LOCOMOTION IN ANIMALS

Locomotion is the movement of the whole organism from one place to another.

Movement is the displacement of part of the body of an organism.

Need for locomotion: organisms locomote for the following reasons;

- in search of food
- to find mates
- to escape predators
- to find shelter
- find favourable environmental conditions
- carry out migratory movements

Forms of locomotion

Animals locomote in a variety of different ways. Some animals are however capable of locomotion in more than one form which include the following;

- By crawling
- By walking
- By flying
- By creeping
- By hopping
- By running

NB: *For locomotion to occur, animals need a skeleton and muscles which act on it for the animal to move*.

SKELETON: ***A skeleton is a framework against which muscles act to cause movement.***

Functions of a skeleton

i. To support the body of the organism against various environmental forces.
ii. Provide protection to delicate body organs.
iii. Facilitate movement and locomotion in which muscles act on the skeletal material
iv. Skeletal frame works give the body of an organism shape

TYPES OF SKELETON

1. ENDOSKELETON (Bones and cartilage)
2. EXOSKELETON (cuticle)
3. HYDROSTATIC SKELETON (fluid)

a) Hydrostatic skeleton

It is found in soft bodied animals e.g. earthworms, slugs, snails, leeches, cnidarians etc. Bodies of such animals are supported by a fluid present in the coelom and cavities between structures. The fluid is surrounded by layers of muscle such that pressure caused by differential contraction of muscles against the fluid causes locomotion. **The skeletal material is a fluid**

b) Exoskeleton

Here, the hard skeletal element is found outside the body cavity. Exoskeleton is common in arthropods. The hard exoskeleton is called ***cuticle*** made from ***chitin.*** The cuticle however limits growth during much of the arthropods life except during moulting (ecdysis). The cuticle has the following functions;

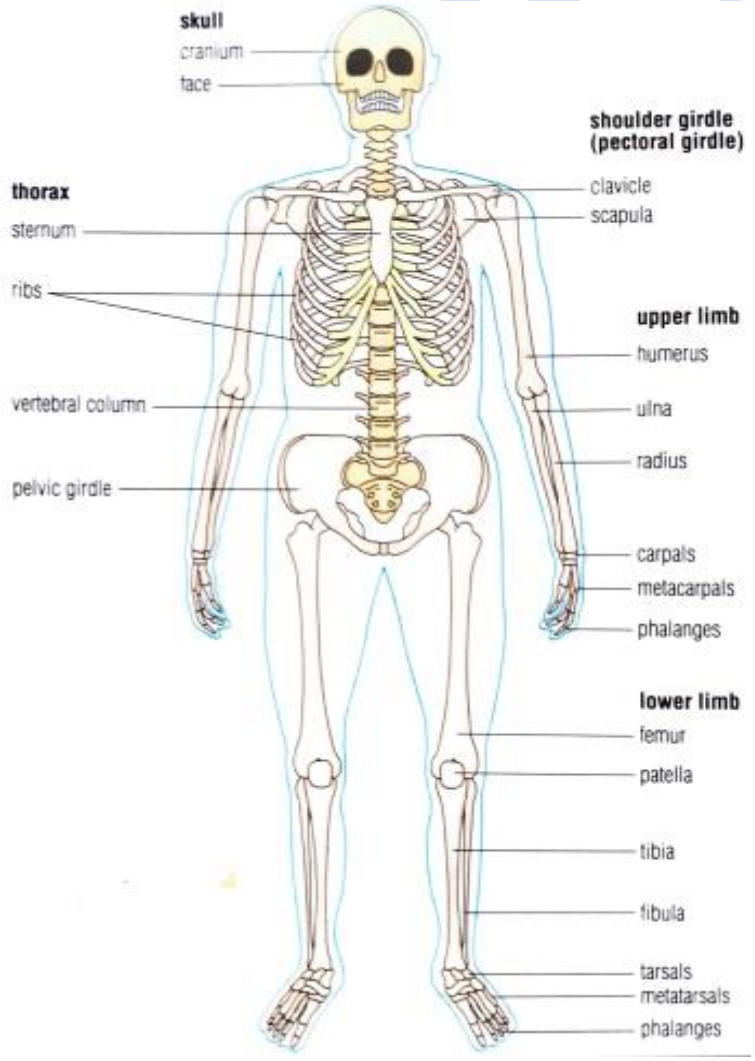
- ✓ Protection from mechanical injury
- ✓ Attachment of muscles for locomotion
- ✓ Prevents water loss from the body of organism

c) Endo skeleton

This is an internal skeleton mainly found in vertebrate animals consisting of bone and cartilage. Bone is the harder rigid tissue while cartilage is softer than bone and less rigid. For an endo skeleton, bones articulate at **joints. (Comparison between bone and cartilage)**

Draw the structure of human skeleton introduction to biology on page 119

THE HUMAN SKELETON



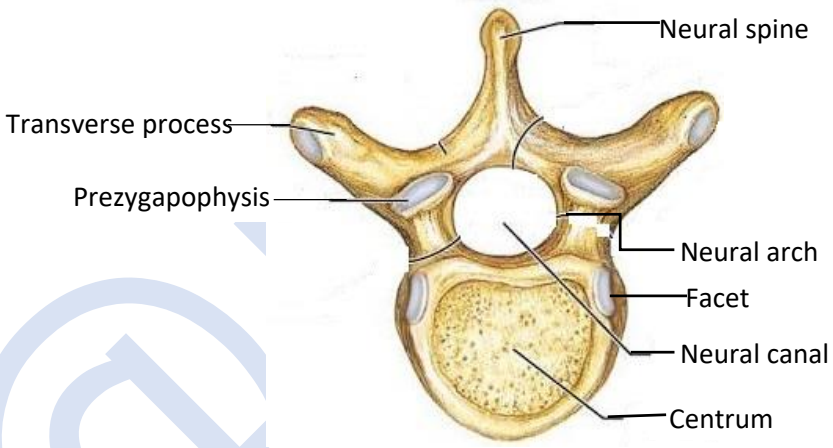
The endoskeleton consists of two divisions; **axial skeleton** and **appendicular skeleton**

a) The axial skeleton; the axial skeleton consists of the **skull** and the **vertebral column**

- ***Skull:*** made up of 22 bones which are tightly joined together by sutures (immovable joints). The skull (cranium) protects the brain, eyes and inner ear.
  The skull has two condyles at the base which articulate with the first vertebra (atlas vertebra).
  The skull also has a hole through which the spinal cord passes
- ***Vertebral column*****:** also called the back bone consists of a linear assembly of 33 bones specifically called **vertebrae.** The vertebrae thus form a long flexible column which is the main centre of support of the entire skeleton frame work, supporting the head and rest of the body. Except between the atlas and axis, a disc of cartilage (intervertebral discs) cushions each vertebra supported on the next one below and above it.
  There are five distinct types of vertebrae named according to the region of location along the body. These are;

i. Cervical vertebrae (neck region)
ii. Thoracic vertebrae (chest/thorax region)
iii. Lumber vertebrae (abdominal region)
iv. Sacral vertebrae (lower back/ sacrum)
v. Caudal vertebrae (coccyx/tail)

General structure of a vertebra



Parts of a vertebra

- **Centrum:** this is normally thick, solid, smooth and flat.
  Function: *support adjacent vertebra.*
- **Transverse process:** normally two per vertebra, that appear to project laterally away on opposite sides of the vertebra
  Function: *for attachment of muscles*
- **Neural spine:** structure that projects away from the body of the vertebra between the transverse processes.
  Function: *for muscle attachment*
- **Neural arch:** this forms the boundary of the neural canal
  Function: protects the spinal cord
- **Neural canal:** protects and allows passage of spinal cord.

- **Zygapophyses (facets):** each vertebra has two facets on the anterior and two facets on the posterior. The anterior pair are the prezygapophyses while the posterior pair are the postzygapophyses.
  Function: for articulation with other vertebrae

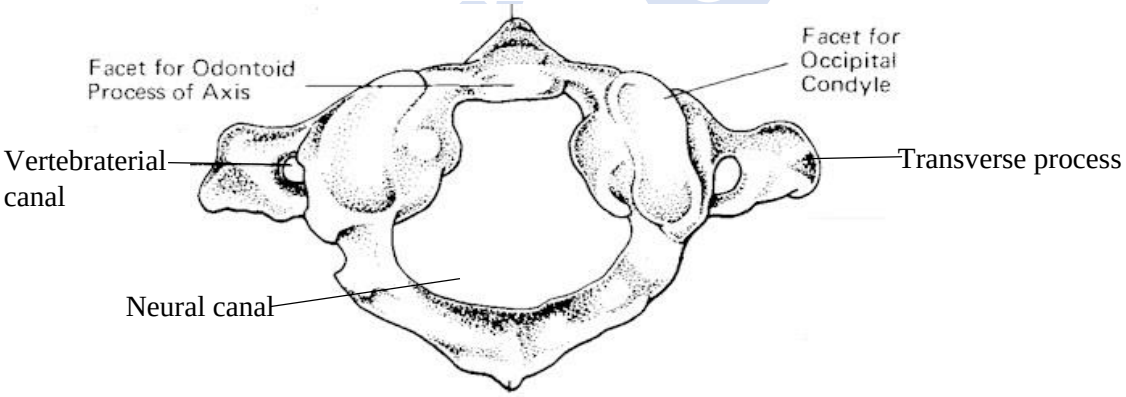
i. Cervical vertebrae

- ✓ Seven in number in man
- ✓ The first two cervical vertebrae i.e. atlas and axis are significantly different from each other and from the rest of the five cervical vertebrae
- ✓ They have a pair of cervical ribs which partially divide at the terminal end
- ✓ Have a relatively small centrum
- ✓ Have a pair of short transverse processes
- ✓ Have a short neural spine
- ✓ Anteriorly, they have a pair of upwardly projecting prezygapophyses
- ✓ posteriorly, they have a pair of projecting postzygapophyses
- ✓ have a pair of vertebraterial canals through which arterials pass

