LOCOMOTION

Locomotion is the displacement of the ***whole body*** of an organism from one place to another. However, **movement** is the displacement of ***part*** of an organism form one point to another. This implies that movement is a characteristic of all living things including plants and animals while locomotion is for animals only.

Locomotion in animals is important for the following reasons:

i) To obtain food from the environment.
ii) To escape from predators e.g. antelopes escaping from lions in a national park. etc
iii) To find mates in order for reproduction to take place.
iv) Some animals move away in order to avoid competition with others hence they find new virgin space to stay.
v) To avoid danger in the environment e.g. fires.

Requirements for locomotion

i) ***Energy***: This is supplied by respiration within the animal. Such energy helps in muscle contraction, heartbeat, breathing/ventilation etc.
ii) ***The skeleton***: This provides a framework for attachment of muscles. This supports the body and strengthens the whole system.
iii) ***Support stability and propulsion***.

Types of skeletons

Depending on the nature and location, skeletons are classified as follows:

i) **Endoskeleton:** This is common in vertebrates. Here the bones and cartilage (skeletal elements) are internal to the muscles which move parts of them.

ii) **Exoskeleton:** This is found in arthropods e.g. insects like cockroaches, millipedes. It is a hard cuticle which lies outside the muscles which move parts of it. The exoskeleton is made of a material called ***chitin*** in insects.

iii) **Hydrostatic skeleton:** This is found in invertebrates e.g. earthworms and body organs like; erected penis, amnion, heart and spinal cord. In earth worm, it consists of a fluid-filled body cavity called ***cleome*** surrounded by antagonistic sets of muscles. ie ***circular*** and ***longitudinal*** muscles. Movement occurs when the contraction of the muscles compresses the fluid that makes up the hydrostatic skeleton.

Locomotion in bony fish

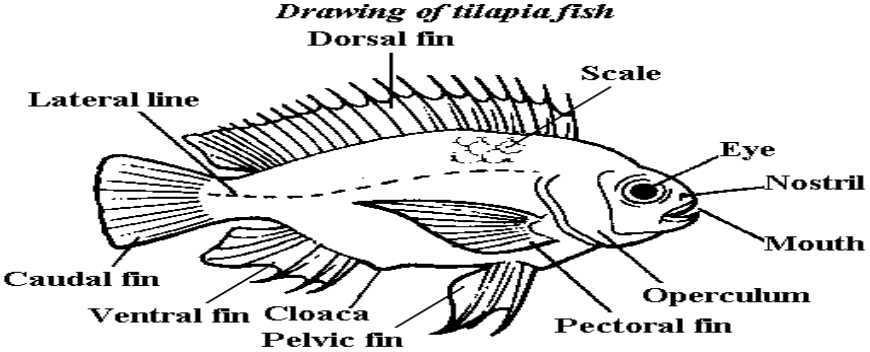
Most fish move by swimming in water. In order to do this, fish have the following adaptations:

i) A stream-lined body shape which gives little resistance to their movement in water.
ii) A lateral line which is sensitive to stimuli like sound vibrations in water.
iii) Fins which provide movement/propulsion, stability and support
*iv) Fish have a swim bladder which they fill with air in order to stay **floating** or expel the air to allow them **sink**. [support]*

Other adaptations for life in water by fish include

(i) Scale prevent entry of pathogen and mechanical damage
(ii) Gills that are able to exchange gases in water
(iii) Operculum; hard enough to protect gills, its valve closes to limit water entry during inhalation
(iv) Nostrils; for sensing sent while in water
(v) Spines in fins for protection from predator
(vi) Mouth is anteriorly placed to let in water during inhalation and ingestion of food

Diagram showing the structures used in the locomotion of bony fish



Action of muscles [propulsion in bony fish]

In bony fish, the side movement of the tail region and caudal fin propels the fish forward. The fish has muscle blocks on either side of the vertebral column called ***myotomes***. The muscles on left and right work antagonistically ie when the left muscle block contracts, right ***myotomes*** relax and the tail moves to the left and when the right muscle block contracts, the left relax and the tail moves to the right. The tail region pushes against water to effect propulsion of the body.

