones, joints, cartilage, muscles, tendons and ligaments work together to maintain posture and mobility. Understanding this system is essential for nursing students when assessing movement, managing musculoskeletal injuries and providing rehabilitation care.

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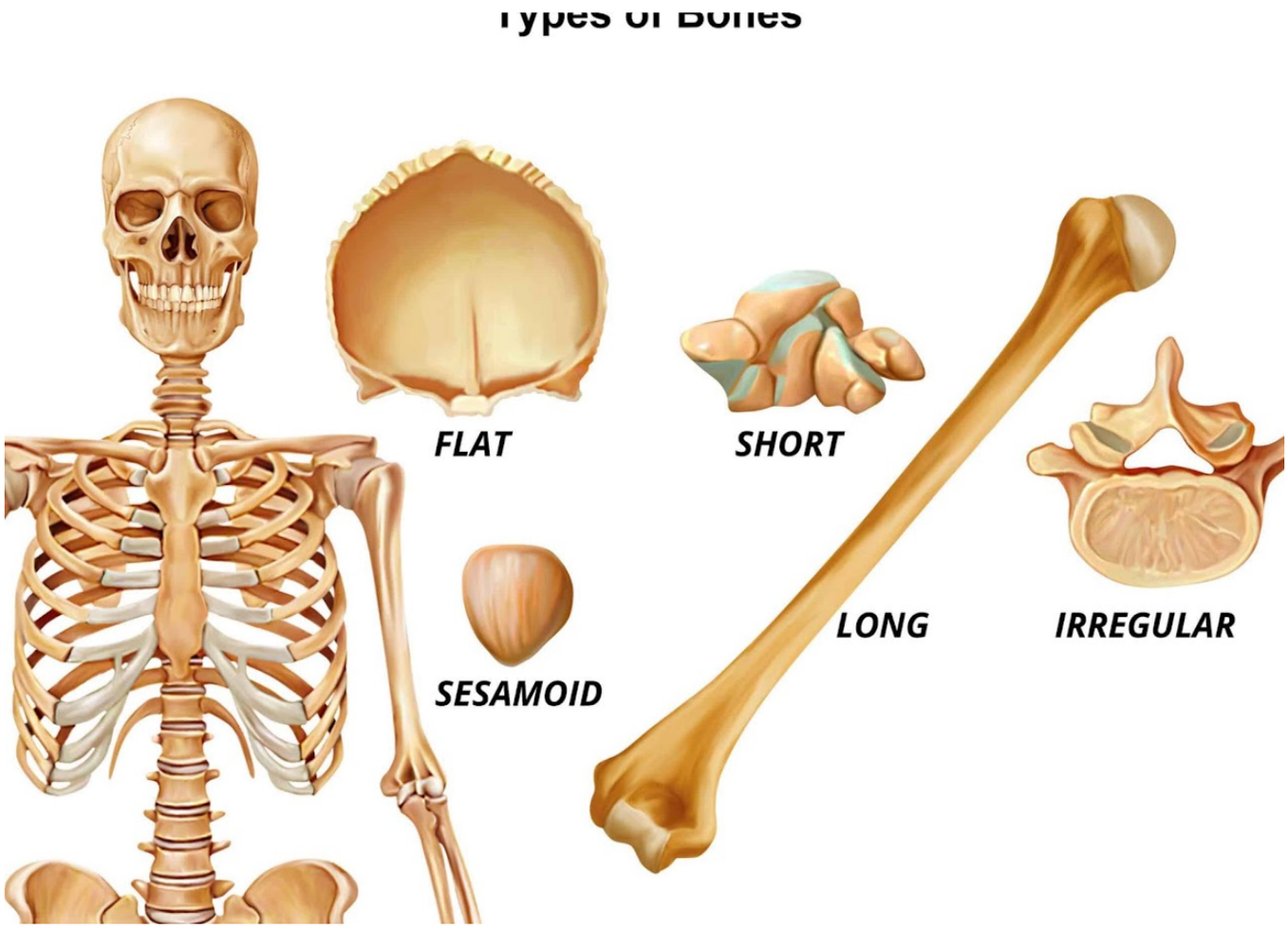
Musculoskeletal System - illustration 1