Structure of the cervical vertebra

Atlas vertebra; this is the first cervical vertebra

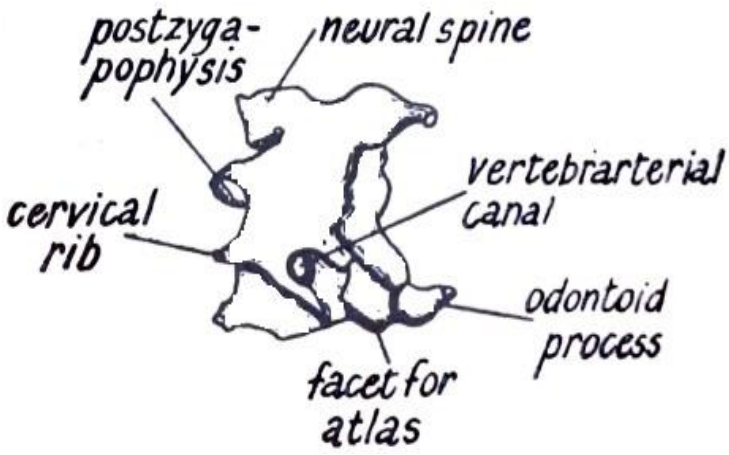
- ✓ short neural spine
- ✓ two vertebraterial canals
- ✓ pair of short transverse processes
- ✓ facets to articulate with occipital condyles of skull
- ✓ no centrum
- ✓ has facet to articu Neural spine oid process of axis



Axis vertebra; this is the second cervical vertebra

- ✓ has a small centrum
- ✓ has odontoid process to articulate with atlas
- ✓ has a pair of vertebraterial canals
- ✓ has 2 postzygapophyses
- ✓ short neural spine
- ✓ has a pair of cervical ribs

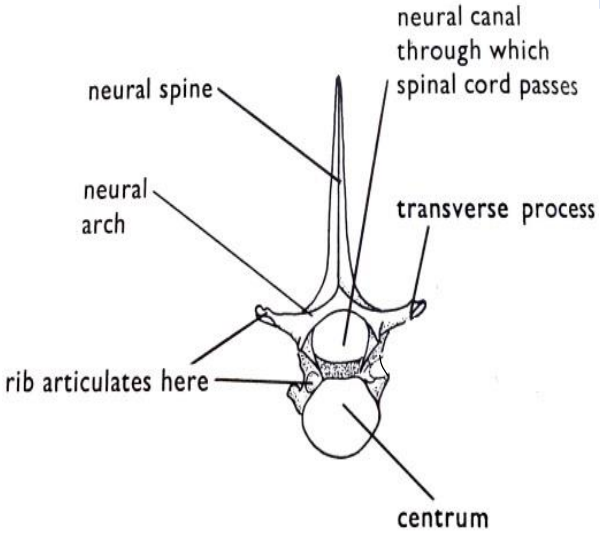
Lateral view of axis vertebra



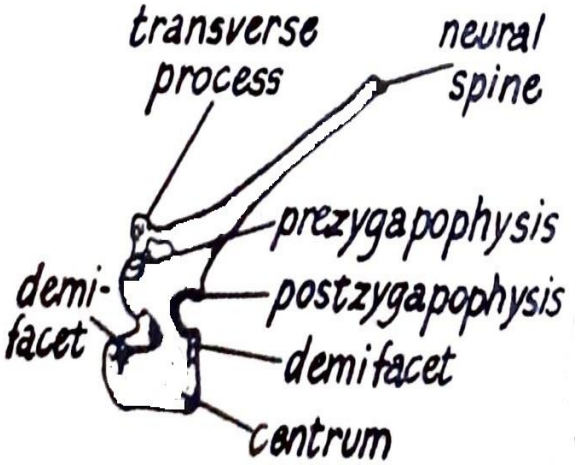
ii. thoracic vertebrae

- ✓ twelve in number
- ✓ long neural spine projecting down ward to the dorsal side
- ✓ two short horizontal transverse processes
- ✓ two demi facets to articulate with capitulum of rib
- ✓ relatively large round centrum
- ✓ has additional facets called prezygapophyses on anterior side and postzygapophyses on posterior side
- ✓ has neural arch
- ✓ has neural canal

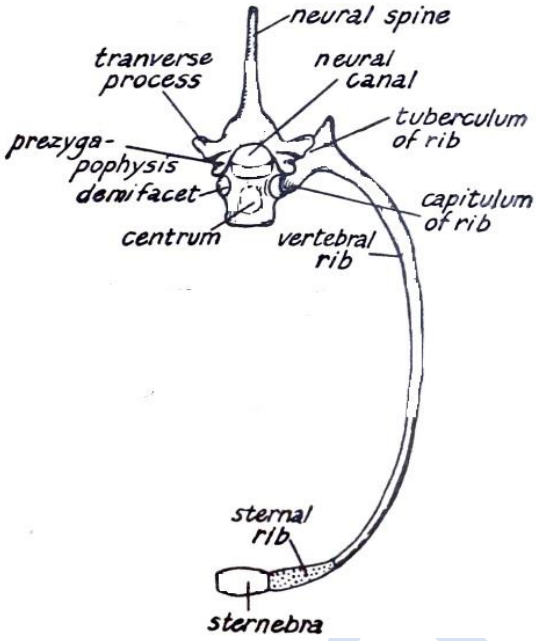
Posterior view of thoracic vertebra



Lateral view of thoracic vertebra



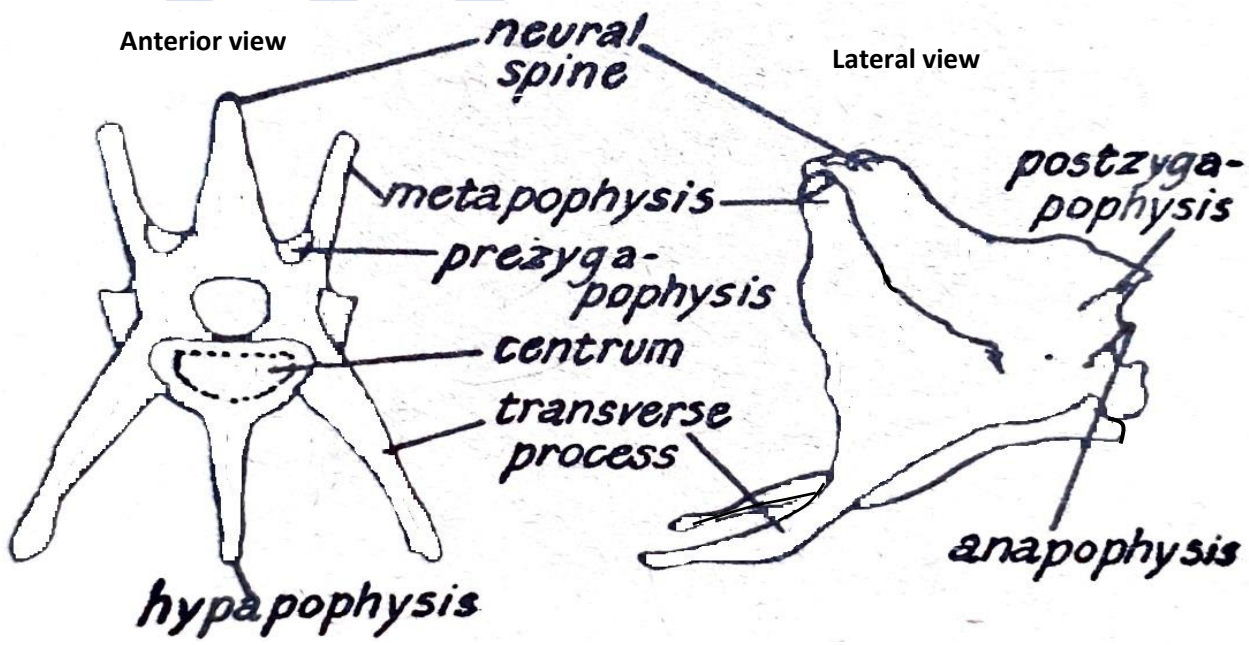
Structure showing thoracic vertebra articulating with rib



iii. Lumber vertebrae

- ✓ Five in number
- ✓ Largest of all vertebrae
- ✓ Have a prominent neural spine
- ✓ Neural spine flanked on both sides by metapophyses
- ✓ Has a pair of anapophyses below postzygapophyses
- ✓ Have a hypapophysis, a medium downward projection of the centrum
- ✓ Large centrum
- ✓ Prominent neural arch
- ✓ Has neural canal

Structure of lumber vertebrae



iv. Sacral vertebrae (sacrum)

- ✓ They are five but fused to form the sacrum
- ✓ Vertebrae have large centrum
- ✓ Each sacral vertebrae linked to the next below it by the centrum and the postzygapophyses. The postzygapophyses articulate with the prezygapophyses of the next vertebra.
- ✓ Transverse processes have facet to articulate with ilium of pelvic girdle

v. Caudal vertebrae (coccyx)