Action of the fins

The ***paired fins*** [pelvic and pectoral fins] are used for steering, balancing, breaking, forward and backward movement. They are also used to avoid instability when swimming. The unpaired fins [dorsal, ventral and anal fins] also called ***median fins*** prevent rolling and yawing instabilities during locomotion and the caudal is involved in propulsion

Support in bony fish

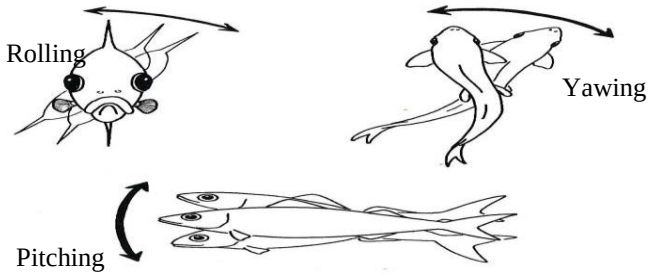
Support is by the ***swim bladder*** that allows in air to reduce its relative density thus rising in water or eject air out increasing the body density thus sinking in water.

Instabilities during locomotion

Fish experience three types of instability namely:

i) **Yawing**: this is the sideways movement of the head from side to side due to side to side movement of the tail. It is balanced out by the dorsal and ventral fins.
ii) **Pitching**: This is the tendency of the nose to plunge down wards as the fish moves. This is prevented by the pectoral and pelvic fins.
iii) **Rolling**: It is the rotation of the fish body about its longitudinal axis. This instability is prevented by all the fins.

Diagrams illustrating the instabilities during locomotion in fish



Locomotion in Insects

Insects have the ability to move by using the legs [walking] as well as the wings (flight).

i) Locomotion by wings[flight in insects]

Flight is brought by the action of the ***flight muscles*** on the exoskeleton and the ***wings***. When these muscles are attached on the wing base they are called ***direct flight muscles*** .However, when they are attached on the exoskeleton [tergum and sternum] but not bases of wings, they are called ***indirect flight muscles***. Direct flight muscles are found in large insects like butterflies and dragon flies. Indirect flight muscles are found in small insects like bees, wasps and flies. Such small insects have small wings and a rapid wing frequency.

Description of flight in insects

Flight occurs by ***down*** and ***up stroke*** which occur by ***antagonistic movement*** of the flight muscles. During the ***down stroke***, Contraction of the ***depressor*** muscles and relaxation of ***elevator*** muscles lowers the wings while during the up-stroke, contraction of the elevator muscles on relaxation of depressor muscles, raises the wings.

Diagram showing the attachment of direct flight muscles in large insects

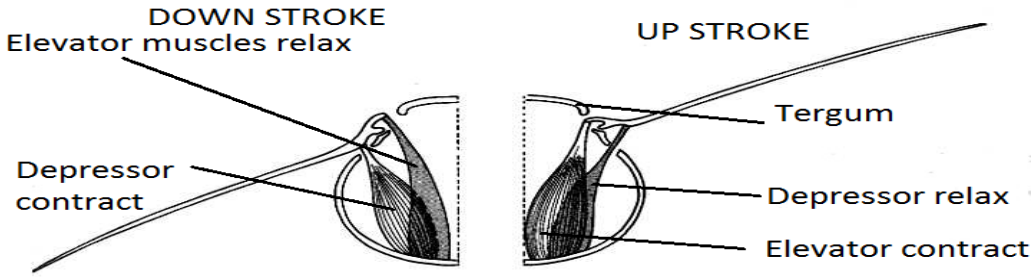
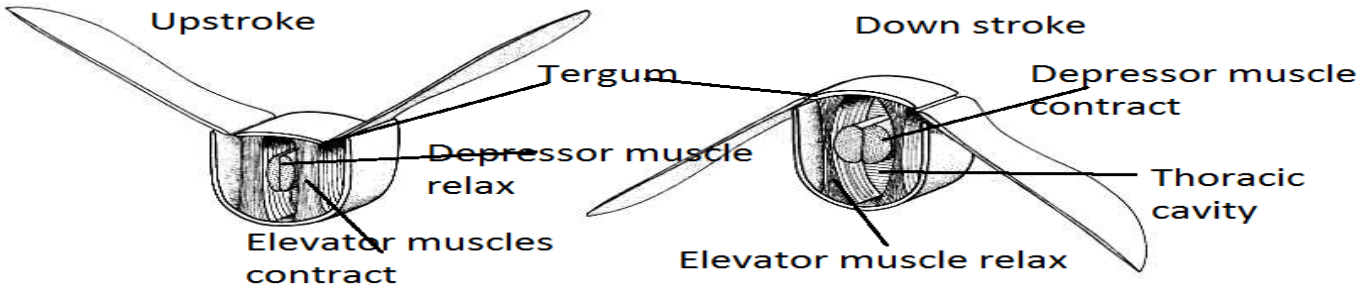


