Locomotion

Locomotion is the type of movement where the animal moves as a whole from one place to another. The animal moves in order to escape danger, look for food, shelter and mates. In animals locomotion is brought about by the action of muscles on a skeleton.

The skeleton

The skeleton is the framework that provides support and movement in animals. There are 3 types of skeletons namely: hydrostatic skeleton, endoskeleton and exoskeleton. The last two forms provide a system of levers to which muscles are attached for efficient locomotion. In higher chordates the skeleton provides other functions in addition to locomotion. These are:

1. **Protection where** the skeleton encloses delicate organs like the heart and lungs (this is done by the ribs),
   spinal cord (by vertebrae), brain (by skull) etc.

2. **Support** and this is mainly done by the vertebral column, pectoral and pelvic girdles, limb bones etc.

3. **Production of red** and **white blood cells** (by marrow in leg bones and ribs).

4. **The** skeleton gives the body shape by forming a frame on to which the internal organs forming a frame on to which the internal are suspended and kept in position.

5. **The** skeleton provides storage for calcium and phosphate which may be added to the blood when needed.

Types of skeletons

1. **Hydrostatic skeleton**

This type of skeleton is provided by fluid-filled cavity under pressure. The pressure enables the body to maintain shape. This skeleton provides the major support in most invertebrates like earthworms, sea anemones leeches etc. Similarly in unicellular organisms and other cells the support system is provided by hydrostatic skeleton, in which case it is known as **cytoskeleton.**

In the earthworm movement is brought about when muscles attached to the skin move against this fluid which is turgid enough to support them.

Draw and label the cross section of an earthworm to show arrangement of muscles and hydrostatic skeleton from page 182 New Biology for Tropical Schools.

2. Exoskeleton

The exoskeleton is found as hard covering on the outside of the body of an organism. It is mainly found in arthropods. The exoskeleton limits the size of an organism and therefore such organisms only grow by ecdysis or moulting. The exoskeleton or cuticle is made of a tough polysaccharide called chitin and has a thin water proof outer covering of wax. The exoskeleton provides effective protection and support for the soft parts of the body.

3. Endoskeleton

This skeleton lies within the major body muscles. It is mainly found in vertebrates. The endoskeletons are of two main types basing on their composition and nature:

a) Cartilage

This is soft and elastic tissue. Lower vertebrates like cartilaginous fish, embryos of all vertebrates have their skeletons made of cartilage, though parts of them may be made more rigid by deposition of **calcareous salts.** In higher vertebrates the embryonic cartilage is largely replaced at an early stage of development by bones. However, it persists in some organs like nose and between vertebrae as discs of cartilage where they provide cushioning to reduce shock.

b) Bone

This is a very hard tissue found only in vertebrates. It is made of widely spread living cells onto which are deposited mineral salts; the main salts are calcium phosphate and calcium carbonate and to a little extent magnesium phosphate. The high

mineral content makes bone to be much stronger and less elastic than cartilage. The organic component of bone consists of bone cells and protein fibres. The bone has a complex network of branching blood vessels in spaces which link the bone cells.

A true bone is made up of a hard part on the outside called **compact bone.** The compact bone is covered by **periosteum** which is a layer of tough fibrous tissue and blood vessels. Underneath the compact bone is a layer of spongy bone which has less mineral deposits than the compact bone. The spongy bone has spaces in it that makes the bone to be light. In the bone 's centre is the **bone marrow** which is soft and has good supply of blood via the blood vessels. The ends of the bones are covered with a layer of cartilage.

Draw the longitudinal section through a long bone from page 183 New Biology for Tropical Schools by Stone and Cozens.

THE MAMMALIAN SKELETON

Types of endoskeleton based on location

Depending on the location of the skeleton, mammals and other vertebrates have two main types of skeleton.

1. Axial skeleton

This type lies in the long axis of the body. It consists of the vertebral column, the skull, ribs and sternum (breastbone). They are mainly for support and protection although the ribs also produce the blood cells.

2. Appendicular skeleton

These are skeletons associated with appendages. It includes the limb (corresponding fins in fish) and limb girdles, which are the pectoral (shoulder) bone and pelvic (hip) girdles.

