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UNIT 05

Support and Movement

Axial Skeleton

SAMPATH LANKADHEERA

B.Sc. (Hons), M.Sc.

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New Syllabus

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Unit 05 **Support and Movement**

Axial Skeleton

ADVANCED LEVEL

Biology

Unit - 05

Support and Movement

- Axial Skeleton

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ADVANCED LEVEL

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THEORY

in English Medium

New Syllabus

Unit 05

Support and Movement

- Axial Skeleton

Smart Note

SAMPATH LANKADHEERA

B.Sc. Hons. M.Sc. (Biotechnlogy)

5.9.3: Investigates the structure and functions of the appendicular skeleton of man
Number of Periods : 06
Learning Outcomes:

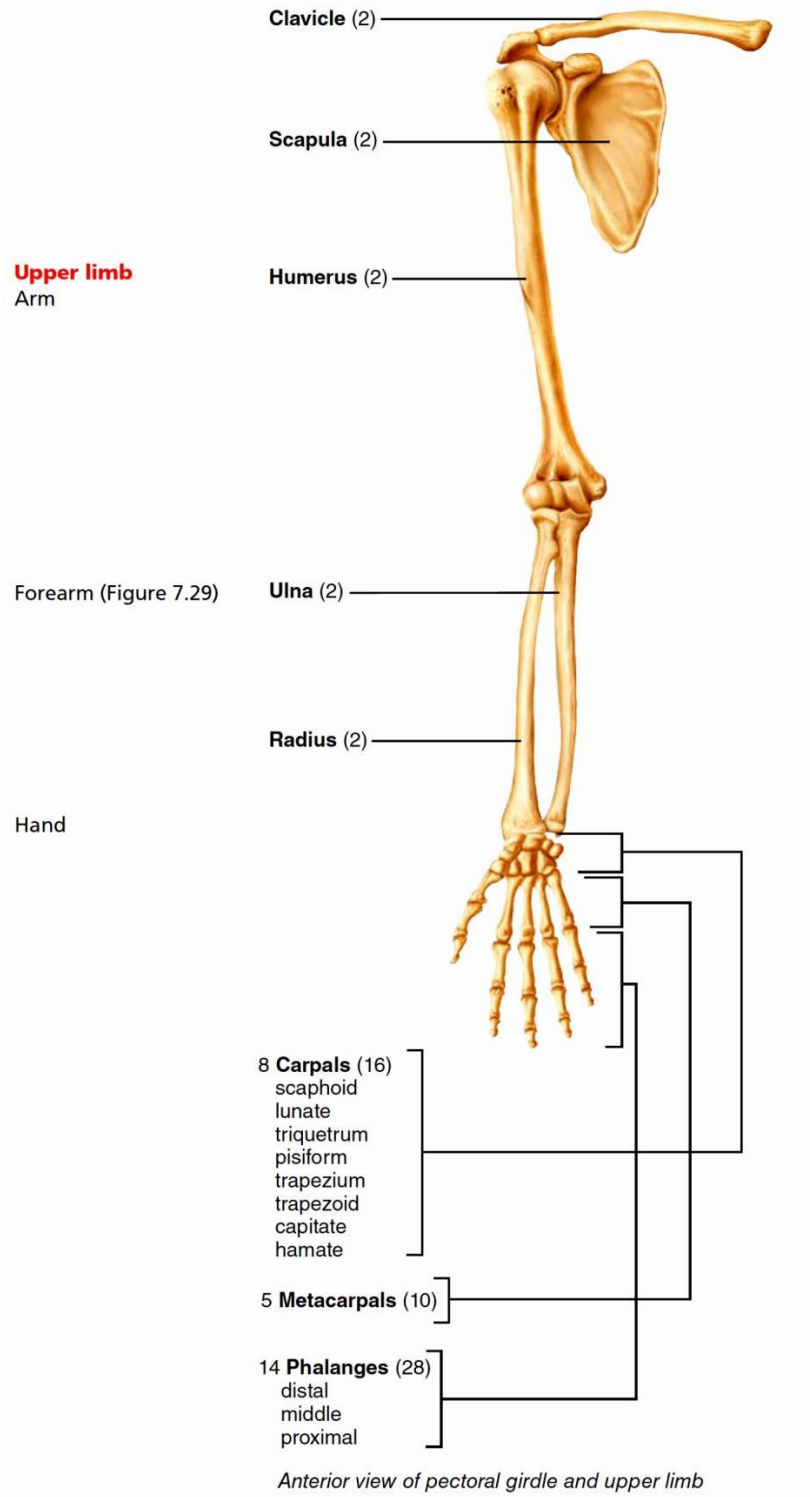
- briefly describes the organization of human appendicular skeleton
- names the main bones of the upper limb (naming the carpal bones and meta carpal bones not required)
- describes how upper limb is adapted to move over a wide range of movements-including grasping, manipulation and weight lifting
- names the main bones of lower limb (naming the tarsal bones and meta tarsal bones not required)
- briefly describes how lower limb is adapted for erect posture, bearing of body weight and walking
- briefly describes arches of foot and their functions
- briefly describes osteoporosis, osteoarthritis and slipped discs
- lists the components of the appendicular skeleton and states the function of each of them
- identifies the importance of correct posture for healthy maintenance of the skeletal system
- identifies the bones of the appendicular skeleton using specimens /models/diagrams (Practical)

Suggested Teaching- Learning Process

- Use specimens/ models/ charts/ diagrams to describe the general structure of human appendicular skeleton.
- Relate the general structure of the human appendicular skeleton to its function.
- Describe the basic structure of the upper limb (naming the carpal bones and meta carpal bones are not required) .
- Guide students to relate how upper limb is adapted to move over a wide range including grasping, manipulation and weight lifting.
- Describe the basic structure of the lower limb (naming the tarsal and meta tarsal are not required).
- Guide students to explore and describe how lower limb is adapted for erect posture, bearing of body weight and walking.
- Describe arches of foot and their functions.
- Guide students to extract information from given resources and make a report on following disorders and abnormalities of the human skeletal system.
    1. Osteoarthritis
    2. Osteoporosis
    3. Slipped disc
- Assign students to conduct a brief speech on the importance of correct posture for healthy maintenance of the skeletal system.

Assessment and Evaluation

- Assess students speech using following criteria,
    1. Accuracy and relevancy of information
    2. Presentation skills
    3. Time management
    4. Adequacy of information



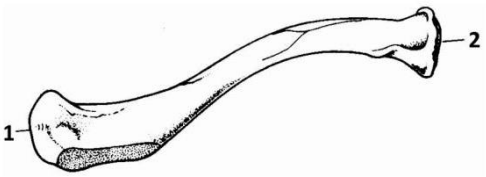
Anterior view of pectoral girdle and upper limb

The structure and functions of the human appendicular skeleton

Appendicular skeleton

- The appendicular skeleton consists of upper limbs with pectoral (shoulder) girdle and lower limbs with the pelvic girdle.
- Through the pectoral girdle the upper limb forms the joints with the trunk. Pectoral girdle connects upper limb with the axial skeleton.
- Pectoral girdle consists of two scapulae (shoulder blades) and two clavicles (collar bones).
- The lower limb forms a joint with the trunk at the pelvic girdle. Pelvic girdle is formed from two hip bones and it is associated with the sacrum.