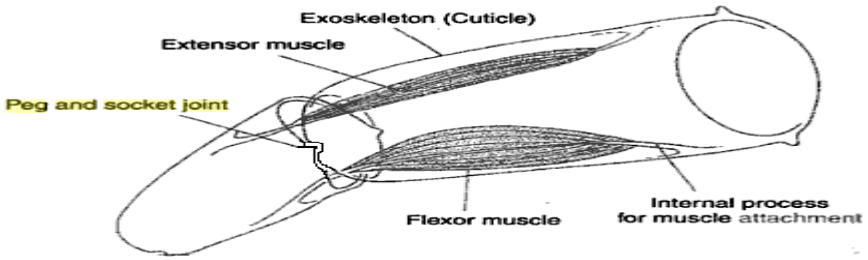
Diagram showing the attachment of indirect flight muscles in small insects



ii) Locomotion by legs [walking]

The type of joint in the insect leg is called the ***peg and socket joint***. It allows movement in only one plane. Therefore it operates like a hinge joint. At the joint are two sets of muscles the ***flexor*** (or depressor) and the ***extensor*** (or elevator). These muscles work antagonistically and are co-ordinated by the nervous system. When the flexor muscles contract and extensor relaxes, the legs bend [flexes] and when the extensor muscles contract and flexor relaxes, the legs straighten pushing the insect forward.

Diagram showing the peg and socket joint



Adaptations of insects' limbs to improve on movement

(i) Claws at the end of the legs to enable them drag and move on rough surfaces.
(ii) Glandular pads [arolium] also at the end of the legs enable them move on water or smooth surfaces and sometimes upside down on the ceiling.
(iii) Longer hind limbs in some insects like locusts to enable them leap over great distances.
(iv) Shorter front limb compared to longer hind limb thus sock absorption on landing
(v) Joints enable flexibility during movement
(vi) Antagonistic muscles that enable straightening and flexing of the limb during locomotion
(vii) Exoskeleton that provides points for attachment to the muscles

LOCOMOTION IN BIRDS

[Flight in birds]

Birds basically move by flying. The birds are adapted to flight in following ways

Adaptations of birds for flight:

(i) Fore limbs modified into ***wings*** to provide a large surface area for movement in air.
(ii) Large ***pectoral[flight] muscles*** which move the wings during flight
(iii) A skeleton made of ***light hollow bones*** which reduce the total weight of the bird.
(iv) Fused bones with a ***deep keel-like extension of the sternum*** which provides a large surface area for attachment of muscles.
(v) An ***efficient circulatory system*** necessary for transporting nutrients and respiratory gases.
(vi) A ***keen eye sight*** to enable them judge distances correctly when landing
(vii) A ***stream lined*** body to reduce air resistance ad provide smooth movement in the air.
(viii) Ability to ***fold legs backwards*** during flight to avoid friction between air and the legs.
(ix) Translucent membrane that covers the eye during flight
(x) Efficient gaseous exchange system with air sacs that carries much oxygen needed for respiration and energy for flight
(xi) Presence of the quill features also provides large surface area for flight

During flight, the bird's wing provides support and the force to move the bird forward. The wing is made up of feathers of different forms. Generally the bird's wing performs a number of roles as far as the bird is concerned.