The axial skeleton

a) The skull

This is the part of the skeleton contained within the head and it consists of two parts, namely cranium and visceral skeleton.

The cranium, encloses the brain and organs of special senses like eyes that are protected in the sockets. **The cranium** posseses **occipital condyles** for articulation with atlas (the most anterior vertebra).

Visceral skeleton

This is made up of the jaws and teeth.

B.The ribs and sternum

Most mammals have 12 pairs of ribs.

The ribs lie ventrally curved in the wall of the thorax, where some of them meet with the **sternum** and are attached to the thoracic vertebrae from the dorsal side. The 8^{th}-9^{th} pairs of ribs (also called **false ribs)** are joined to the **sternum** by cartilages. The last three pairs of ribs are unattached at their ventral ends (thus are called **floating ribs).** This arrangement of the ribs and sternebrae(bones of the sternum) form the bony cage for protecting the heart and lungs.

The rib bone is a long curved bone structure which consists of two projections for articulation. The upper one being the **capitulum** which articulates with articulating process of the centrum of thoracic vertebra while the lower **tuberculum** attaches to the transverse process of the thoracic vertebra.

Draw the ribs and their attachments page 187 New Biology for Tropical Schools by Stone and Cozens.

c) Vertebral column (Back bone)

The vertebral column is composed up of a number of small bones called **vertebrae** (singular vertebra). The vertebrae articulate with each other and are separated from each other by fibres and cartilage called **intervertebral discs.** The vertebrae are classified according to their location along the backbone. The table below shows the types of vertebrae:

Name of vertebra	location in the body	Number of vertebrae		
		Human	Rabbit	Rat
Cervical	Neck	7	7	7
Thoracic	Thorax region	12	12-13	13
Lumbar	Abdominal	5	6-7	6
Sacral	Hip/pelvic	5	3-4	4
Caudal	Tail	4 (much fused into coccyx)	16	27-30

Common structures of a typical vertebra

A typical vertebra possesses the following structures:

a) A body which is known as the **centrum** (plural: **centra)** which is a central disc of bone. It

is the structure which supports the neural arch.

b) The **neural arch** is fused to the dorsal surface of the centrum. It curves to form a hollow structure called **neural canal** where the spinal cord lies. The neural arch also bears 7 projections which include:

1.A neural spine that is situated at the mid-dorsal line of the neural arch.

2.Two transverse processes which arise from the junction of the arch with the centrum (they are branched in thoracic vertebrae for attachment of ribs).

3.Four articulating facets which articulate with the anterior and posterior vertebrae. There are two of these facets that are anteriorly and posteriorly located on the vertebra and articulate with the anterior and posterior vertebrae respectively.

Draw and label the parts of a vertebra from page 184 New Biology for Tropical Schools by Stone and Cozens

Draw and label the parts of all the vertebrae from page 185 and 186 New Biology for Tropical Schools by Stone and Cozens.Write all the notes on those pages.

THE APPENDICULAR SKELETON.

This consists of the girdles and the limbs. The pair of fore limbs are attached to the axial skeleton by the Pectoral girdle while the hindlimbs are attached by the pelvic girdle giving a figure that looks like a bridge in four – footed animals e.g the cow or the dog. Here the weight of the body is carried on the four limbs while the centre of gravity of the system lies between the fore and hind limbs. In man, the fore limbs do not take part in locomotion, leading to a shift in the centre of gravity of the body.

The pectoral girdle

The pectoral girdle consists of two dorsal shoulder blades, the scapulae, carrying small processes (or coracoids) , and a pair of ventral collar bones, the clavicles.

Draw the pectoral girdle and scapula from page 189 New Biology for Tropical Schools by Stone and Cozens.

The pelvic girdle

The pelvic girdle is attached to the vertebral column forming a solid structure. It consists of two halves fused together. Each half consists of an anterior ilium fused to the sacrum, a posterior ischium and a ventral pubis.

Draw the The pelvic girdle from page 189 New Biology for Tropical Schools by Stone and Cozens.

The limbs

In all vertebrates except fish, the limb bones are arranged on a similar plan called the pentadactyl plan of limbs.