The Clavicle/Collar bone



Fore Limbs/Upper limb

- **Upper limb consists of humerus, radius, ulna, eight carpal bones, five metacarpal bones and fourteen phalanges.**

Region	Number of Bones	Name of the Bone
Arm	1	Humerus
Forearm	2	Radius, Ulna
Wrist	8	Carpals
Hand	5 + 14 = 19	Metacarpals, Phalanges

The Adaptation of the Human Upper Limb for Movement of Wide Range

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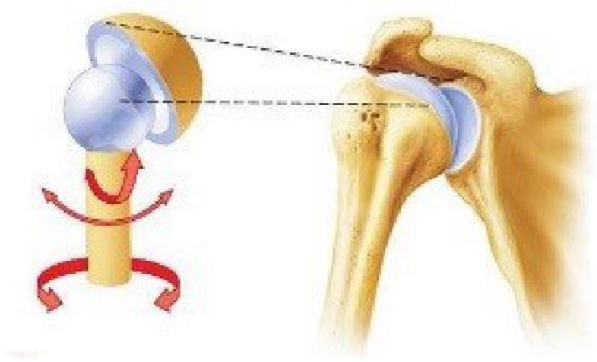

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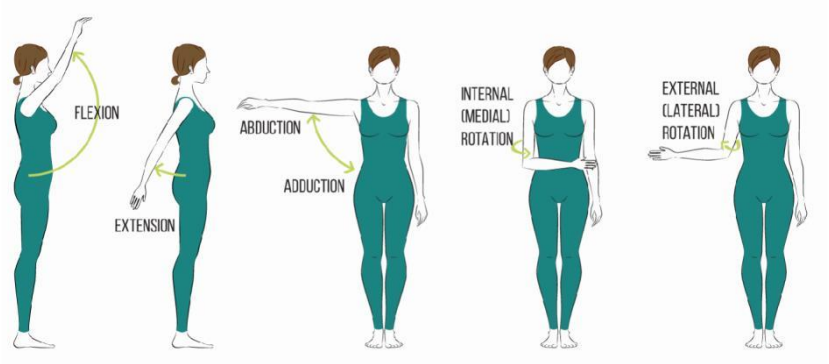

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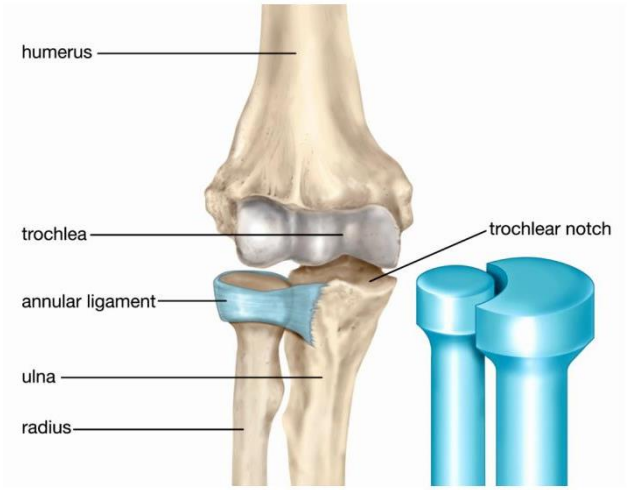
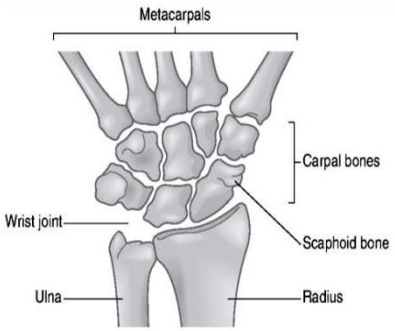
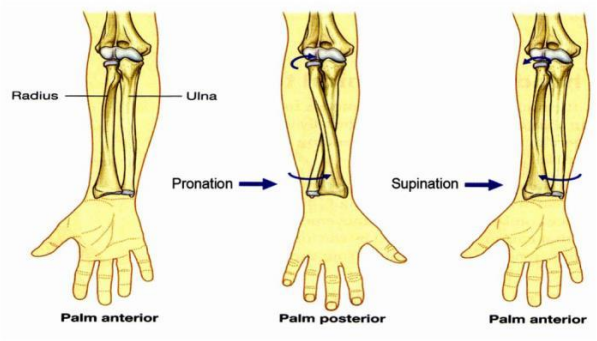


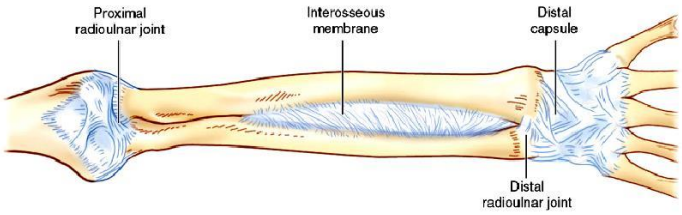
5. Radius articulate with the carpal bones at the wrist joint.



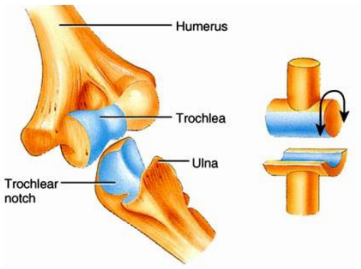
6. **Further ulna and radius are articulated with each other at the proximal and distal radio-ulna joints.**



7. **In addition a fibrous joint connects the bones along their shafts which stabilize their association and maintain their relative position in spite of forces applied from the elbow or wrist.**



8. **The elbow joint act as a hinge joint which permits only flexion and extension of the fore arm.**



9. .....

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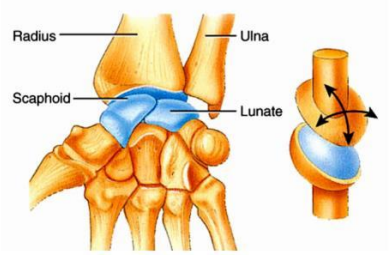
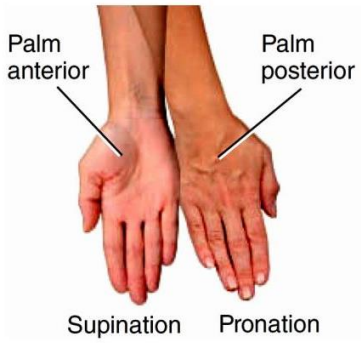
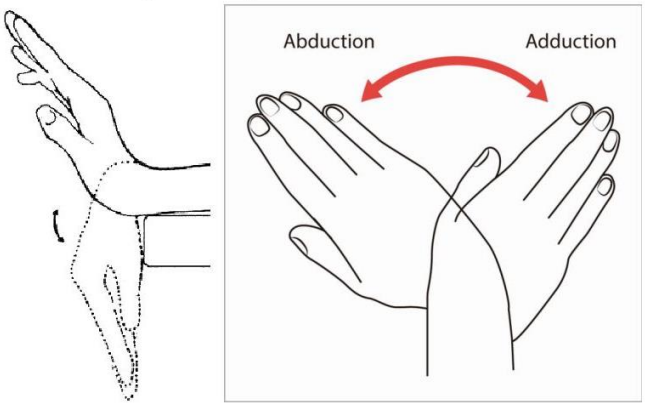
10. **Proximal row bones are associated with the wrist joint and distal row bones form joints with metacarpal bones.**