Structure of the bird's wing

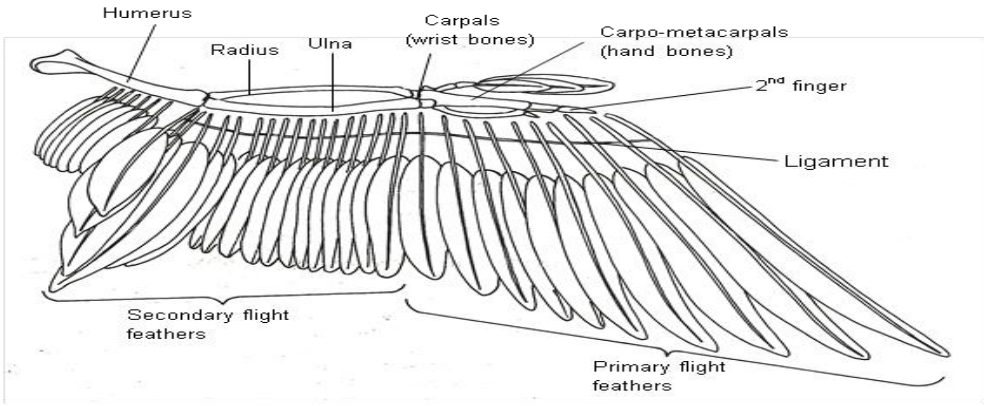
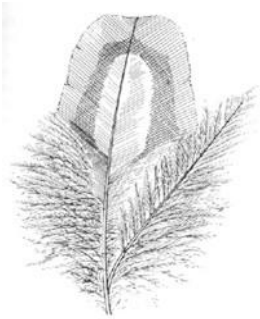


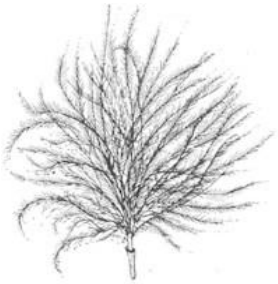
Table showing characteristics, functions and distribution of bird's feathers

Type of feather	Characteristics	Distribution/location on body	Function
Quill feature	-large vane A vane with barbs -a large hollow strong quill -A small after shaft -Superior and inferior umbilicus -Large long hollow shaft	-wings -Tail	-flight -protection to inner parts from damage
Covert feather	-smaller than quil -large after shaft -short vane	Neck and upper side of the body	-Insulation against heat loss -protection
Down feather	-Smaller than the quill -No vane -Very small and short quill -Very small and short shaft -It is soft	Lower side of the body i.e. abdominal region	Insulation against heat loss
Filoplume	-Threadlike in shape -Very few bar -No quil	Throughout the body	Sensory for stimulus

Structures of different feathers

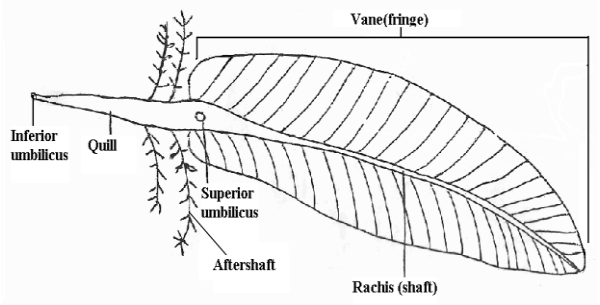


1. ***Covert feather***



2. ***down feather***

3. ***filoplume***



4. ***Quill feather***

Functions of the feathers

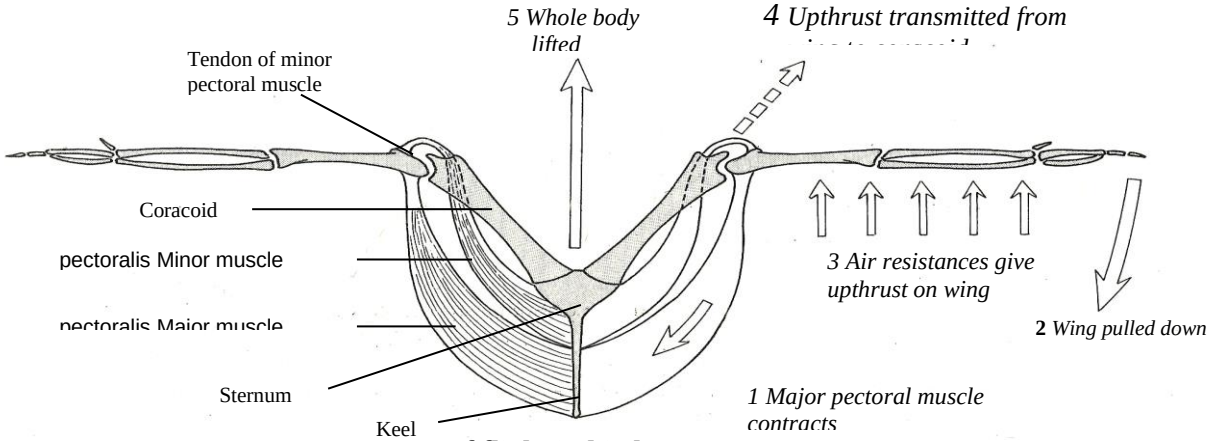
i) Flight
ii) Insulation against heat loss thus regulating temperature
iii) Protection from mechanical injury through soak absorption
iv) Courtship. The feathers are used to recognize members of their species and males from females.
v) Protection from predators through camouflage