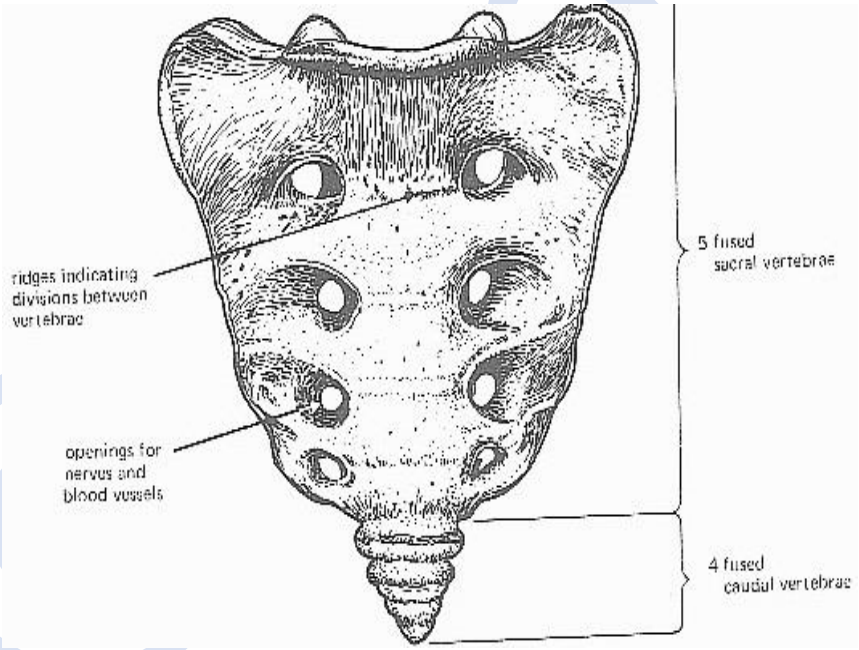
- ✓ They are four fused to form a coccyx.
- ✓ Vertebrae have no neural canal
- ✓ Vertebrae have no neural arch

PRACTICAL ACTIVITY:

Examine vertebrae and state the characteristics, adaptations of each type of vertebra

Make labelled drawings of posterior, anterior and lateral views of each type of vertebra

Structure of sacrum and coccyx



Function of the vertebral column

- ❖ Protect the spinal cord
- ❖ Allows movement of neck in all planes at the joint between atlas and axis
- ❖ For attachment of muscles responsible for posture and balance of the body
- ❖ Pivotal centre of support for the entire body and head
- ❖ Provides surface for attachment of the rib cage
- ❖ Provides surface for attachment of tendons and ligaments which aid in support.

b) Appendicular skeleton; this consists of the girdles and the limbs.

It is by the girdles that the limbs are linked to the axial skeleton. There are two types of girdles each associated with a pair of limbs as below;

- The **pectoral girdle** to which a pair of fore limbs articulate.
- The **pelvic girdle** to which a pair of hind limbs articulate.

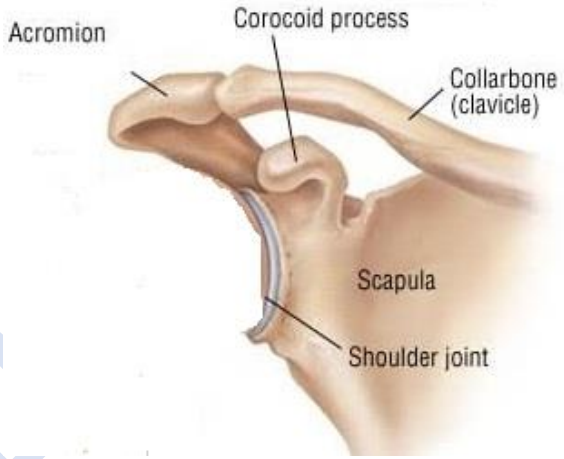
PECTORAL GIRDLE

In vertebrates (man), the pectoral girdle consists of the two clavicles (collar bones) and two scapulae (shoulder blades).

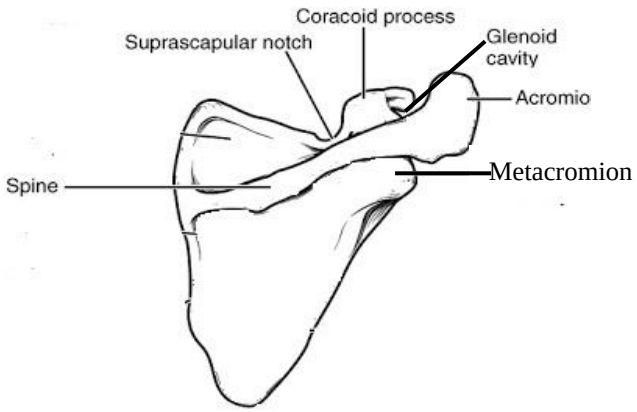
- ✓ In man, the clavicles articulate with the sternum ventrally while the scapulae are attached by muscles to the rib cage at the dorsal end. This allows for greater mobility of the fore limbs
- ✓ The pectoral girdle is therefore not directly attached to the axial skeleton

ACTIVITY: ***name the bones that make up the pectoral girdles in man***

Diagram of the pectoral girdle



Scapular



- ✓ It's a flat triangular bone that tappers to the glenoid cavity
- ✓ Has a raised ridge on dorsal surface called the spine
- ✓ Towards glenoid cavity, it has a coracoid process and the acromion which articulates with the clavicle

PELVIC GIRDLE

This girdle consists of two halves joined together ventrally by a thin cartilage called *pubis symphysis*. Dorsally, the pelvic girdle is tightly attached to the vertebral column at the *sacrum.*

Each half of the pelvic girdle consists of three bones;

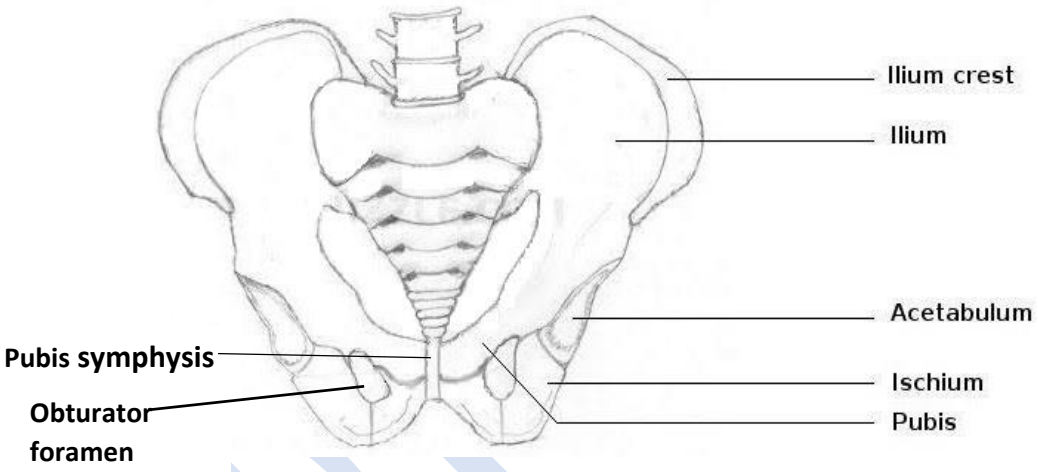
i. Ilium
ii. Ischium
iii. Pubis

The bones meet at a socket called *acetabulum*, where the head of the femur articulates.

A part called Obturator foramen (hole) allows for passage of blood vessels and nerves.

The attachment of the pelvic girdle directly to the vertebral column means that the thrust of the legs during movement is transmitted to the spine to cause body movement

Structure of the pelvic girdle



Ribs

There are twelve pairs of ribs that run from the ventral region of the thorax dorsally to articulate with the thoracic vertebrae. The anterior end of ribs is attached by cartilage to the sternum on ventral side of body while the posterior of each rib attaches to a respective thoracic vertebra on dorsal side of the body. All ribs together form the rib cage anterior to which is the sternum (breast bone) that protects the heart, lungs and important during breathing movements.

Structure of a rib

Function of the mammalian skeleton

- ✓ To support the body of the organism against various environmental forces.
- ✓ Provide protection to delicate body organs such as the lungs and brain in mammals
- ✓ Facilitate movement and locomotion in which the bones of the skeleton act as levers.
- ✓ Skeletal frame works give the body of an organism shape
- ✓ Formation of blood cells for example red blood cells are made in bone marrow of long bones.
- ✓ Storage of calcium and phosphate ions

PENTADACTYL LIMBS

The limbs of man consists of five digits or phalanges and are thus said to be pentadactyl. The presence of pentadactyl limbs is common to vertebrates from amphibians, some reptiles, birds and mammals. The pentadactyl limb of these vertebrates thus shows the same basic plan though the form differs.

The fore limb of man is adapted to grip while the hind limb is adapted to firm traction

Generalized structure of a pentadactyl limb

LIMBS: man has two sets of limbs i.e. fore limbs and the hind limbs which occur in pairs.

Fore limbs (arm). Each fore limb consists of the following;

- ***Humerus bone*** in the upper arm which has a rounded head that articulates with the glenoid cavity of the scapula.
- One ***ulna bone*** and one ***radius bone*** in the fore arm
- ***Eight carpels*** in the wrist
- ***Five metacarpals*** in the palm
- ***Fourteen phalanges*** in the fingers i.e. 2 in the thumb and 3 in each finger.