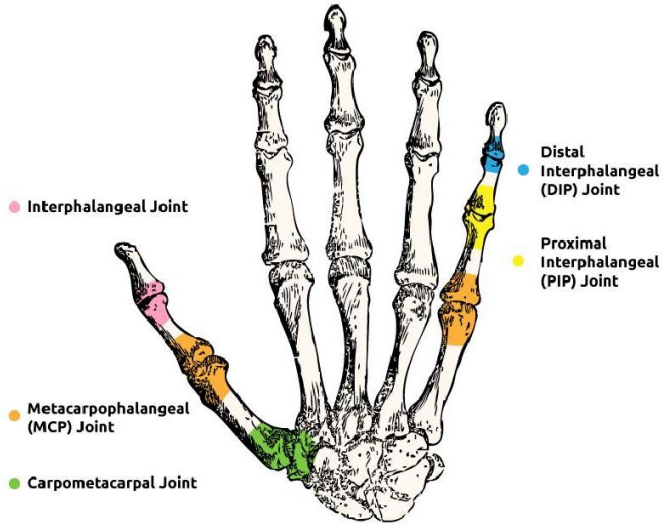
11. **Wrist joint is present between the distal end of radius and three proximal carpal bones. This arrangement allows pronation (palm down) and supination (palm up) of the lower part of the upper limb.**



12. **In addition the wrist can be flexed, extended, abducted and adducted.**

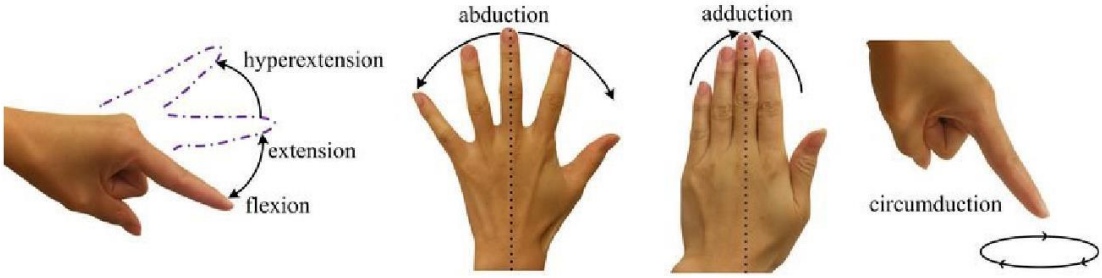


13. **The proximal ends of metacarpal bones in the palm articulate with carpal bones and their distal ends articulate with phalanges.**

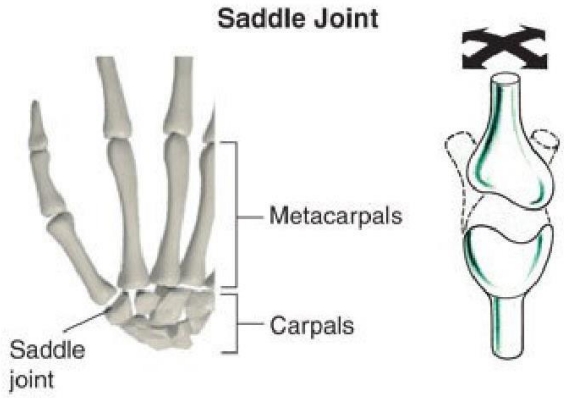


14. **The joints between metacarpal and phalanges allow movement of the fingers and permits the power grip.**

15. **Fingers may be flexed extended, adducted, abducted and circumducted with the first finger more flexible than the other.**



16. **The joint present at the base of the thumb between a specific carpal bone and the first metacarpal bone allows more mobility to the thumb than the other fingers.**



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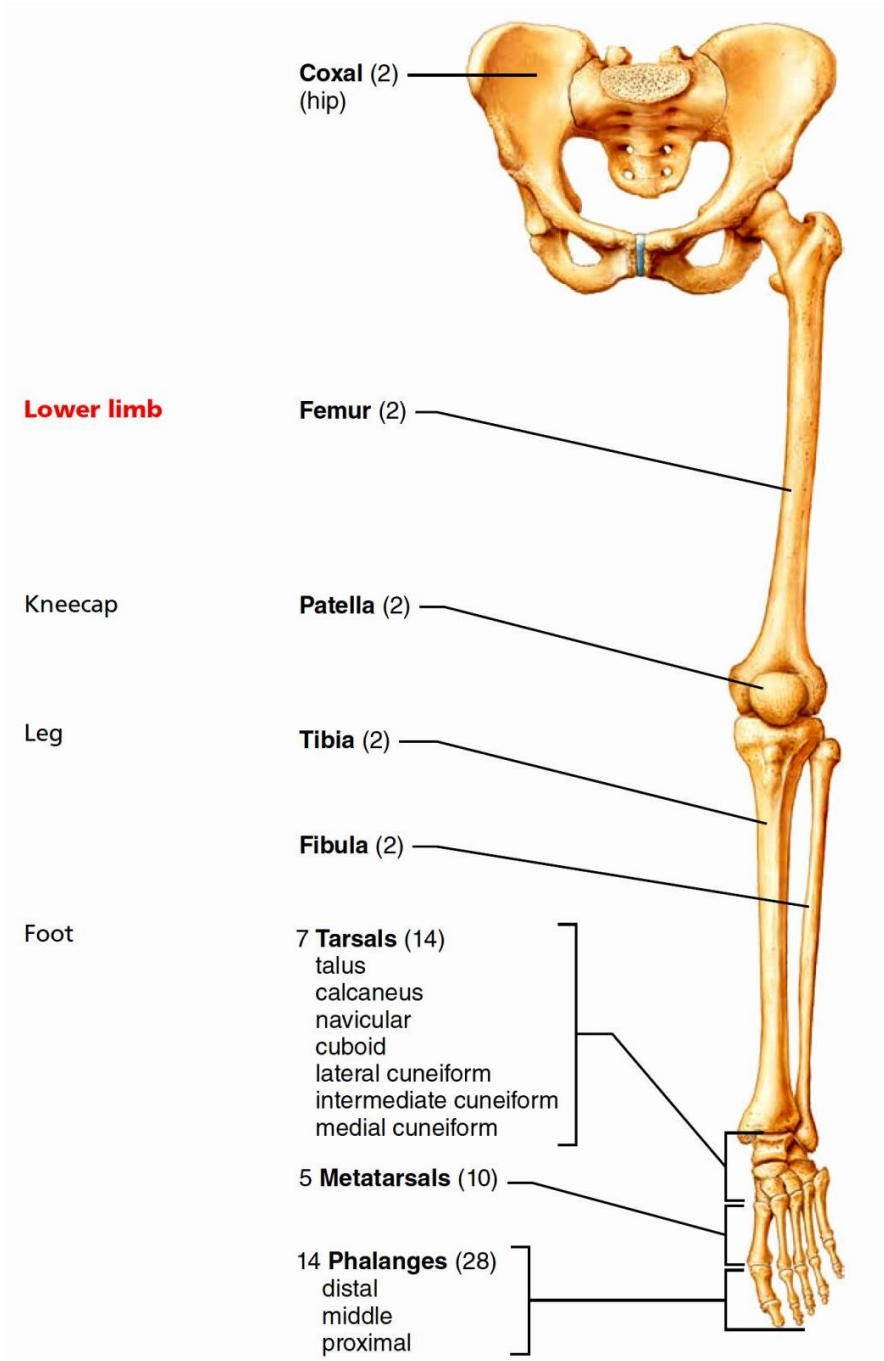

Coxal (2)
(hip)
Lower limb
Femur (2)
Kneecap
Patella (2)
Leg
Tibia (2)
Fibula (2)
Foot
7 Tarsals (14)
talus
calcaneus
navicular
cuboid
lateral cuneiform
intermediate cuneiform
medial cuneiform
5 Metatarsals (10)
14 Phalanges (28)
distal
middle
proximal

Pelvic Girdle and Lower Limb

- Lower limbs forms a joint with the trunk at the pelvic girdle.

Bones of the Pelvic Girdle

- **Pelvic girdle is formed from two hip bones and it is associated with the sacrum.**
- The two innominate bones, sacrum and coccyx form the bony pelvis.