Action of muscles during flight in birds

Flight is achieved by the movement of wings. The wings are moved by powerful direct flight muscles called ***pectoral muscles*** attached at the wing base and to the keel –like extension of the sternum (breastbone) of the bird. There are two types of pectoral muscles: ***Pectoralis major*** and ***Pectoralis minor***

During the ***down stroke***,the ***pectoralis major*** contracts as the pectoralis minor relax , the wing is pulled down and backward as it pushes against the air underneath thus causing the bird to gain height and move forward. During the upstroke, the ***pectoralis minor*** contracts, as pectoralis major relaxes, the wing is raised and the cycle continues. These two sets of muscles work antagonistically.

Diagram showing the attachment of flight muscles in birds



Types of flight in birds

There two modes of flight in birds ie; ***flapping*** [active flight] and ***gliding*** [passive]

i) ***Flapping flight***: during flapping flight, the bird is actively flying by raising and lowering its wings actively. It involves greater use of respiratory energy for muscle contraction and relaxation and as such, this type of flight is also referred to as active flight.
ii) ***Gliding/soaring flight***: Here, the bird simply spreads out its wings and uses rising air currents to maintain its position in air. The bird can easily lose height by sliding through the air at an angle to the ground.

Similarities between flight in birds and insects

i) Both use wings.
ii) In both, the wings are moved by sets of antagonistic muscles.
iii) Most birds and insects have a stream lined shape to minimize air resistance during flight.
iv) Large insects like butterflies and dragon flies, just like most birds can show both active and gliding flight.
v) In both, muscle contraction is controlled by the nervous system.

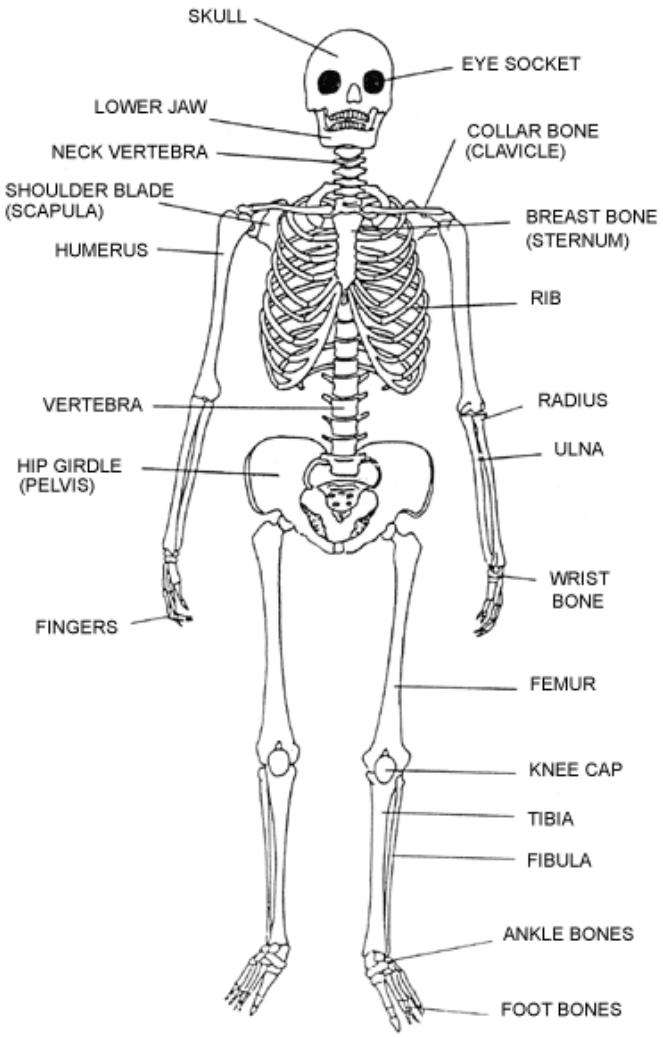
Differences between flight in insects and birds.