Diagram of Humerus

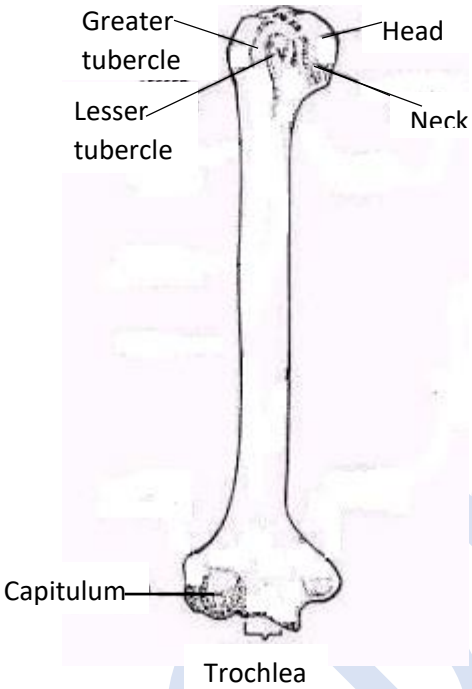
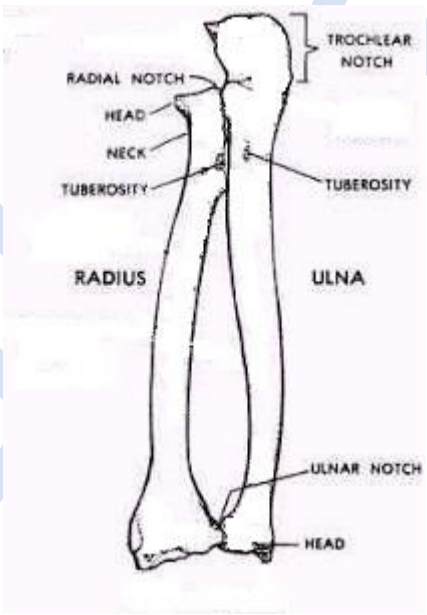


Diagram of radius and ulna



Hind limbs (legs). Each hind limb consists of the following;

- **One femur** (thigh bone)
- **Patella** (knee cap)
- One **tibia** and one **fibula** in the sheen
- **Seven tarsals** in the ankle
- **Five metatarsals** in the sole
- **Fourteen phalanges** in the toes

Diagram of anterior view of femur

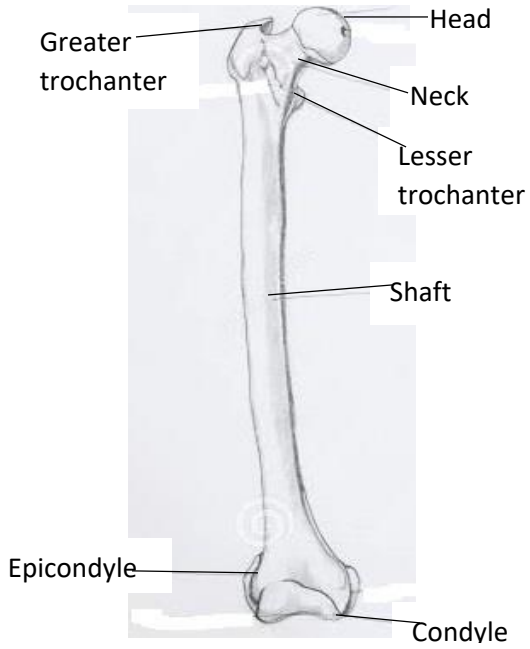
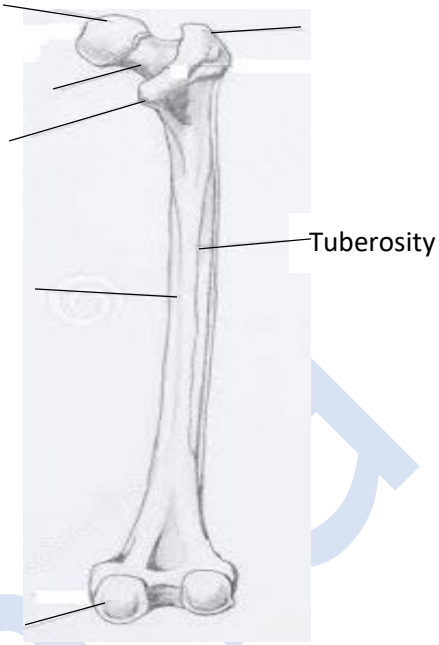


Diagram of posterior view of femur



ACTIVITY; Name the structures labelled above for the posterior view of the femur

Diagram of the tibia and fibula

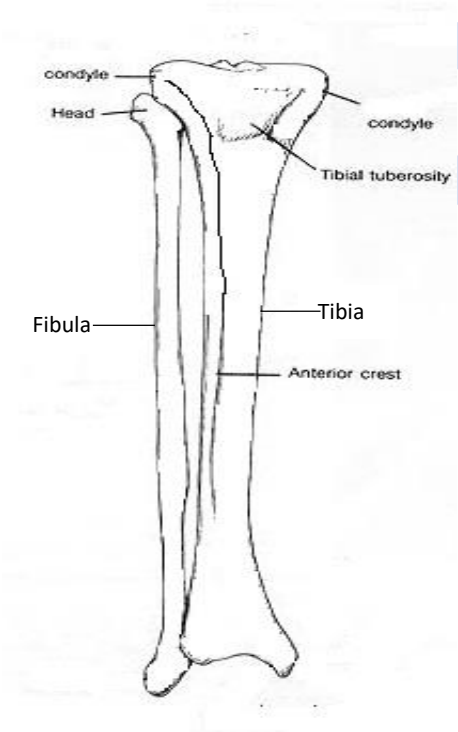
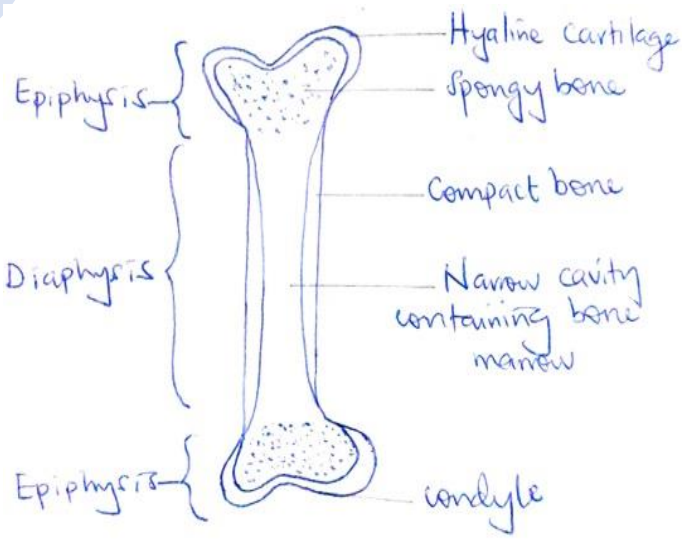


Diagram of the internal structure of a long bone



COMPARISON BETWEEN BONE AND CARTILAHE

Similarities

- ✓ Both are connective tissues
- ✓ Both are endoskeleton materials.

Differences

BONE	CARTILAGE
▪ **Hard and rigid**	▪ **Soft and flexible**
▪ **Blood vessels pass through them**	▪ **Blood vessels don't pass through them**
▪ **Some bones contain marrow**	▪ **Does not contain marrow**
▪ **Synthesis of red blood cells occurs in some bones**	▪ **No synthesis of red blood cells occus**
▪ **Contains calcium, magnesium and phosphorus salts**	▪ **Does not contains calcium, magnesium and phosphorus salts**

JOINTS

In man, joint occur where bones meet. *A joint is thus referred to as a point where two more bones meet in the skeleton.* There are basically two types of joints;

Immovable joints: these are rigid and do not allow movement e.g. sutures of the skull and the joint between pelvic girdle and sacrum.

Movable joint: these are flexible and allow movement in different planes e.g. hinge joint, ball and socket joint, gliding joint, pivot joint, saddle joint.

NOTE: joints may also be categorised as **synovial joints**, if they contain *synovial fluid* or **non-synovial joints** if they do not contain synovial joints

A TABLE SHOWING THE TYPES OF JOINT AND LOCATION IN THE BODY

Example of joint	Type of joint	Location in body	Movement allowed
1. **Sutures(immovable)**	*immovable*	*skull*	*none*
2. **Hinge joint**	*moveable*	*At elbow, knee, divisions of digits*	*One plane*
3. **Ball and socket**	*moveable*	*Shoulder, hip(groin/pelvis)*	*three planes*
4. **Gliding joint**	*moveable*	*Wrist, ankle, between some vertebrae*	*All planes*
5. **Pivot joint**	*moveable*	*Neck(between atlas & axis)*	*All planes*
6. **Saddle joint**	*moveable*	*radius and ulna*	*Two planes*
7. **Joint between sacrum & pelvic girdle**	*immovable*	*pelvis*	*none*

SYNOVIAL JOINTS: *these are joints that contain synovial fluid.* There are basically two synovial joints i.e. hinge joint and ball and socket joint.

- **Hinge joint:** it allows movement in only one plane e.g. _____
- **Ball and socket joint:** allows movement in three planes e.g. _____

Diagram of Hinge joint at knee

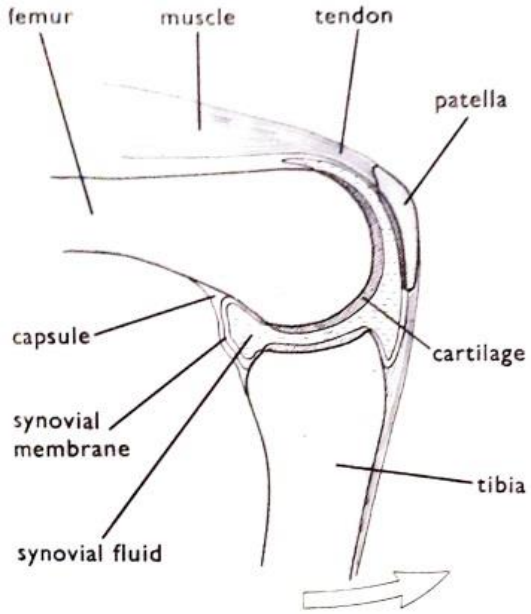
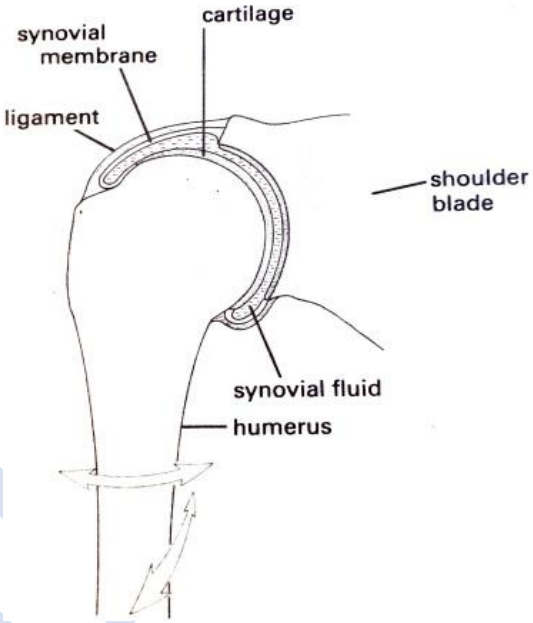


Diagram of ball and socket joint



NB: *arrows show the planes of movement allowed in the two joints.* ***Arrows must not be included in your drawings.***

FUNCTION OF PARTS OF THE JOINTS

1. **Capsule;** this surrounds the joint
2. **Synovial membrane;** secrets synovial fluid.
3. **Synovial fluid;** lubricates the joint to prevent friction during movement.
   It also provides nourishment to surrounding articular cartilage
4. **Cartilage;** prevents direct contact between articulating bones so they don't wear each other.
   The cartilage also cushions the ends of bones, absorbing shock during strain to the joint.
5. **Tendon;** joins a muscle to a bone at a joint.
6. **Ligament;** joins a bone to a bone at a joint.
7. **Muscle;** contracts to cause movement at a joint.