Lower limb

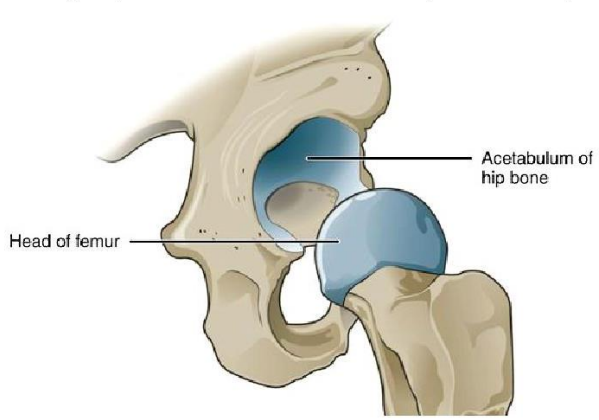
- **Lower limb consists of femur (thigh bone), tibia (shin bone), fibula, patella (knee cap), seven tarsal bones (ankle bones), five metatarsal bones (bones of the foot) and fourteen phalanges (toe bones).**

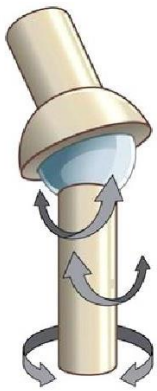
Region	Number of Bones	Name of the Bone
Thigh		
Leg		
Knee		
Foot		

Adaptations of the Lower Limb for the Erect Posture, Bearing of Body Weight and Walking

1. **Structure of the lower limb is adapted for strength, erect body posture, bearing body weight and walking.**

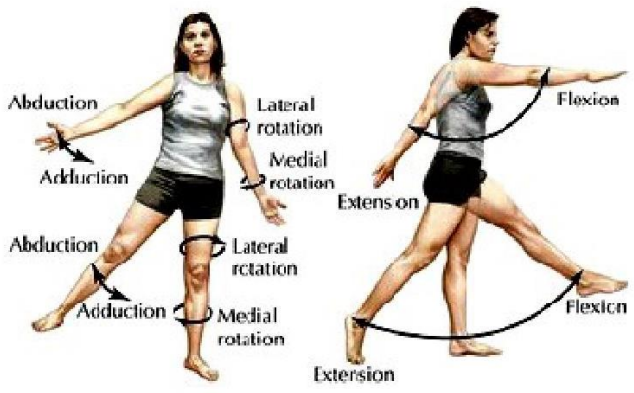
2. **Femur is the longest, heaviest and the strongest bone of the body. Head of the femur forms the hip joint (ball and socket joint) with the acetabulum of the hip bone of the pelvis.**



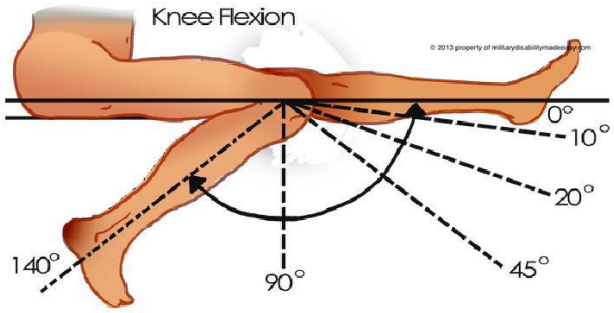


4. **This hip joint is very sturdy and powerful as it bears all body weight when standing.**

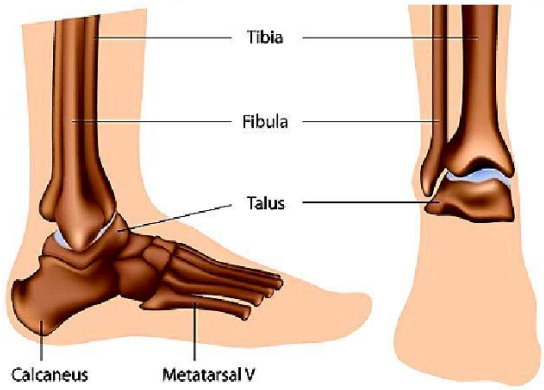
5. **The lower limb can be extended, flexed, abducted, adducted, rotated and circumducted at the hip joint.**



6. **Lower end of femur articulates with tibia and patella to form the knee joint. Tibia is the medial of the two bones. Possible movements at the knee joint are flexion, extension and a rotator movement that locks the joint when it is fully extended. When this joint is locked it is possible to stand upright for long period of time.**

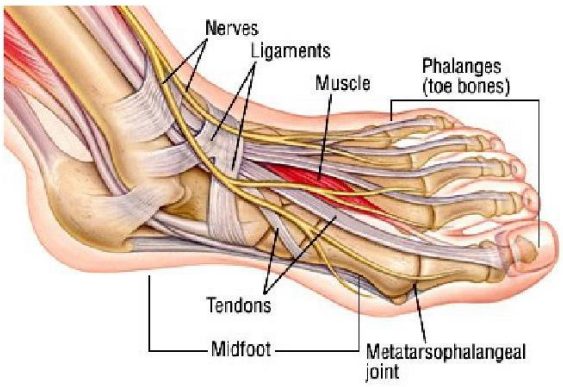


7. **Femur transmits the weight of the body through the bones below the knee to the foot. All the lower ends of both tibia and fibula articulate with a specific tarsal bone to form the ankle joint.**

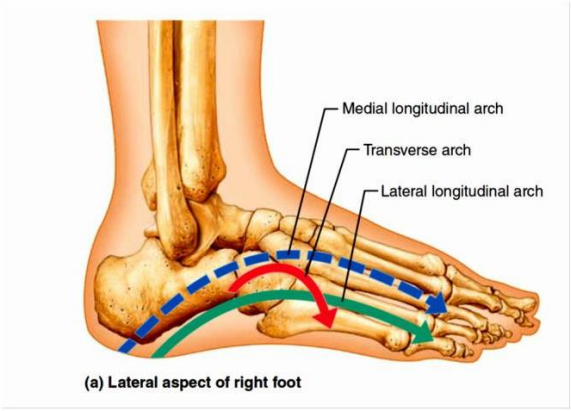


8. **The ankle joint allows rising in tip-toe and lifting toes towards calf.**

9. **The arrangement of bones in the foot supported by associated ligaments and muscles gives the sole of the foot an arched or curved shape.**



10. **There are two longitudinal arches and one transverse arch in the foot. Curve running heel to toe is called the longitudinal arch and the curve running across the foot is called the transverse arch. In the upright position, these arches of the foot are important in distributing the weight of the body evenly whether stationary or moving.**