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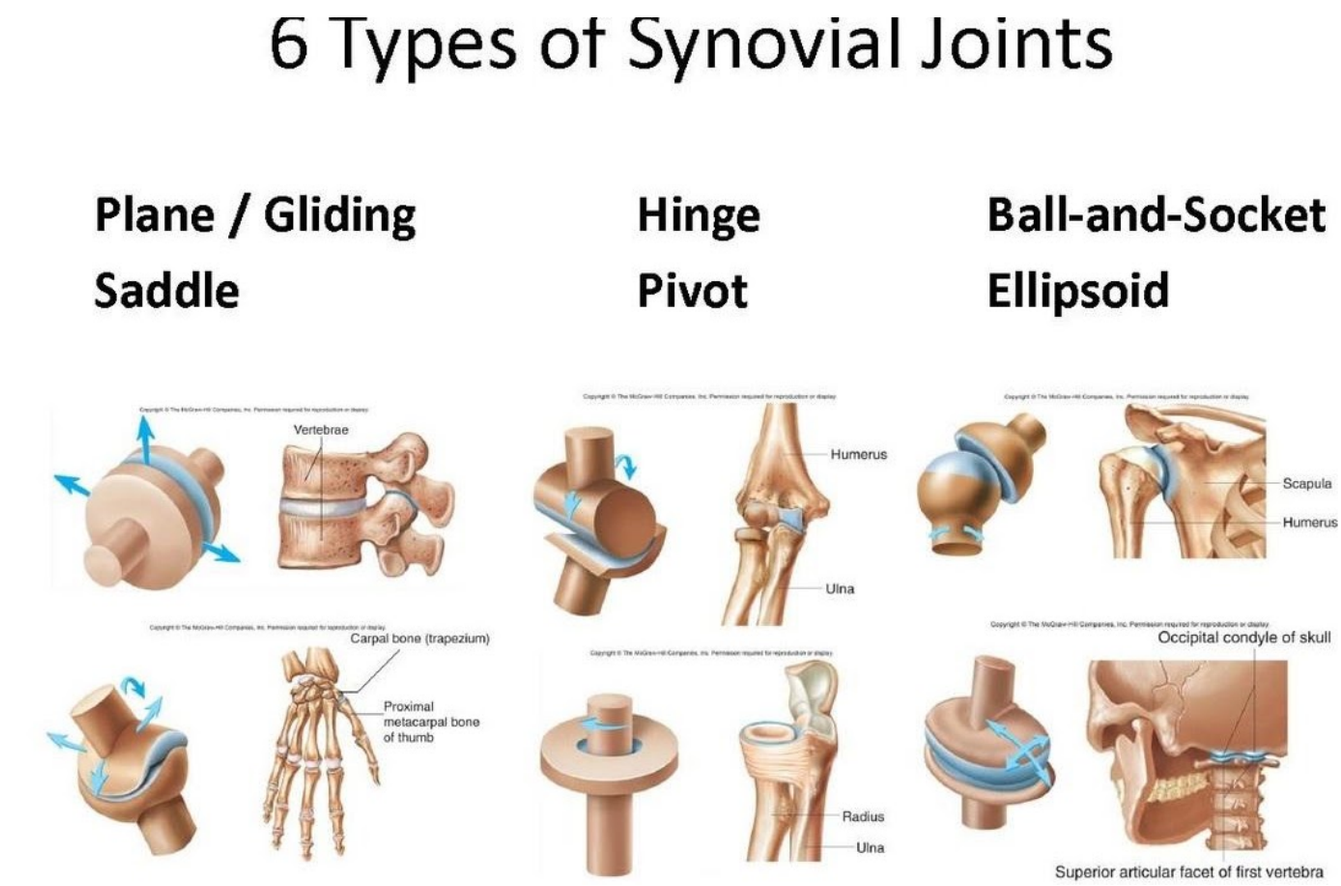