Insects	Birds
(i) Wings are moved by both indirect and direct flight muscles	-Wings may be moved by direct flight muscles
(ii) Muscles are attached to the exoskeleton	-The flight muscles are attached to the sternum/endoskeleton
(iii) Wings are membranous, supported by veins of chitin.	-Wings are thick, with bones and muscles covered by feathers.

LOCOMOTION IN MAMMALS.

The bodies of mammals are made of a rigid structure known as the skeleton. The main component of the skeleton is ***bone***. Another component called ***cartilage*** is also located at the joints especially the movable joints. Both bone and cartilage consist of a ground substance called ***Osteon*** and ***condrin*** respectively. This ground substance is made of dead material. Bones also contain calcium salts.

Diagram showing the general structure of the skeleton



Differences between bones and cartilage

Bone	Cartilage
❖ Has a hard solid ground substance	❖ -Has relatively flexible ground substance
❖ Contain calcium and phosphorous salts	❖ -Does not contain salts
❖ Long bones have marrow	❖ -No marrow
❖ Contains blood vessels	❖ -No blood vessels
❖ Contains nerves	❖ -No nerves
❖ Bone cells are arranged in circular layers around a system of canals.	❖ -Cartilage cells are in single pairs or fours, scattered in the ground substance.
❖ It is an active tissue which can make blood cells	❖ -It cannot make blood cells
❖ Has got two types namely: spongy and contact bone	❖ Has three types i.e. hyaline, fibro and elastic cartilage
❖ Ground substance is called Osteon	❖ Ground substance is called Condrin

General functions of the skeleton.

(i) It provides a framework for the body where the internal body organs are held and prevented from crushing into each other.
(ii) It protects the delicate body organs e.g. the skull protects the brain inner ear and parts of eye, the ribs protect the lungs and heart while the vertebral column protects the spinal cord.
(iii) It enables in locomotion by providing areas where muscles can be attached and joints for flexibility.
(iv) The ribcage enables gaseous exchange by adjusting the volume and pressure of the thoracic cavity during ventilation
(v) Involved in transmission of sound in the ear i.e. the ear ossicles.
(vi) Production of blood cells in the bore narrow.
(vii) Storage of calcium and phosphorus in the bones.

PARTS OF THE SKELETON

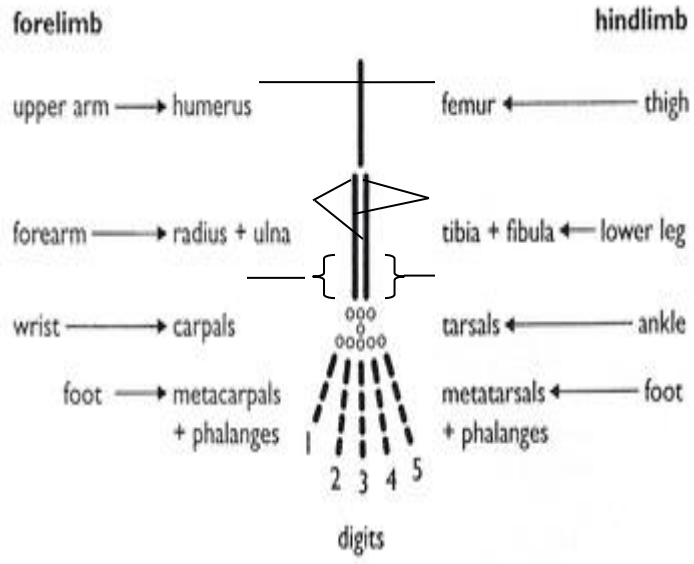
Altogether, there are about 200 bones in the human skeleton.The mammalian skeleton can be broadly divided into two**:**
The ***appendicular skeleton*** and the ***axial skeleton***

The appendicular skeleton

This is the skeleton of the ***limbs*** [legs/hind limb and arms/fore limbs] and ***limb girdles*** [pectoral and pelvic girdle].the pectoral girdle is made up of the scapula (shoulder blade) and clavicle (collar bone) and the pelvic girdle consists of the hip bone.
The limb in mammals ends in a five digit structure known as the ***pentadactyl limb*** and this is a characteristic of all vertebrates. Due to evolution (change in environment and organisms), in order to adapt to environment, animals have started using the pentadactyl limb for various purposes like;

(i) providing a grasping structure e.g. in monkeys
(ii) flying e.g. in birds and bats
(iii) walking e.g. in man
(iv) Running e.g. in horses
(v) Digging the ground e.g. in moles