Some disorders and abnormalities associated with human skeletal system

Osteoporosis

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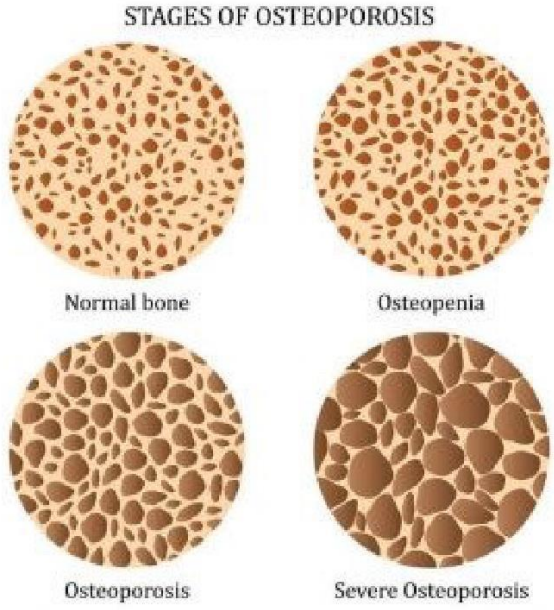
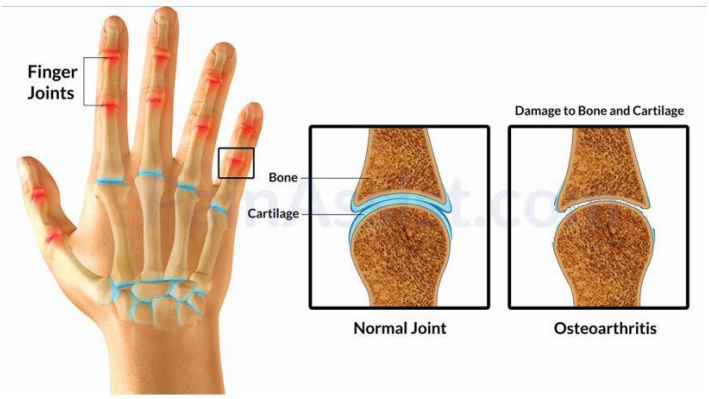


Osteoarthritis



Slipped disc

- **The bodies of adjacent vertebrae are separated by intervertebral discs which serve as shock absorbers.**
- **These intervertebral discs consist of an outer ring of cartilage and a central core of soft gelatinous material.**
- **An injury or weakness can cause the inner portion of the intervertebral disc to protrude through the outer ring. This condition is called slipped disc .**
- **This leads to pain and discomfort. If the slipped disc compresses a spinal nerve, there can be numbness and pain along the affected nerve.**
- **Slipped disc condition can arise when lifting heavy weights without bending knees.**

Main types of joints in the human skeletal system

- **Main types of the joints in the human skeletal system are ball and socket joint, hinge joint and pivot joint.**

Ball and Socket Joints

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Hinge Joints

- **The articulating ends of the bone fit together in such a way so it looks like a hinge of a door.**
- **This allows only restricted movements such as flexion and extensions.**
- **Examples for hinge joints are elbow joint, knee joint, ankle joint and joints between the phalanges of the fingers and toes.**

Pivot Joints

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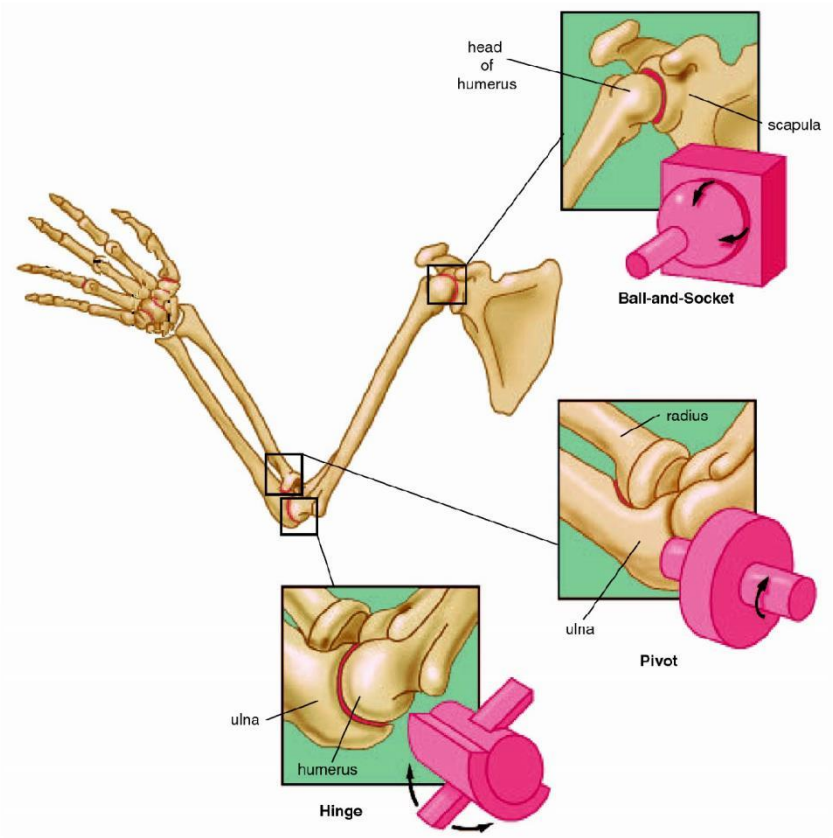

PRACTICAL NO.34

Describing the human appendicular skeleton using specimens/ models/ diagrams Objectives

- Students should be able to

1. relate the skeletal structure of upper limb to the range of functions performed,
2. relate skeletal structure of joints and bones of lower limb to erect body posture, bearing of body weight and walking.

Materials and equipment

- Charts /models/specimens/ illustrations/computer illustrations showing the bones of the upper arm, forearm, wrist and hand.
- Charts/models/specimens/illustrations/computer illustrations/ computer animations/ of pronation and supination and opposability of thumb and fingers.
- Charts / models/specimens/illustrations/computer illustration of bones of thigh, shank, ankle and foot.
- Charts/models/specimens/illustrations/computer illustrations/ computer animations/ to show involvement of lower limb in maintenance of erect posture, bearing of body weight and walking
- Charts/models /specimens/illustrations/computer illustration of complete human skeleton.

Instructions

- Allow students to observe and study upper limb.
- Direct the students to study and record the movement of the limbs including joints, pronation, supination and opposability.
- Lead a discussion on weight bearing & bipedalism and structure of the foot.
- Highlight the movements of the leg, joints, heel and toe during walking

5.9.4: Investigates the main types of joints and mechanism of skeletal muscle movement

Learning Outcomes:

- names main types of joints and lists the functions and importance of joints
- states features of the muscle tissue
- briefly describes the structure of the sarcomere and basic mechanism of skeletal muscle movement
- briefly describes the basic concepts of the sliding filament theory
- appreciates the way of muscles performance in their functions

Suggested Teaching- Learning Process

- Describe functioning of main types of joints (ball and socket, hinge and pivot) and their importance.
- Conduct a brain storming session on the features of muscle tissue.
- Describe the structure of the sarcomere using video clips/ animations/diagrams.
- Explain the basic concept of the sliding filament theory using video clips/diagrams.

Assessment and Evaluation

- Assess students' performance by oral questioning method using relevant criteria.

Skeletal muscle and mechanism of contraction

Features of skeletal muscle tissue

- **The skeletal muscles are generally attached to the skeletal system and mainly cause voluntary body movements.**
- **Skeletal muscle tissue is composed of bundles of long cylindrical cells.**
- **These cells are aligned parallel to each other along the length of the muscle.**
- **Each cell contain multiple nuclei close to the cell membrane.**
- **Inside the cell, bundles of myofibrils containing contractile microfilaments are located longitudinally along the length of the cell.**
- **Myofibrils in the muscle cell form repeating sections called sarcomeres.**
- **The repeating arrangement of sarcomeres within the skeletal muscle cell gives its striated appearance under the microscope.**
- **Sarcomeres are the basic contractile units of the striated muscle cell.**
- **Like smooth muscle cells and cardiac muscle cells, skeletal muscle cells show excitability or irritability (ability to receive and respond to stimuli), contractility (ability to contract or shorten), extensibility (ability to stretch or contract) and elasticity (ability to return to its original length after being stretched or contracted).**
- **The skeletal muscle is under the voluntary control of the somatic nervous system.**