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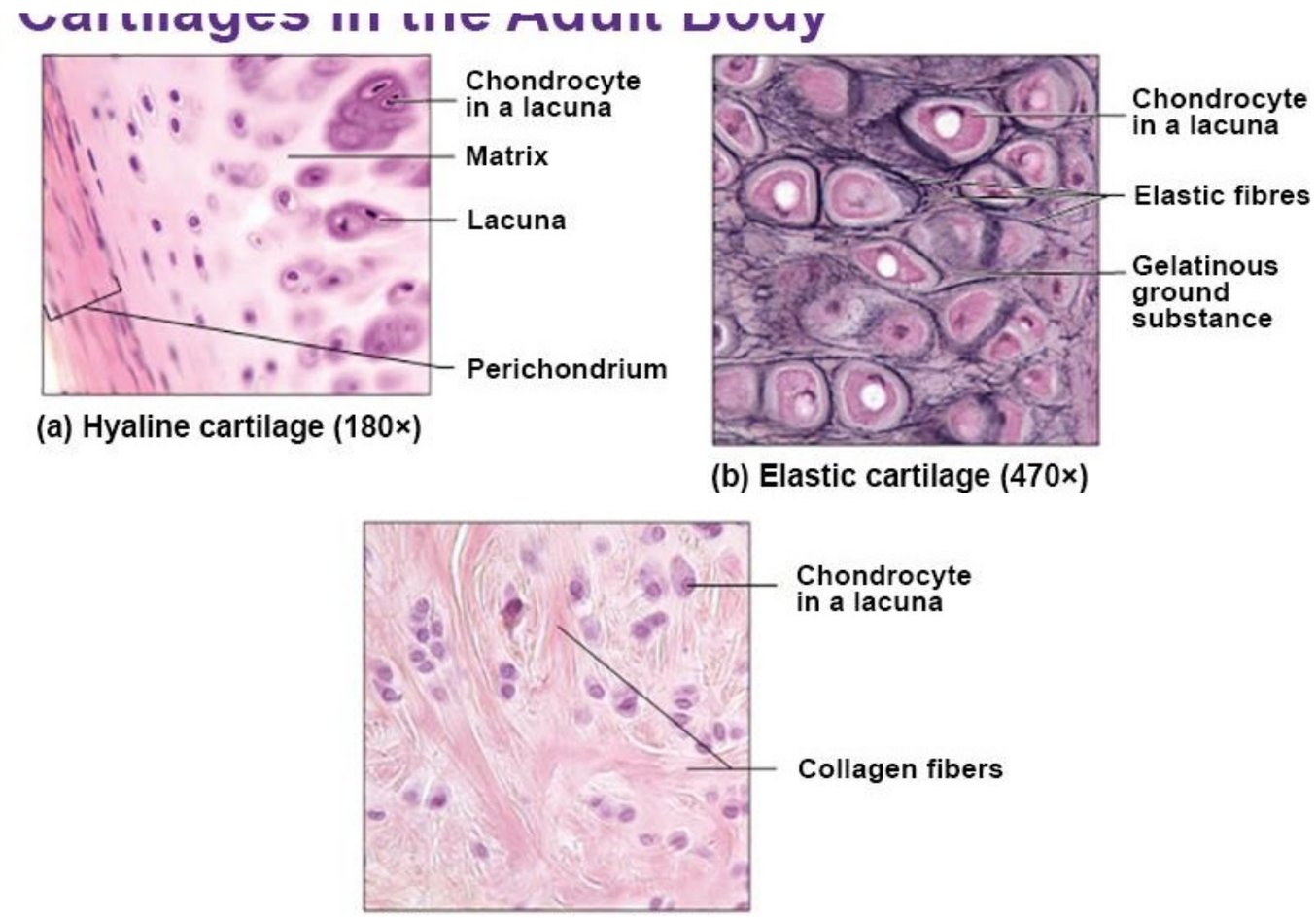