Illustration of the pentadactyl limb



Functions of the appendicular skeleton

(i) Provides connection between it self and the axial skeleton.
(ii) Provides suitable surfaces for the attachment of muscles that move the limb.
(iii) It provides stability by separating the limb

The Axial skeleton

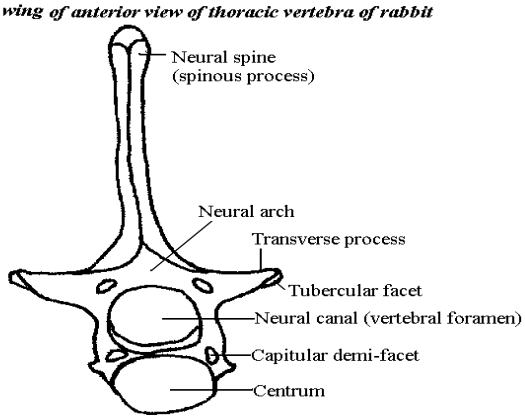
It is the skeleton of the trunk. It is made of skull, bones of the ***vertebral column***, ***ribs*** and ***sternum***. The skull is made up of 22 flat bones connected by immovable joints called ***sutures***. The vertebral column is made up of 33 bones in man and these bones are called ***vertebrae*** [singular; ***vertebra***]. Each vertebra is named according to the region of the vertebral column where it is found. There are 7 ***cervical vertebrae*** in the neck region, 12 ***thoracic vertebrae*** in the thoracic region, 5 ***Lumbar vertebrae*** in the abdominal region, 5 ***Sacral*** and 5 ***caudal*** vertebrae in the lower abdomen.
Special cervical vertebrae occur in the neck regions which are responsible for the nodding action of the head these include the ***atlas*** that is pivoted by the axis vertebrae.
The Sacral and Caudal vertebrae are both fused together and for ***mammals*** with tails, many more caudal vertebrae are found. There are also 12 pairs of ribs connected to the vertebral column at the back [***dorsally***] and sternum at the front [***ventrally***]

Functions of parts of vertebra

Part of vertebra	
Neural spine	For attachment of muscles.
Transverse process	Attachment of muscles, Articulation with ribs in the thoracic vertebrae
Centrum	Articulation with adjust vertebrae
Neural Canal	Protects the spinal cord
Neural arch	Passage of the spinal cord, protects the spinal cord
Vertebraterial canal	Passage of the neck blood vessels
Facets	Articulation with other vertebrae and ribs in the thoracic vertebrae

Diagram showing the thoracic vertebra

Drawing of anterior view of thoracic vertebra of rabbit

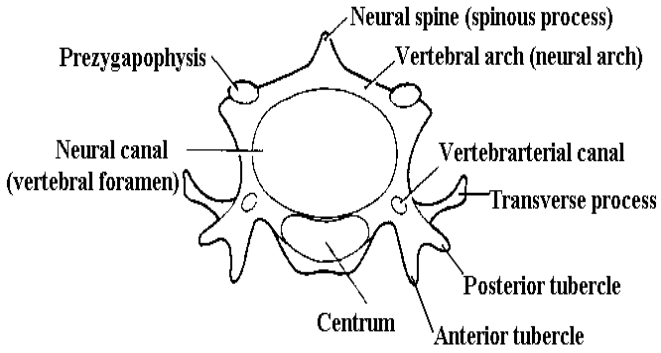


Characteristics

- A long neural spine
- A pair of articular facets
- A pair of short transverse process
- Large centrum

Diagram showing the Cervical vertebra

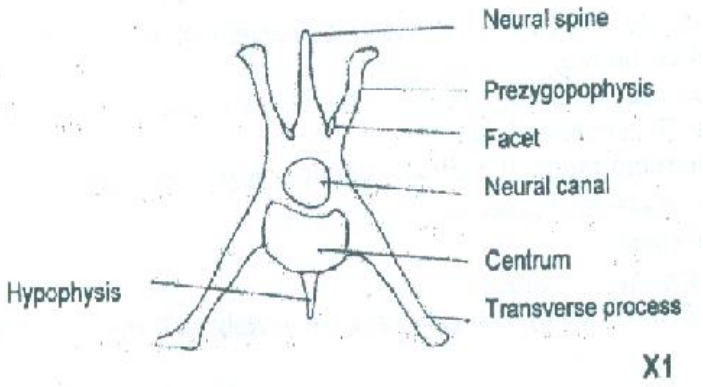
Drawing of anterior view of cervical vertebra 5 of rabbit



Characteristics

- A pair of canals in the neural arch known as the vertebraterial canals
- Flattened transverse process
- Small neural spine
- Large neural canal
- Small centrum
- No neural spine

LUMBAR VERTEBRA



Characteristics

- Long transverse process facing forward.
- Extra processes called metapophyses for muscle attachment.
- A larger centrum than that in the cervical and thoracic vertebra.
- A broad neural spine.
- A small neural canal.