Structure of the sarcomere, basic mechanism of skeletal muscle movement

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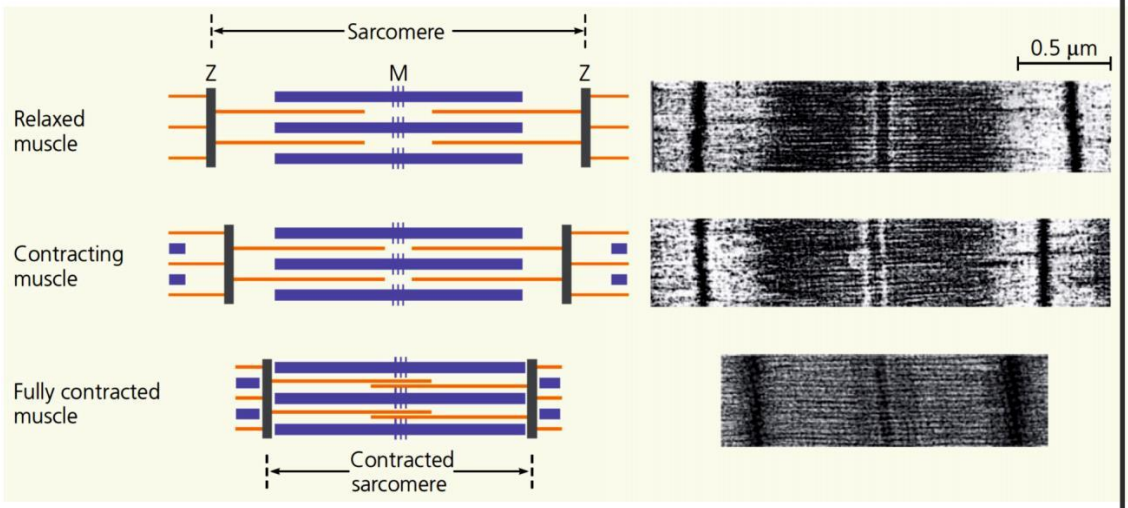
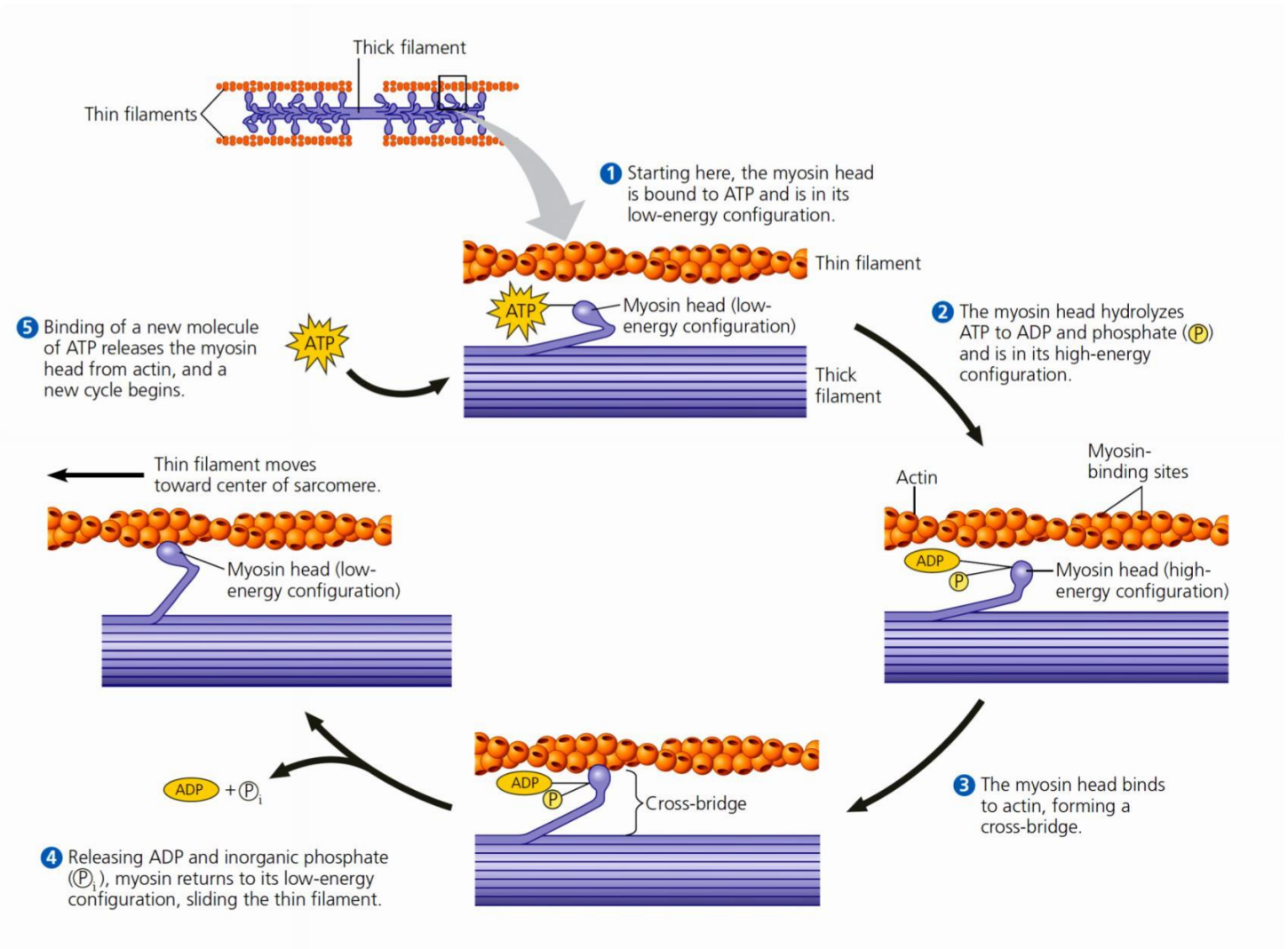
- **The thick filaments (formed from myosin protein) are fixed (at the M line) in the middle region of the sarcomere.**