NON SYNOVIAL JOINTS; these are joints without synovial fluid.

- **Gliding joints;** these allow gliding movements of small bones over each other such that movement at a joint can occur. Gliding joints permit varying degrees of movements
- **Sutures (immovable joint);** these exists between the bones that make up the skull. No movement is permitted at these joints.

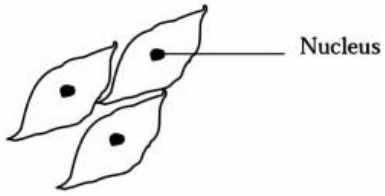
- ❖ **Pivot joints;** these involve one bone acting as a pivot at which movement is allowed by the second bone. This joint is unique and is responsible for the head movements in the neck, between the atlas and axis vertebrae.
- ❖ **Saddle joints;** this is found between the radius and ulna and allows twisting movements in two planes.

MUSCLES; there are three types of muscles each with a unique set of characteristics. These characteristics enable the muscle to perform a particular function in the body.

a) Smooth muscles; *found in blood vessels, wall of urinary bladder, gut, reproductive organs*

- They are not striated i.e. do not have a pattern of bands
- Each muscle cell has one nucleus
- They are involuntary in action
- Controlled by the autonomic nervous system

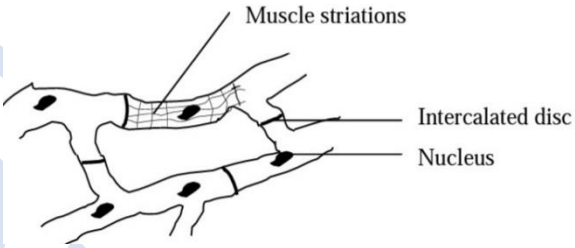
Structure of a smooth muscle



b) **Cardiac muscle;** *found in wall of the heart*

- Has striations i.e. a pattern of bands
- Cells linked together by intercalated discs
- Muscle cell may have one or two nuclei
- Involuntary in action.
- Muscle is myogenic i.e. contraction not initiated by nervous system but by heart muscle itself.
- Does not fatigue

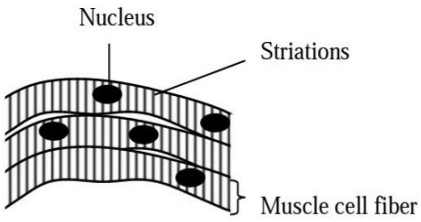
Structure of a cardiac muscle



c) Skeletal muscle; attached to bones

- Consists of elongated muscle cells
- Muscle is striated
- Single cell has more than one nucleus
- Voluntary in action
- Action initiated by nervous system; neurogenic

Structure of the skeletal muscle



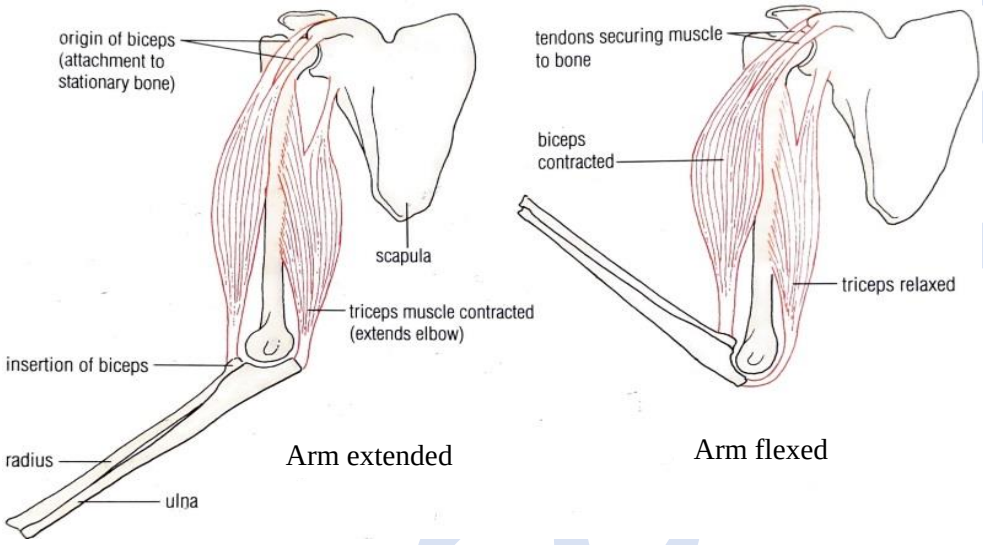
Movement of limbs at joints

In man, limb movement is brought about by the action of skeletal muscles. Two sets of muscles operate to cause movement of a limb. The two sets of muscles are called **antagonistic muscles.**

They are called antagonistic muscles because they cause opposite movements of the same limb alternately. They however do not cause movement of the same limb at the same time.

The action of antagonistic muscles is such that as one muscle contracts, the other one relaxes and this causes movement of the limb in a particular direction.

Action of antagonistic muscles to cause movement of the arm



Arm extended Arm flexed

Extension of arm

This occurs when the triceps muscle attached to the ulna by a tendon contracts while the biceps relaxes. This results into pulling of the fore arm outward resulting into the arm extending.

Flexion of the arm

This occurs when the biceps muscle attached to the radius contracts while the triceps relaxes. This results into pulling of the fore arm inward resulting into the arm being flexed.

LOCOMOTION IN INSECTS e.g. grasshopper

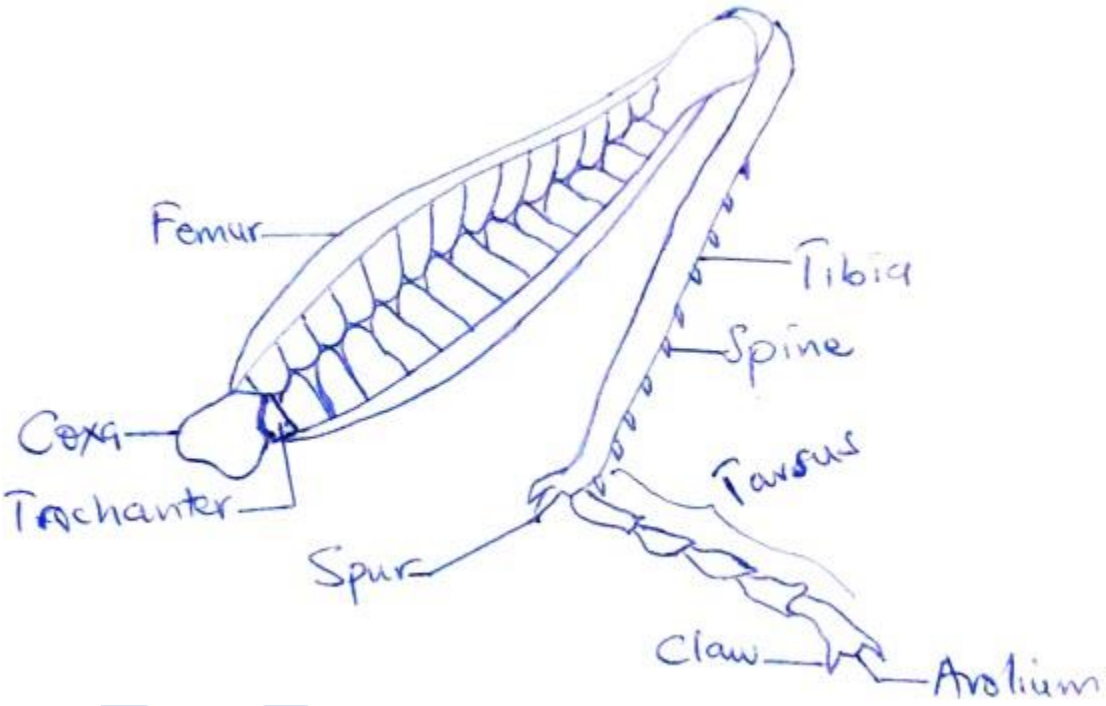
Insect locomotion is mainly by *walking* or *flying*, however, grasshoppers also carry out a unique mode of locomotion called *hopping.*

Hopping; during this type of locomotion, a grasshopper jumps from one point, forward to another point. Hopping is powered mainly by the hind limbs.

Description of structure of the hind limb of a grasshopper

- The hind limbs are longer and considerably larger than the front two pairs of limbs
- The femur is long and thickened due to presence of muscles that cause hopping
- The tibia is elongated but slender with pointed short spines facing downward along its length.
- The tarsus is small but all of it lies on the ground which improves traction. Has claws and glandular pads.