Musculoskeletal System - illustration 3

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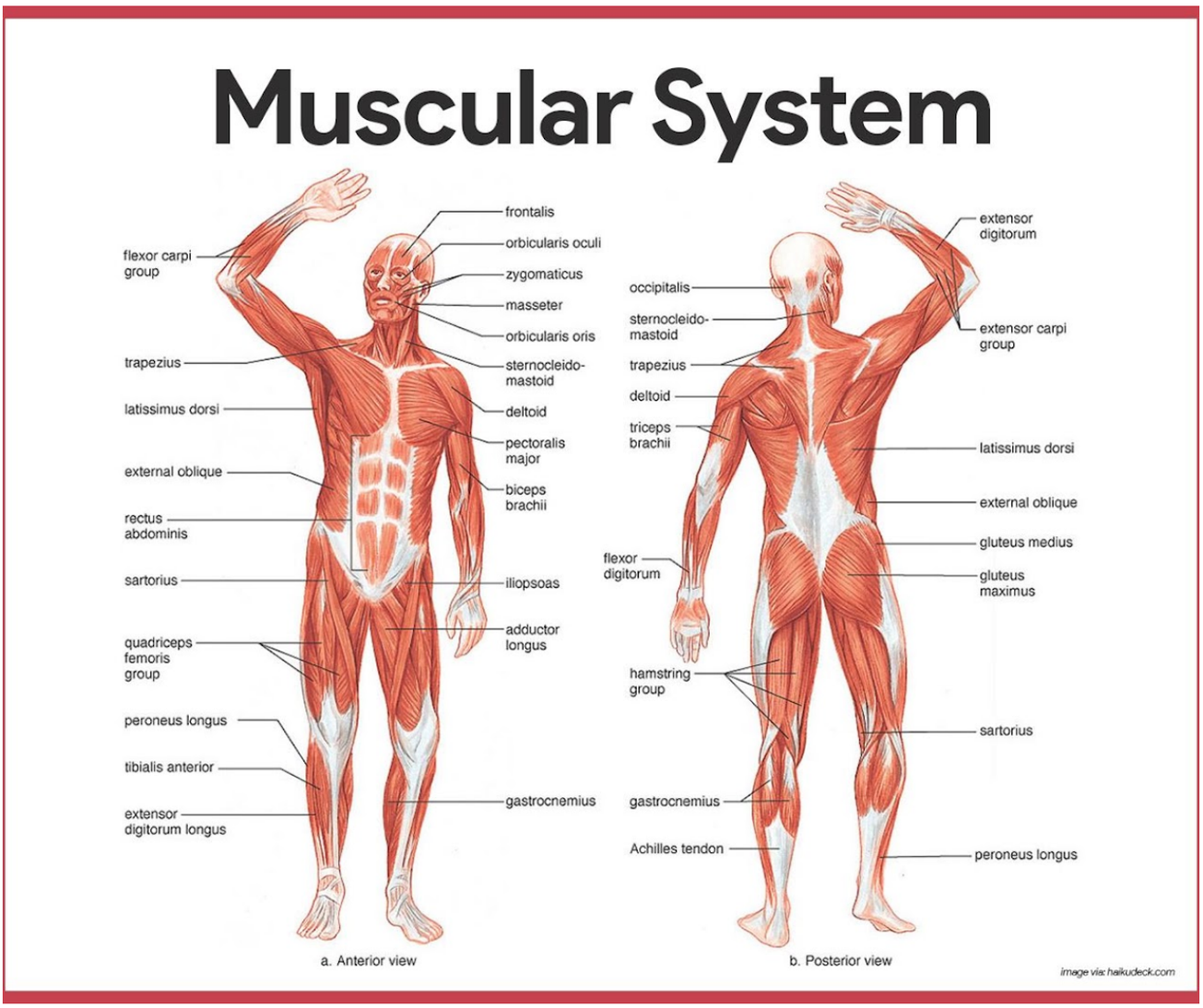


Musculoskeletal System - illustration 4



Musculoskeletal System - illustration 5

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Musculoskeletal System - illustration 6

Quick Revision

- Skeleton & bone structure: The typical adult skeleton has 206 bones. The axial skeleton includes skull, vertebral column and thoracic cage; the appendicular skeleton includes girdles and limbs. Bone shapes include long, short, flat, irregular and sesamoid.

- Joints & movements: A synovial joint contains a cavity, articular cartilage, capsule, synovial membrane and fluid. Hinge joints mainly permit flexion/extension; ball-and-socket joints allow movement in multiple planes.

- Cartilage & muscle types: Hyaline cartilage reduces friction at most synovial articular surfaces. Fibrocartilage resists compression in discs and menisci; elastic cartilage supports flexible structures.

- Major muscles & landmarks: Deltoid covers the shoulder; biceps brachii flexes the elbow; triceps extends it. Diaphragm and intercostals are respiratory muscles. Abdominal muscles support the trunk; pelvic floor muscles support pelvic organs. Gluteal muscles act at the hip; vastus lateralis is part of quadriceps.

Examination questions

1. Distinguish axial and appendicular skeleton.

2. Describe a synovial joint.

3. Compare skeletal, cardiac and smooth muscle.

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Practice questions

Choose one best answer. The answer key and explanations follow the questions.

1. Which structure belongs to the axial skeleton?

A. Femur

B. Scapula

C. Sternum

D. Humerus

2. Which muscle has intercalated discs?

A. Skeletal

B. Cardiac

C. Smooth

D. All types

3. Which joint has a synovial cavity?

A. Skull suture

B. Pubic symphysis

C. Knee

D. Intervertebral symphysis

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Answer key and explanations

1. C - Sternum

The sternum is part of the thoracic cage in the axial skeleton.

2. B - Cardiac

Intercalated discs are characteristic of cardiac muscle.

3. C - Knee

The knee is a synovial joint.

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