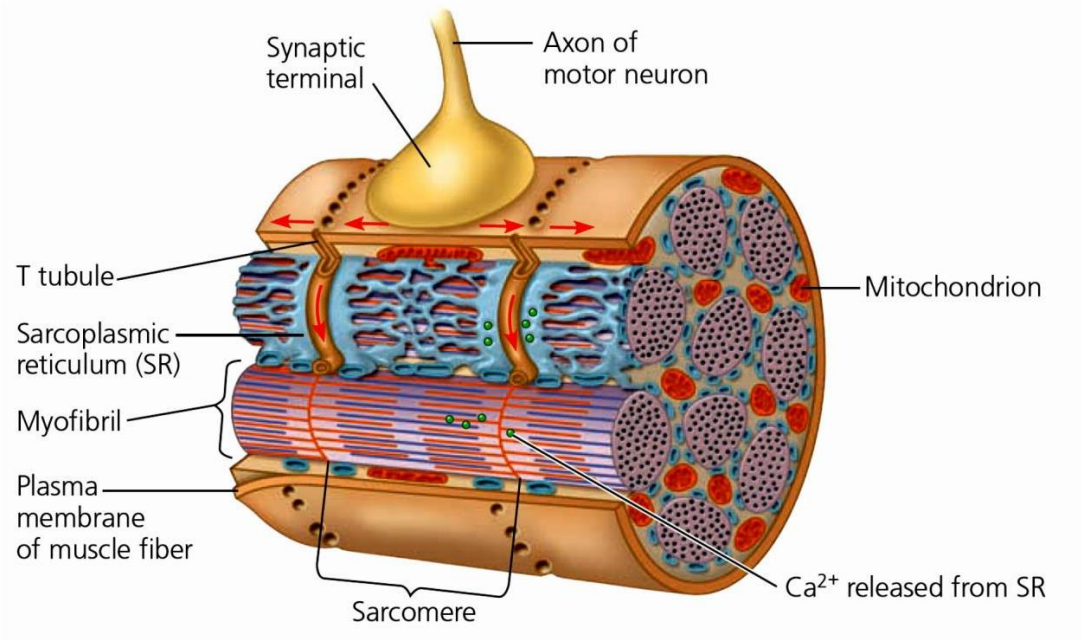


- **Sarcomeres are found repeatedly between two Z lines in a skeletal muscle cell. At the resting stage of myofibrils, thick and thin filaments are partially overlapped.**
- **At the edge of the sarcomere there are only thin filaments while at the center of the sarcomere only thick fi laments are present.**
- **Such arrangement of thick and thin filaments in the sarcomeres permits the shortening of the skeletal muscle cell during contraction and return to the original state during relaxation.**
- **The mechanical function arising from sarcomeres is produced by actin (found in thin filaments) and myosin (found in thick filaments) proteins.**
- **The skeletal muscle contraction is mainly voluntary and under the control of the somatic nervous system.**
- **Upon stimulation, individual muscle cells in the skeletal muscle shortens due to the shortening of its sarcomeres, and thus the whole muscle may contract.**
- **Converting muscle contraction to movement needs a skeleton to which the muscles attach. Skeletal muscle contractions pull on the tendons attached to the bones.**
- **If contraction of the muscle causes the muscle to shorten, the bone and the body part will move.**
- **When the nervous stimulation is stopped, the muscles will return to the original length after being contracted.**

Sliding Filament Theory

- The head region of the myosin can also bind with an ATP molecule when its 'low energy state'.
- When the ATP molecule is hydrolyzed to form ADP and phosphate while releasing energy, the myosin head enters into the 'higher energy state'.
- At this state, the myosin head binds to myosin binding site of actin forming a cross bridge.
- Thereafter the myosin head returns to its lower energy state by releasing ADP and phosphate, which pulls (slides) the thin filament toward the centre of the sarcomere and so shortening the sarcomere.
- When a new molecule of ATP binds to the myosin head, the cross bridge is broken, myosin head detaches from actin. A new cross bridge cycle begins again.
- The contraction of muscles requires many number of repeated cycles of binding and releasing. In each cycle, the myosin head is released from the cross bridge and newly bound ATP is hydrolyzed which promotes binding of myosin again to a new actin molecule.
- This process occurs along the entire length of every myofibril in the muscle cell. Since in the earlier cycle the thin filament has moved towards the centre of the sarcomere, a new binding site for the myosin head region is exposed in the thin filament.
- The entire process causes the thick and thin filaments in the muscle cell to slide past each other pulling the Z lines at each end of the sarcomere closer to one another shortening the sarcomere.
- Many myosin heads can be found in one thick filament.
- Within one second, each of these heads can form cross bridges. Ca2+ and some other proteins also play a major role in muscle contraction.
- Myosin can only bind to actin when the binding sites on actin are exposed by the action of calcium ions.


Thick filament
Thin filaments
1 Starting here, the myosin head is bound to ATP and is in its low-energy configuration.
Thin filament
ATP
Myosin head (low-energy configuration)
Thick filament
2 The myosin head hydrolyzes ATP to ADP and phosphate (P) and is in its high-energy configuration.
Actin
Myosin-binding sites
ADP
P
Myosin head (high-energy configuration)
3 The myosin head binds to actin, forming a cross-bridge.
ADP
P
Cross-bridge
ADP + Pi
4 Releasing ADP and inorganic phosphate (Pi), myosin returns to its low-energy configuration, sliding the thin filament.
Thin filament moves toward center of sarcomere.
Myosin head (low-energy configuration)
5 Binding of a new molecule of ATP releases the myosin head from actin, and a new cycle begins.
ATP



MCQ

1. Which one of the following is **false** regarding the human thumb?
   (1) Thumb has less mobility than the other fingers. (2) It has two phalanges.
   (3) It is opposable with the other fingers. (4) It greatly enhances the e ciency of the hand.
   (5) Its movements are regulated by the somatic nervous system. (1999)

2. Which of the following statements is correct regarding the upper limb of man?
   (1) Distal end of radius is over the ulna during supination. (2) Immovable joints are present between carpels.
   (3) Opposability of the thumb is due to high movability of its first phalange.
   (4) Ulna is longer than the radius. (5) Elbow joint is formed by the articulation of ulna with humerus. (2010)

3. Which one of the following contributes least in weight lifting by the human upper limb?
   (1) Long and strong humerus (2) Pronation (3) Supination (4) Precision grip (5) Broad palm (2014)

Exam Questions

AL /1987

1. Name the bones labeled as X and Y
   X- ..... Y- .....

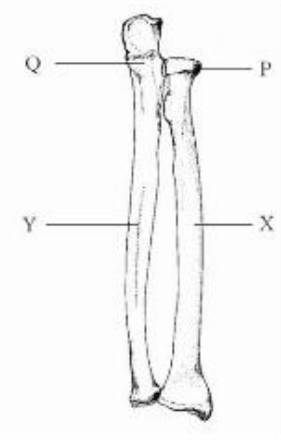
2. Name the joint formed at the Q end humerus.
   .....

3. What is the bone present on the lateral side at anatomical descriptive position?
   .....

4. Which finger is present on the side of Y bone at anatomical descriptive position?
   .....

5. What is/are the bone/s articulate with distal end of bone X?

.....



6. With two thick lines show the position of X and Y bones in

1. Supination 2. Pronation

7. What is the name of joint help to maintain wide range of movements of fore limb?

.....

8. Name another joint of human skeleton has wide range movement?

.....

9. Name two ball and socket joins present in human skeleton.

.....

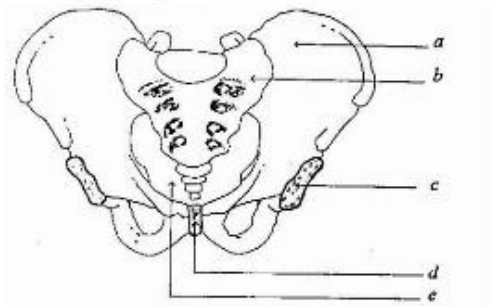
10. What are fingers involve in power grip and precision grip

.....

.....

AL/ 2002

Questions D (I) - D (iii) are based on the following diagram.



(i) Identify the structure given in the diagram.

.....

(ii) Name the parts labelled a, *b*, c, *d* and *e*.

a ..... *b* .....

c ..... *d* .....

e .....

(iii) How does the structure shown in the above diagram contribute to the upright posture of man?

.....

.....

5.9.4: Investigates the main types of joints and mechanism of skeletal muscle movement

1. Which of the statement regarding sarcomere of a skeletal muscle fiber is incorrect.
   (1) It is the functional unit of muscle contraction. (2) It is the area between two adjacent Z lines
   (3) The I bands contain only thin filaments (4) A bands is shortened during muscle contraction
   (5) During muscle contraction H-zone is reduced. (2012)

2. Which one of the following statements regarding human skeletal muscle contraction is incorrect?
   (1) A motor nerve stimulation is essential for its initiation.
   (2) Cross bridges are formed between myosin heads and actin binding sites.
   (3) Actin filaments shorten.
   (4) I-bands shorten.
   (5) Calcium ions are essential for the formation of cross bridges. (2013)

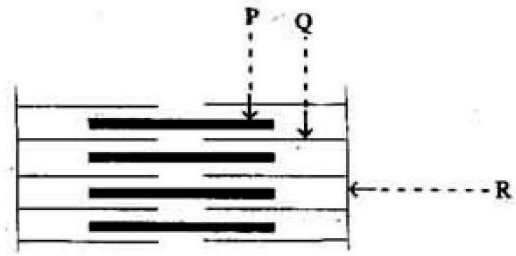
3. Which one of the following statements regarding human smooth muscles is correct?
   (1) They all show rhythmic contractions. (2) Their unit of contraction is not the sarcomere.
   (3) They fatigue quickly. (4) They are innervated by the somatic nervous system. (5) They are not elastic. (2014)

AL/ 1994 Zoo

1. (A) Question A (i) – A (v) are based on the diagram of a sarcomere of skeletal muscle given below.