Diagram of a hind limb of a grasshopper

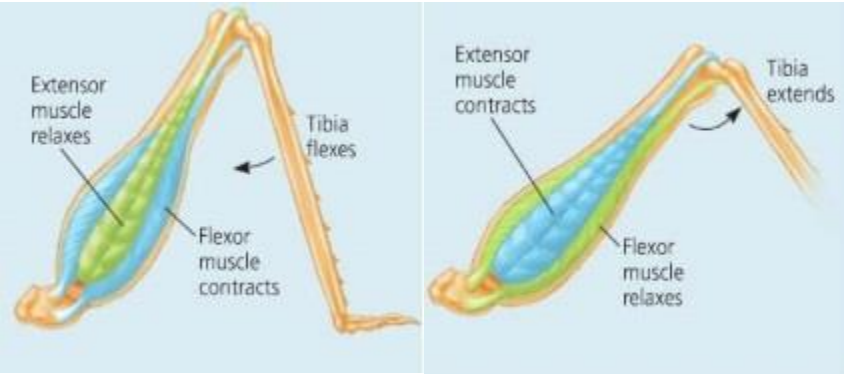


Mechanism of hopping

- ✓ The flexor muscle contracts, pulling the tibia tight to the femur.
- ✓ During this period, strain is imposed onto the tendons in the joint between the femur and tibia.
- ✓ The extensor muscle now starts to contract slowly before the flexor muscle relaxes
- ✓ At full contraction of the extensor muscle, the flexor muscle relaxes suddenly
- ✓ Energy stored as strain in the tendons is released as a recoil which is coupled with action of the extensor muscle such that the grasshopper jumps in the air against traction off the ground.

Illustration

Flexor muscle contracts pulling tibia close to femur while extensor muscle is relaxed	Extensor muscle contracts while flexor muscle relaxes, tibia extends, hopping occurs



Flying: flight in insects is brought about by wings. There are two types of flight muscles in insects.

Small compact insects such as bees, wasps, mosquitoes and houseflies have indirect flight muscles which aid their flight. Indirect flight muscles are muscles which are not directly attached to the wing base. Indirect flight muscles are associated with rapid wing beat.

Larger insects such as the grasshopper, cockroach and dragon fly have direct flight muscles. Direct flight muscles attach directly to the wing. Both indirect and direct flight muscles consist of the depressor muscle and the elevator muscles

Mechanism of flight in a grasshopper (action of direct flight muscles)

DOWN STROKE

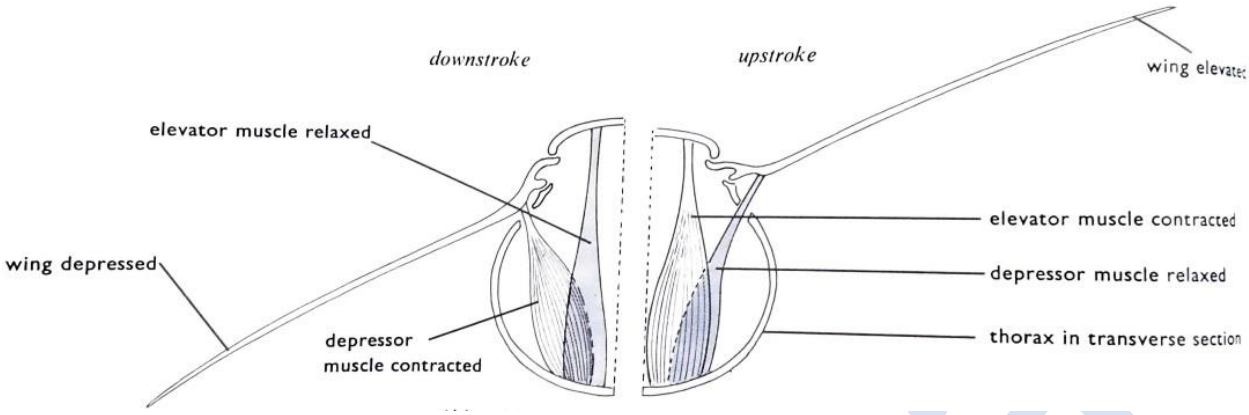
- ✓ Here, the depressor muscle attached directly to the wing base contracts while the elevator muscle is relaxed.
- ✓ The wing is pulled downward, thrusting against the air to bring about a lifting force of the insect

UP STROKE

- ✓ The elevator muscles, attached to the roof of the thorax contract while the depressor muscle are relaxed.
- ✓ The roof of the thorax is pulled down ward, pivoting the wing upward.
- ✓ This brings about a slight lowering in altitude of insect.

Note: ***in both direct and indirect flight, there are direct flight muscles which by acting on the wing insertion can alter the wing angle in air***

Illustration



Walking; this is made possible by a pair of antagonistic muscles i.e. the *flexor* and *extensor* muscles attached to the inner surface of the cuticle acting to cause movement at the *peg and socket joint.* Similar to a hinge joint, movement in the peg and socket joint occurs in only one plane.

However, there are numerous such joints in a single limb each causing movement in a given plane. The flexor muscle folds the joint while the extensor muscle extends the joint during movement.

Mechanism of walking

- ✓ During walking, the front pair of limbs pulls the insect forward while the other two pairs push it.
- ✓ At any one moment of walking, three legs move forward while the other tripod of legs supports the insect off the ground.
- ✓ The first and third leg on one side together with the middle leg of the opposite side move while the remaining three legs are supporting the insect.
- ✓ The alternate pattern of leg movement and support is responsible for the zigzag locomotion observed in insects.
- ✓ During locomotion, the arolium enables the insect to move on smooth surfaces by secreting a sticky substance. The claws enable the insect to move on rough surfaces.

ACTIVITY:

State any three types of locomotion in insects

Describe direct flight in insects

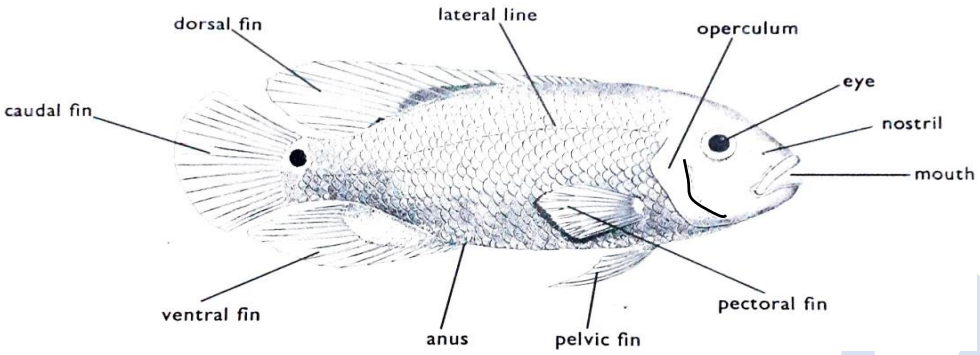
Describe the mechanism of walking in insects

Explain why insects move in a zigzag pattern

LOCOMOTION IN BONY FISH.

Fish are ectothermic vertebrates that live in aquatic environments. Fish locomote by swimming.

Structure of a bony fish



Function of parts of a fish

- **Nostrils;** allow water to pass to organs of smell, to detect smell of food
- **Eyes;** for sight
- **Mouth;** for taking in food. Also allow water currents in to facilitate gaseous exchange.
- **Operculum;** bony flap which protects the gills from mechanical damage.

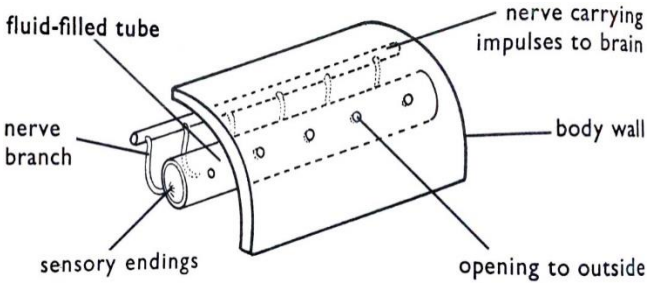
Operculum allows water containing high carbon dioxide concentration to move out of fish. Movements of operculum create pressure gradients for flow of water for gaseous exchange

- **Scales;** bony structures which protect the body of the fish from mechanical damage and attack by pathogens.
- **Paired fins i.e. pectoral fins and pectoral fins;** this exist in pairs on opposite sides of the fish. They are used for;
  - reducing speed of locomotion
  - brakes to enable the fish stop
  - stabilize fish when swimming
  - enable fish to turn through 180^{o} in its own length
- **Median fins i.e. dorsal fin, anal fin and ventral fin;** increase vertical surface area of fish exposed to water to prevent sideways deflection of its head and to prevent deflection from its vertical axis of swimming.

Note: *the **main** function of fins is to control stability and direction of fish movement*

- **Lateral line;** this is a fluid filled tube just below the skin marked by a series of pores along the skin of a fish.
  Function**:** to detect vibrations in water, enabling fish to navigate objects, and escape predators.

Structure of lateral line



Lateral line picks up vibrations from water.
Vibrations cause impulses that are transmitted to the brain for interpretation.
Fish is able to effect change by navigating about an object.

- **Swim bladder;** though not seen externally, the swim bladder is very important to enable a fish maintain buoyancy at a particular depth of water when swimming.
- **Sacculus and utriculus;** found in inner ear, for hearing.

Mechanism of swimming

The muscles called myotomes on either side of the spine contract in series from head to tail and down each side alternately causing a wave of movement to pass down the body of the fish. This is also possible because of the highly flexible vertebral column.

Due to the greater weight and limited flexibility of the head, the wave like movements are more pronounced in the tail as it thrusts against the water for the whole fish to be propelled forward.