The vertebrate limbs exhibit a uniformity of the pentadactyl plan of limbs.

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Draw the the pentadactyl plan of limbs *from page 187 New Biology for Tropical Schools by Stone and Cozens.*

The first bone of the limb is a single solid bone usually with a long shaft and a head modified for articulation with the girdles.

In the forelimbs, the first bone is called the humerus and it fits into the hollow glenoid cavity of the scapula a part of the pectoral girdle. In the hind limbs, the first bone is the femur which fits into the hollow acetabulum of the pelvic girdle.

In the pentadactyl plan two bones articulate with the first bone. In the fore limb, these are the radius and ulna, while in the hind limbs these are the tibia and fibula .The radius is shorter than the ulna .The ulna projects backwards at the elbow to form the olecranon . The tibia is a larger bone than the fibula .These two are joined to each other at the distal end which is nearer the ankle

these are followed by a number of small bones arranged to form the wrist or ankle bones, the hand or foot bones and the bones of the fingers and toes respectively.

Draw the fore and hind limbs from page 188 New Biology for Tropical Schools by Stone and Cozens.

JOINTS:

Bones are joined together by means of joints. Inelastic tendons join muscles to bones and flexible ligaments join the bones to each other. Joints are classifified by the type of movement they allow. There are several types:which include:Ball and Socket joints, Hinge Joints ,Gliding joints ,Pivot joint,Suture Joint.

Ball and Socket joints:

Draw the Ball and Socket joints from page 121 Introduction to Biology by D G Mackean.

The end of the bone is rounded while the other is hollowed out to form a shallow cup. Such a joint allows freedom of movement in any plane. In the case of the shoulder joint, complete circular rotation of the arm is possible.

The hip joint is somewhat limited in movement

Hinge Joints:

Here there is freedom of movement in one plane only, e.g the knee and elbow.

Draw the Hinge Joint from page 121 Introduction to Biology by D G Mackean.

Gliding joints:

These occur between the small bones of the wrist and ankle as well as between adjacent vertebrae.The two articulating surfaces are almost flat and slide over one another easily, giving flexibility but limited movement. This is a partly moveable joint.

Pivot joint:

There is one pivot joint in the body that is the one between the first cervical vertebra, the atlas and the second, the axis. The axis has a small peg-like projection, the odontoid process which fits into the atlas and allows. A certain amount of rotation to take place.

Suture Joint:

This is an unmoveable joint found between bones of the skull and also between sacrum and ilia of pelvic girdle.

Muscular movement

Muscles in the body, by their contraction, lead to body movements; this includes movement of the internal organs as well as the limbs. The contraction of such muscles is usually initiated, controlled and coordinated by the central nervous system.

Types of muscles:

The mammalian body has three main kinds of muscles,namely: Voluntary / skeletal muscles, Involuntary or unstripped muscles,Cardiac muscle.

Voluntary / skeletal muscles.

These bring about the limb movements .These muscles are connected to different parts of the skeleton.These muscles are controlled consciously by the brain .They contract and relax fairly fast.

Involuntary/smooth or unstripped muscles.

These are found in the gut, gonads, excretory system and blood vessels. These muscles are controlled unconsciously by the brain .They contract and relax fairly slowly.

Cardiac muscle:

This is a special kind of involuntary muscle found only in the heart.Contractions originate from the heart and continue throughout life.

Muscular insertion.

Skeletal muscles are attached to bones at both ends; one end of the block, known as the origin of the muscle, is usually attached to an unmoveable or rigid bone, while the other end, known as the insertion, is attached to the end of the moveable bone. Muscles which may have more than one origin are usually attached directly to the bone or indirectly by means of tough white cords of fibrous tissue, called the tendons. Muscles are usually attached in pairs along each the side of a bone. Each of them can contract and relax . When a muscle contracts, it becomes shorter and thicker, thus exerting a pulling force on the bone to which is is attached. When the muscle relaxes, it becomes thinner. Because the muscles are in pairs, when the reverse happens, the bone is moved in the opposite direction.The pair of muscles are described as antagonistic; one is called the extensor and the other the flexor. Most movements of the body are brought about by the action of antagonistic muscles on bones.