   (i) Where are the sarcomeres located within the muscle fiber?
   .....

   (ii) Name the parts shown by the arrows in the diagram.



   P .....

   Q .....

   R .....

   (iii) What is the main protein in P?
   .....

   (iv) What is the main protein in Q?
   .....

   (v) In normal skeletal muscle contraction what happens to the length of Q?
   .....

   (B) (i) Name the currently accepted theory of skeletal muscle contraction.
   .....

   (ii) Which germ layer given rise to muscles?
   .....

   (iii) Name the connective tissue sheaths associated with skeletal muscles.
   .....

(iv) What is the oxygen binding pigment within the skeletal muscle fiber?

.....

(v) Which nervous system in man controls the contraction of skeletal muscles?

.....

(C) Give three structural differences between skeletal and cardiac muscle fibers.

(i) .....

(ii) .....

(iii) .....

Give two functional differences between skeletal and smooth muscles.

(iv) .....

(v) .....

(D) (i) Name three organs from different systems in the human body where smooth muscles predominate.

(a) .....

(b) .....

(c) .....

(ii) Why are skeletal muscles in the human limbs arranged in antagonistic pairs?

.....

(iii) Name the ion that is directly associated with the mechanism of skeletal muscle contraction.

.....

(iv) What is the immediate source of energy for skeletal muscle contraction?

.....

(v) Why does lactic acid accumulate in skeletal muscles as a result of strenuous exercise?

.....

.....

AL 2013

1. (A) (i) What is the basic physiological feature of muscles?

.....

(ii) What is a muscle fibre?

.....

(iii) State three physiological differences between human cardiac muscle fibres and skeletal muscle fibres.

Cardiac muscle fibres	Skeletal muscle fibres

(iv) State three structural differences between human cardiac muscle fibres and smooth muscle fibres.

Cardiac muscle fibres	Smooth muscle fibres

(v) According to the sliding filament theory what happens to the length of A-band, If-zone and I-band during skeletal muscle contraction?

Length

(a) A - band - .....

(b) H - zone - .....

(c) I - band - .....

(vi) What is the by product of muscle contraction used in homoeostasis? .....

(vii) Name two hormones which act on human skeletal muscles.

....

PRACTICAL NO.34

- Describing the human appendicular skeleton using specimens/ models/ diagrams

Objectives

- Students should be able to relate the skeletal structure of upper limb to the range of functions performed, relate skeletal structure of joints and bones of lower limb to erect body posture, bearing of body weight and walking.

Materials and equipment

- Charts /models/specimens/ illustrations/computer illustrations showing the bones of the upper arm, forearm, wrist and hand.
- Charts/models/specimens/illustrations/computer illustrations/ computer animations/ of pronation and supination and opposability of thumb and fingers.
- Charts / models/specimens/illustrations/computer illustration of bones of thigh, shank, ankle and foot.
- Charts/models/specimens/illustrations/computer illustrations/ computer animations/ to show involvement of lower limb in maintenance of erect posture, bearing of body weight and walking
- Charts/models /specimens/illustrations/computer illustration of complete human skeleton.

Instructions

- Allow students to observe and study upper limb.
- Direct the students to study and record the movement of the limbs including joints, pronation, supination and opposability.
- Lead a discussion on weight bearing & bipedalism and structure of the foot.
- Highlight the movements of the leg, joints, heel and toe during walking.

Prototype paper 2011

1. (*a*) Briefly describe the structure of a sarcomere in human skeletal muscle fibre.

(*b*) Briefly explain how a human skeletal muscle fibre contracts.

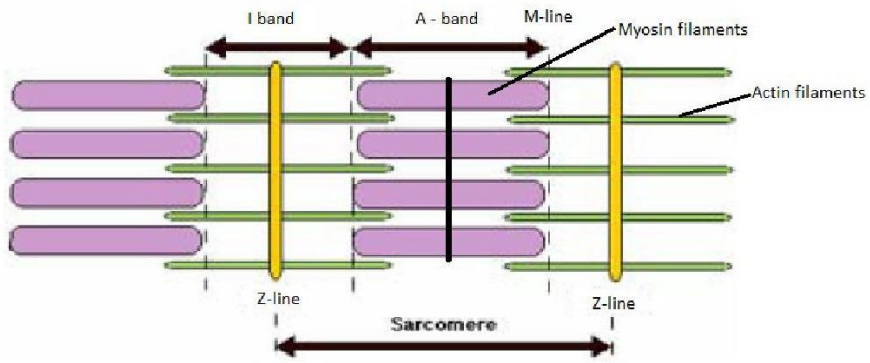
1.(*a*) Briefly describe the structure of a sarcomere in human skeletal muscle fibre.

1.Sarcomere is the region between two dark lines.
2.In a myofibril which is called as z lines.
3.These Z lines are made up of a protein
4.called actin.
5.Sarcomere contain thick filaments and thin filaments.
6.Thick filaments are made up of a protein
7.called myosin.
8.Thin filaments are made up of actin.
9.These filaments are longitudinally arranged in the sarcomere.
10.Sarcomere has dark bands
11.and light bands
12.Dark bands are called as A bands
13.Light bands are called as I bands.
14.Dark bands/A bands have thick and thin filaments.
15.Light bands/I bands contain thin filaments only.
16.Thin filaments are attached to Z lines.
17.Thick filaments are free and not attached to Z lines.
18.Each thick filament is surrounded by 6 thin filaments
19.Thin filaments are stacked between thick filaments.
20.The gap between two thin filaments are the H zone.
21.Only thick filaments are present in H zone.
22.In H zone thick filaments are connected to end by
23.A thin membrane,
24.which is called as M line.

(*b*) Briefly explain how a human skeletal muscle fibre contracts.

1.During muscle contraction sarcomere length reduces.
2.Length of I band reduces.
3.Length of H zone reduces.
4.Length of A band remain constant.
5.Sliding of thin filaments over thick filaments take place.
6.Filaments/myosin filaments do not contract.
7.Action potential form in sarcolemma
8.Cause release of Ca++ ions,
9.From sarcoplsmic reticulum,
10.To sarcoplasm.
11.Ca++ binds with thin filaments/actin filaments.
12.Binding sites of thin filaments are exposed
13.Heads of myosin filaments bind with binding sites of thin filaments
14.to form cross bridges.
15.Several cross bridges are in sarcomere.
16.Cross bridges are formed 50-100 times per second.
17.ATPase in myosin heads activates
18.And hydrolyses/breakdown ATP
19.Releasing energy
20.Using this energy, myosin heads bend twords
21.The center of sarcomere
22.Dragging thin filaments along the thick filaments
23.This happens in all sarcomeres in the muscle fiber
24.Causing contraction of the fiber

48 x 3 = 144 marks
Diagram = 10 marks
Total = 154
Maximum = 150




I have a skeleton joke, but I'm not sure if it's humerus.