Adaptations of fish to swim

- Stream lined body to reduce water resistance during swimming
- Presence of myotomes along the whole length of the body which contract and relax to bring about wavelike movements when swimming
- Large prominent eyes to enable fish to see well when swimming
- Have nictitating membrane to protect eyes from damage when swimming to maintain sight.
- Have fins for stability during swimming.
- Have fins to enable fish change direction swiftly when swimming
- Have swim bladder to enable fish maintain buoyancy at a particular depth.
- Have a lateral line to enable fish detect vibrations of objects when swimming.
- Paired fins which enable fish to reduce speed or stop instantly when swimming
- The vertebral column is highly flexible to ease swimming movements.

VERY IMPORTANT; swimming movement in fish are brought about by the whole muscular body.

It's only in a few fish that fins contribute a propulsive force

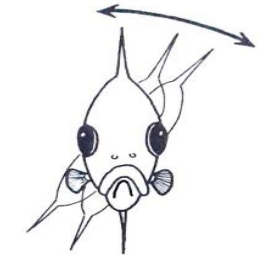
CONTROL OF STABILITY IN FISH

The swimming movements of fish described bring about 3 destabilizing forces to movement. The distabilising forces are due to the greater weight of the head and its limited flexibility

i. Rolling
ii. Yawing
iii. Pitching

i. Rolling; this is the deflection of the fish off its vertical axis when swimming.

Illustration



ROLL (*median fins*)

Control: *rolling is controlled by the median fins i.e. dorsal fin, anal fin and ventral fin*

ii. Yawing; this is the lateral deflection of a fish when swimming. Here, the head is deflected sideways.

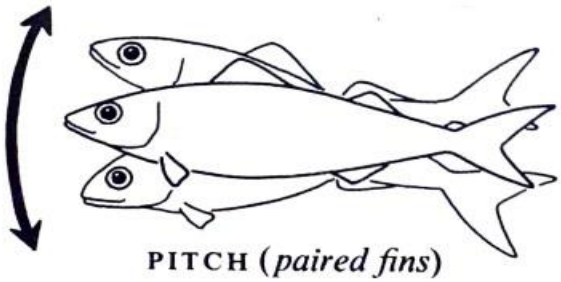
Illustration

YAW (*median fins*)

Control: *yawing is controlled by the median fins i.e. dorsal fin, anal fin and ventral fin*

iii. Pitching; this is the vertical plunging of a fish when swimming. The fish keeps moving upward and downward when swimming

Illustration



PITCH (*paired fins*)

Control; *pitching movements are controlled by the paired fins i.e. pectoral fins and pelvic fins.*

ACTIVITY:

i. Give the adaptations of tilapia to its mode of locomotion
ii. Give two advantages of fish staying in water than on land
iii. Explain instabilities encountered by tilapia when swimming and explain how they are dealt with.

LOCOMOTION IN BIRDS

Birds are endothermic vertebrates whose fore limbs are modified to wings. The body of birds is covered with feathers which are produced by the skin. Their skin has no sweat glands.

Feathers are the single external features that distinguish birds from other vertebrates.

Most birds exhibit two forms of locomotion i.e. *walking* and *flying*. Walking is possible due the ***pair of hind limbs*** that function in a way similar to those of man.

Flight is possible due to the modified fore limbs which form wings with feathers that increase their surface area.

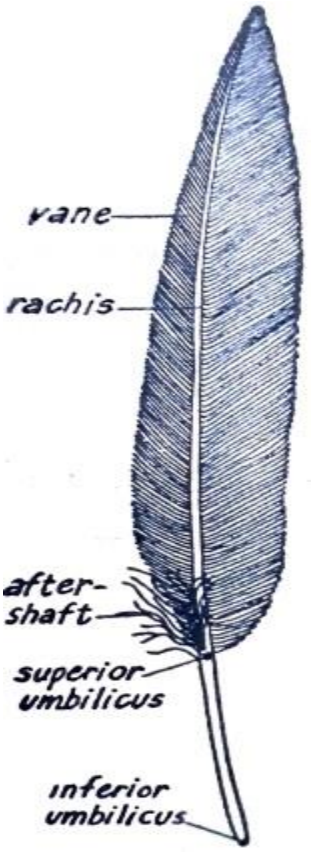
Functions of feathers

i. Body insulation against heat loss
ii. Prevent water from reaching the skin of the bird due to their plumage
iii. Prevent water loss from the body of the bird.
iv. Mechanical protection of the body of the bird from injury
v. Brightly coloured feathers may be used in courtship displays in some birds.
vi. The filoplumes carry out sensitivity.

TYPES OF FEATHERS.

a) Quill feather
b) Covert feather
c) Contour feather
d) Down feather
e) Filoplume
f) Bristles

a) QUILL FEATHER; *found on wings and tail*



Characteristics

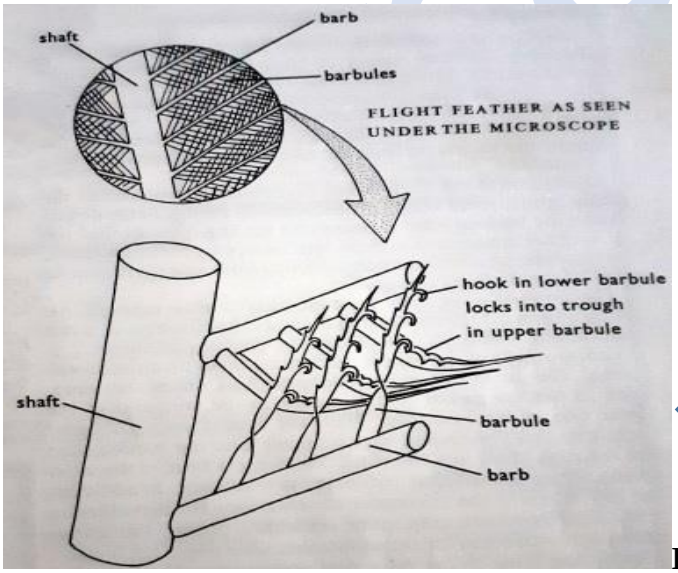
- Has a large vane
- Flattened vane
- Has a hollow calamus
- Has a long quill
- Long rachis (shaft)
- Rachis is rigid
- Rachis is solid
- Small after shaft
- Has superior and inferior umbilici

Function

- ✓ Flight
- ✓ Protection
- ✓ Courtship display
- ✓ Offer resistance to air passage during flight

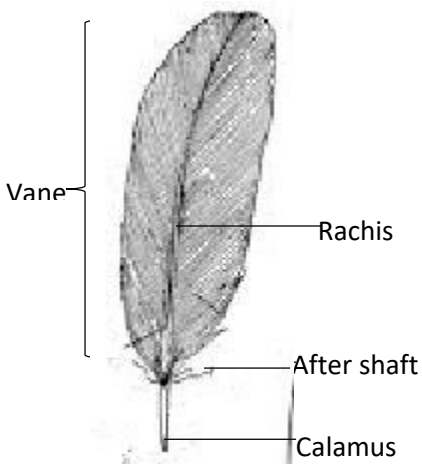
The vane of the quill feather consists of interlocking barbules which are found on barbs that branch off the rachis

Diagram showing how barbules interlock to form a vane



Draw the second diagram only (arrow)

b) COVERT FEATHER; *found on wings and tail*



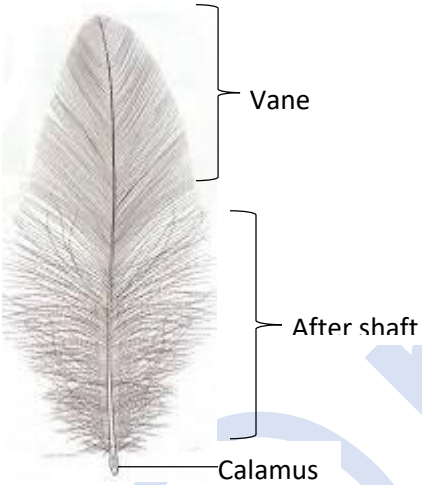
Features

- Relatively large vane
- Small after shaft
- Relatively long calamus

Function

- ✓ Protects body from mechanical damage
- ✓ Enable smooth air flow without turbulence
- ✓ Offer resistance to air passage during flight

c) CONTOUR FEATHER;