Draw the diagrams to show the movement of the fore limbs whenthe Limb is extended. (arm straighted)and when the limb is folded.

As wel l as the action of antagonistic muscles on bones.

from page 191 New Biology for Tropical Schools by Stone and Cozens.Describe the movement.

Locomotion in birds:

Locomotion is brought about by contraction of muscles in most of the vertebrates. The normal way of movement is walking but birds and bats are unique animals in that they have the ability to fly. A few birds are completely unable to fly e.g ostriches, Emus, kiwis, etc.

These have evolved long legs suitable for running and happen to be fast runners. The ability to walk also varies from species to species and this depends upon the habitats in which the animals are found. Some good fliers e.g the European swift have almost lost the ability to walk. Some aboreal ones eg the terokos walk by hopping method which is good for their type of life.

Adaptations of the birds for flight.

i) Fore limbs have been modified to form wings for flapping.
ii) Wings provide a large surface area for movement in air.

iii) Presence of large pectoral muscles the pectoralis major and pectoralis minor which flap the wings when they contract.

iv) A light and strong skeleton made up of hollow and small bones which can be easily moved in the air.

v) A rigid skeleton made up of fused bones with a deep keel like extension of the sternum which provides a large surface area for the attachment of muscles.

vi) An efficient breathing system with air sacs attached to the lungs necessary to provide the necessary oxygen for respiration and to removing the resulting carbondioxide.

vii) A high metabolic rate for providing the high amount of energy required for flight

viii) An efficient circulatory system necessary for transporting both the nutrients and respiratory gases as fast as the body needs require.

ix) A high red blood cell count for efficient oxygen transport.

x) A keen eyesight to enable them to judge distances correctly especially on quick landing.

xi) A stream lined shape to reduce air resistance and provide smooth movement in the air.

xii) Ability to fold the leg away during flight so as not to cause any unnecessary friction with the air.

xiii) Possesion of feathers for beating the air.Also feathers insulate the body against heat loss during the flight.Feathers are light to reduce the body weight.

<u>Structure and functions of feathers.</u>

Feathers:

There are four types of feathers 1. Quill feathers 2. Covert feathers 3. Down feathers.
4. Filoplumes.

On the body, feathers are arranged in rows.

1. Quill feathers

Structure:

A typical quill feather has the stiff shaft that supports the vane and resists breakage due to air pressure.The long quill is hollow with a hole at the base called inferior umbilicus and another hole

known as superior umbilicus.The quill is hollow to reduce weight during flight.The quill is also long for attachment of the feather into the skin.

The shaft has tiny branches called barbs arranged obliquely on either side. Each barb bears two rows of small branches called barbules. Some barbules have hooks while others have ridges. Those with hooks are opposite those with ridges and the result is that they interlock with those that have ridges.This binds the whole vane together so that it can beat the air.All the barbules in the vane of a quill feather are interlocked to make smooth vane that resists air pressure during flight.

The vane is large to provide a large surface area for resisting the air during flight.

Diagram:

Draw and label the Quill feather from page 58 New Biology for Tropical Schools by Stone and Cozens.

Draw and label the part of a feather to show interlocking barbules from page 58 New Biology for Tropical Schools by Stone and Cozens.

2. Covert feathers/Contour feathers.

The contour feathers cover the bird's body. Their arrangement is like tiles on a roof. Water proofing the bird is their main function. The covert feathers also prevent heat loss from the bird's body.These feathers are found on the neck and the upper part of the body.

This feather has a large aftershaft ,half the vane is fluffy and has free barbs to insulate the bird's body while the other half has interlocking barbs to result into a smooth vane which in the long run leads to a streamlined bird's shape. The covert feather is smaller than the quill feather.

Diagram:

Draw and label the Covert feather *from page 58 New Biology for Tropical Schools by Stone and Cozens.*

3. Down feathers.

These are found on the lower part of the body. These are fluffy and so trap a layer of air close to the body, which prevents heat loss from the bird.

This feather is very small,soft, and has short shaft and is smaller than the quill feather.The barbs are free.