Revision questions

1. ***Compare structures of the thoracic and lumbar vertebra***
2. ***How is each vertebra adapted to its function?***

JOINTS

A joint is an area or point where two or more bones meet. Most joints allow movement while others do not allow any degree of movement e.g. suture joint between the bones in the skull.

Types of joints

1. **Immovable joints**: These are joints which do not allow any movement at all. As a result, they are found in the rigid areas of the body e.g. between the bones of the skull, sacrum and pubic bones.
2. **Partly movable joint:** This allows limited movement for it is not entirely free e.g. gliding joint found between the bones of the ankle, wrist and adjacent vertebrae.
3. **Movable joint**: This allows free movement between the bones.

Table showing the joints in the mammalian skeleton

Name of joint	Type of joint	Location
Suture	Immovable	Skull, sacrum, pubic bones
Gliding	Partly movable	Wrist, ankle &between adjacent vertebrae
Pivot	Partly movable	Between axis and atlas
Hinge	Synovial	Elbow, knee, fingers
Ball and Socket	Synovial	Shoulder, hip

The synovial joint

At the joint, bones are not directly connected. If this was the case, the bones would crack during movement. Between the bones at the joint is a space called ***synovial cavity*** which contains a lubricating fluid known as ***Synovial fluid***. The bone surfaces are also covered by cartilage in order to reduce friction. Cartilage in the joints also works as a shock absorber. The joint is strengthened by ***ligaments*** which connect one bone to another and ***tendons*** which connect muscles to bones.

Diagram showing the synovial joint at the knee

Leave 12 lines

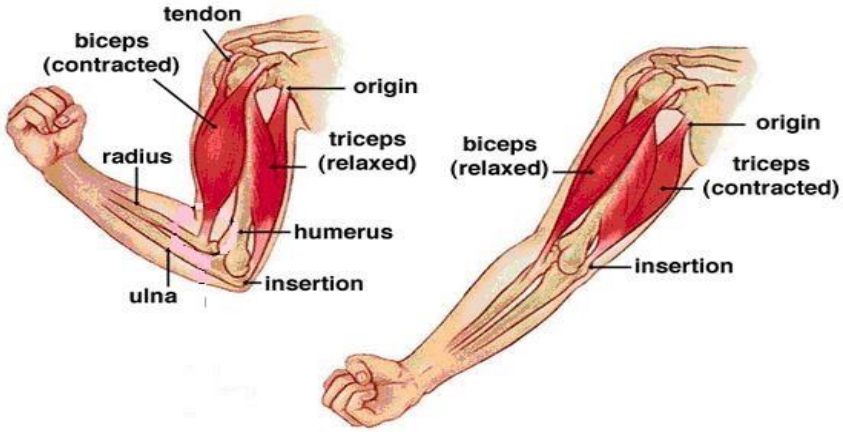
Antagonistic action of muscles

Muscles that cause movement usually occur in pairs. They work antagonistically such that when one muscle contracts, the other muscle of the pair relaxes and vice versa.

Description of movement of the lower hand/fore limb

The human arm is moved by a pair of antagonistic muscles namely **biceps (flexor)** and ***triceps (extensor)*** whci cause the limb to bend (flex) and extend at the elbow. During flexing, the triceps relax, biceps contract, the biceps pull on the radius thus raising [flexes] the fore arm as it bends at the elbow. During extension, the biceps relax and the triceps contract, triceps pull on the ulna thus straightening [extends] the arm. triceps are thus called the extensor muscle because it extends the arm at the elbow.

Diagram showing muscle attachment at the elbow



QUESTION

1. Explain how the structures below, are adapted to their respective function
   - Pectoral fin
   - Knee joint
   - Insect wing
   - Bird wing

END