Contour feathers are found around the neck region towards kill extension

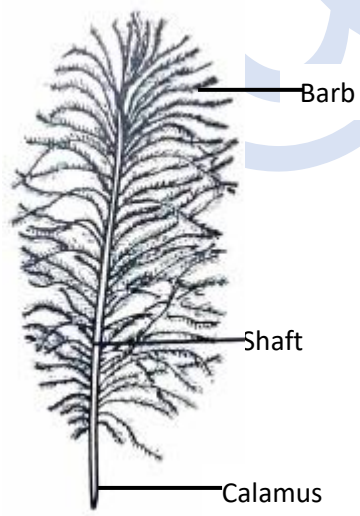
Features

- Small vane
- Large after shaft
- Short calamus

Function

- ✓ Insulate body against heat loss

d) DOWN FEATHER



Down feathers are found in neck region, keel and entire ventral region

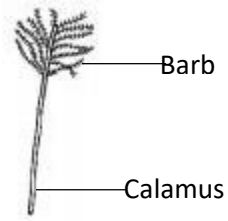
Features

- Soft and fluffy
- Consists of free barbs
- Relatively short calamus

Function

- ✓ Insulation against heat loss

e) FILOPLUME; *spread throughout the entire body*



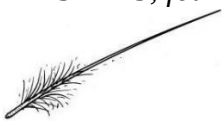
Features

- Long calamus
- Consist of few barbs

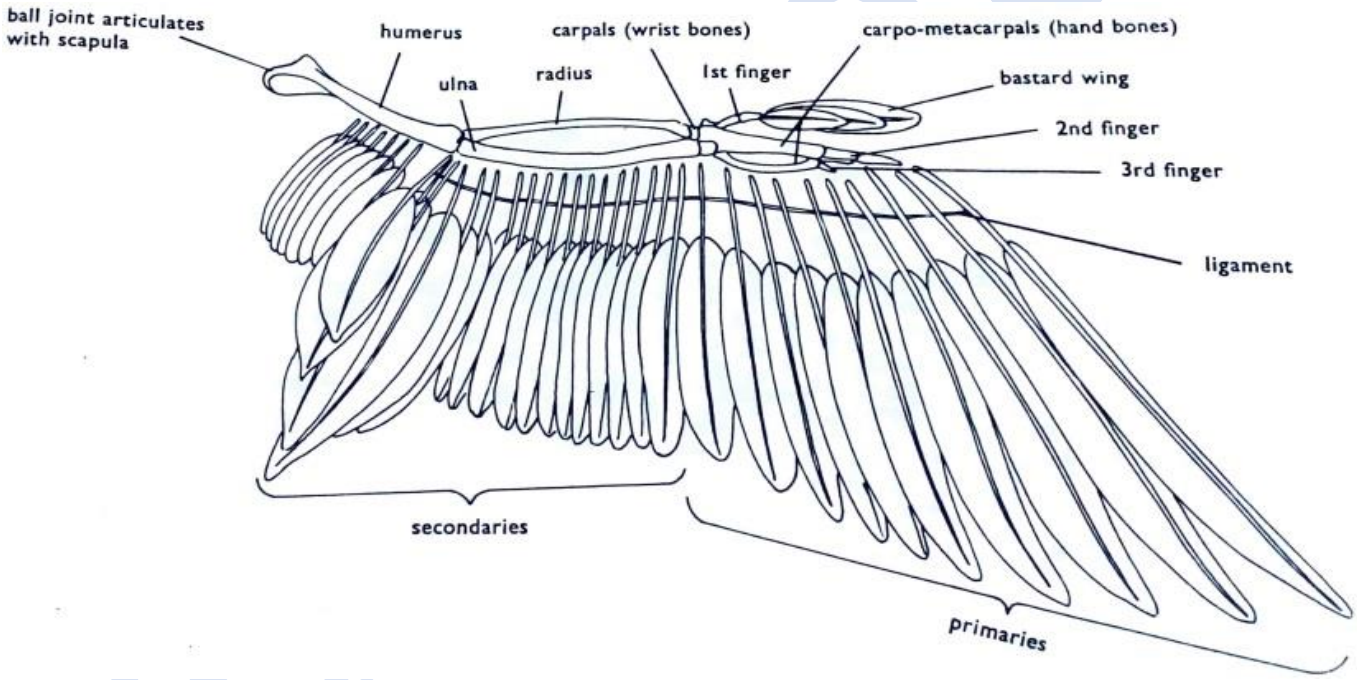
Function

✓ For sensory activity

f) BRISTLES; *found around the eyes and the beak*



<u>Diagram to show arrangement of flight feathers on a skeleton of a bird wing</u>



On the wing, flight feathers are divided into two;

- ❖ **Primaries,** which mostly bring about the forward thrust during flight
- ❖ **Secondaries,** which mostly bring about the upward lift force during flapping action.

The bastard wing may be important during takeoff, for giving a forward thrust.

FLIGHT IN BIRDS; flight in birds can be categorised into flapping, gliding and soaring.

Gliding

This is a flight movement in which the wings are spread out and remain almost stationary at a low angle of attack such that the bird gradually loses height.

Soaring

This is a flight movement in which the wings are spread out and used as aerofoils such that a bird can gain height resulting from lift by upward air currents.

Flapping

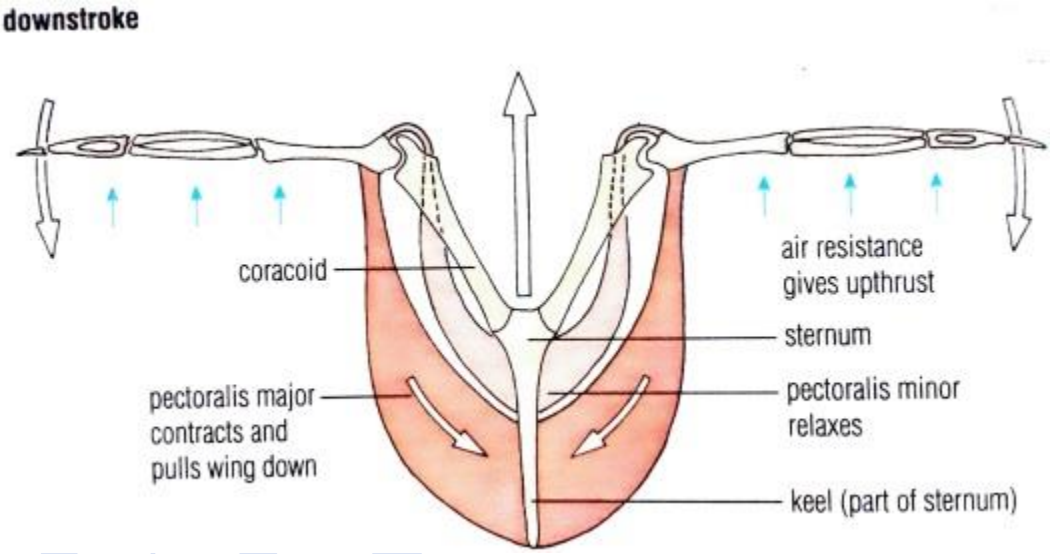
This is a flight movement which involves contraction and relaxation of the pectoralis muscles to generate propulsion as well as a lift.

Flapping therefore involves alternate upward and downward strokes of the wings of the bird.

Mechanism of flapping.

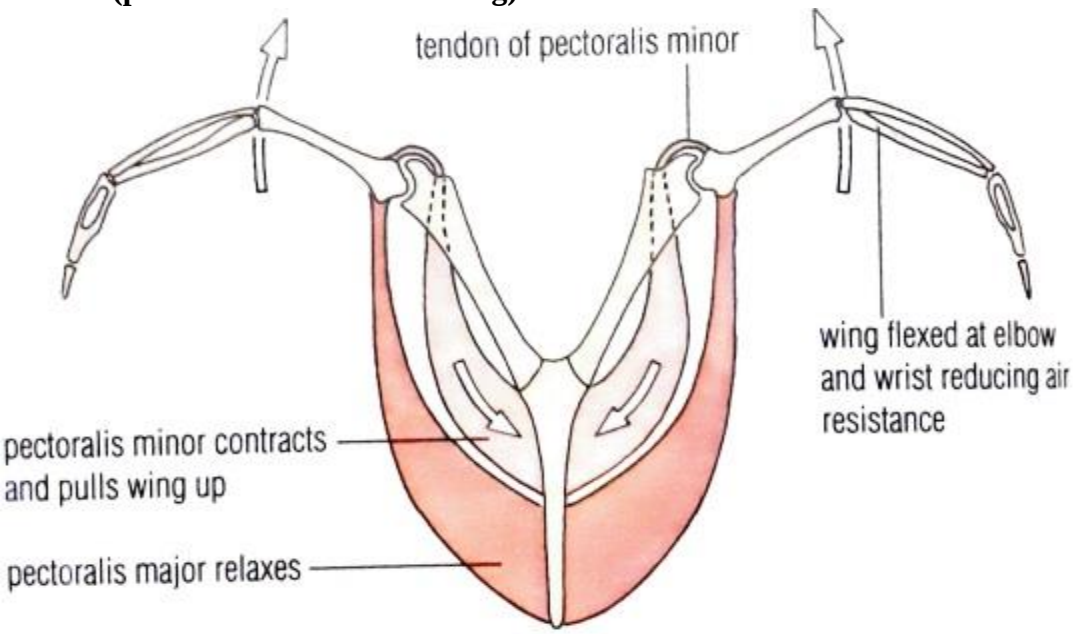
This is effected by the pectoralis major and pectoralis minor muscles

1. **Down stroke (pectoralis major depresses wing)**



- ✓ During the down stroke, the pectoralis major attached to the lower side of the Humerus contracts, pulling the wing downward.
- ✓ Meanwhile, the pectoralis minor muscle is relaxed
- ✓ During the downward stroke, air resistance closes gaps between feathers.
- ✓ The force from wings is transmitted through the coracoid bones to the sternum, acting through the bird's centre of gravity to lift it as a whole upwards.
- ✓ Also, the leading edge of the wing is below its trailing edge so that the air is thrust backward and the bird moves forward.

2. **Up stroke. (pectoralis minor raises wing)**



- ✓ During the upstroke, the pectoralis minor muscles which attach to the upper side of the humerus by a tendon contract while the pectoralis major muscles relax
- ✓ This raises the wings
- ✓ The wing is rotated slightly so that the leading edge is higher than the trailing edge and the rush of air lifts the wings.
- ✓ The wing is bet at the wrist during the up stroke thus reducing air resistance.

Adaptations of birds for flight

- ❖ Fore limbs are modified to form wings with feathers to increase surface area for flapping during flight
- ❖ Strong pectoralis muscles to power wing movements during flapping.
- ❖ Sternum extends to form keel to increase surface area for attachment of pectoralis muscles which power flight movements
- ❖ Reduced bone marrow in bones so that some are hollow to reduce weight during flight.
- ❖ Birds have a stream lined body to reduce air resistance during flight.
- ❖ Orientation of the legs backwards during flight to reduce resistance.
- ❖ Wings adapt an aerofoil shape to enable soaring as air pressure above is kept lower than that below wing.
- ❖ Feathers are smooth and streamlined to reduce on air resistance during flight.
- ❖ Have prominent eyes with well-developed sense of sight to avoid obstacles during flight.
- ❖ Reduction in free bones by bone fusion to ensure a light skeleton to ease flight.
- ❖ High metabolic rate sustained by high optimum temperature of 39^{o}C to 42^{o}C to provide energy required during flight.
- ❖ Stout coracoid bone to transmit thrust movements from humerus to rest of the body.

END