Diagram:

Draw and label the down feather from page 58 New Biology for Tropical Schools by Stone and Cozens.

4. Filoplumes.

These are found all over the body. These are for sensitivity This feather is very small,soft, and has a slender,thread like shaft with free barbs.

THE WING:

Draw and label the wing fig 31.3 from page 167 Introduction to biology and

Fig 5.7 page 59 New Biology for Tropical Schools by Stone and Cozens.

Wings perform two main functions.

(i) They provide support for the bird in air.
(ii) They propel the bird forward during flight.

The Quill feathers fixed to the posterior border of the wing are called the primaries.

Those at the anterior border are called secondaries. The bases of the quill feathers are covered by small feathers called wing coverts which prevent air from passing through the bases.A birds wing is shaped like an arch ie it is rounded on top and hollowed underneath. Therefore a bird's wing is said to be shaped like an aerofoil.

FLIGHT IN BIRDS:

There are two main types of flight in birds.

(i) Flapping flight (ii) Soaring and Gliding flight.

(i) FLAPPING FLIGHT:

This is also called activeflight because the bird uses energy. The wings are moved(flapped)up and down.The upward movement of the wing is called the upstroke. The down ward movement of the wing is called the Down stroke. These two movements are brought about by the action of the powerful breast muscles. These muscles are of two types.

i)The Depressor muscle (Pectoralis major) which causes the down stroke by pulling the wings downwards.

ii)The elevator muscle (pectoralis minor) which causes the up stroke by pulling the wing upwards.

Diagram to show attachment of the muscles to the humerus,keel and sternum:

Draw and label the diagram fig 31.4 from page 168 Introduction to biology

A wing has the shape of an aerofoil which makes the air to move faster over the top of the wing and slower beneath it .

The secondaries produce the lifting force while the primaries produce the forward propulsion of a bird. The First moving air on top of the wing creates low pressure there, while the slow moving air under neath the wing creates high pressure.

Upstroke.

This is brought about by the contraction of the elevator muscle(pectoralis minor) and relaxation of the depressor muscle(Pectoralis major) . It is a much faster movement than the down stroke the concave shape of the wing reduces air resistance as the wing is pulled upwards. During upstroke, the leading edge of the wing is higher than the trailing edge.

As a result air pressure opens the primaries and secondaries of the wing and air passes through. This also reduces air resistance.

Downstroke:

This is brought about by the contraction of the depressor muscle(Pectoralis major) and relaxation of elevator muscle(pectoralis minor). This makes the wing move downwards and forward. The leading edge of the wing is lower than the trailing edge; this makes the wing press down on the air.This gives the bird the lift force. This also pushes the air backwards and gives the bird the forward driving force. The pushing of the air downwards and backwards is made possible because during both movements because the primaries are held together air tightly.

(ii) PASSIVE FLIGHT:

This is where a bird uses little or no energy but maintains its self in the air. Normally the wings are held still for sometime. Passive flight is of two types:

(i) The Gliding – depression movement where by the bird loses height without flapping.

(ii) The soaring - elevation movement where by the bird gains height without flapping.

Normally birds carry out passive flight when there is an air current.

These air currents normally arise when air from the ground is heated e.g on a hot day or when bushes are being burned.Cool currents moving downwards are for gliding. Storks, Kites and eagles can soar and glide for long distances. Migration birds also use passive flight during their long journeys.

FLIGHT IN INSECTS:

Flying insects have either two or four wings. Insect wings do not have muscles. The muscles that cause wing movements in insects are not attached to the wings but to the walls of the thorax. The power to drive the wings of insects, therefore comes from the thorax.

There are two sets of flight muscles in the thorax of an insect.

(i) The elevator muscles which run from the roof to the floor of the thorax.

(ii) The longitidunal muscles (depressor muscles) which run from the anterior surface of the domelike roof to the posterior surface.

The two sets of muscles are antagonistic. When an insect flaps its wings up and down, a stream of air is created which moves down wards and backwards. The downward movement of air creates a force that lifts the insect up. The backward movement of air makes the insect go forward.

To raise the wings, the elevator muscles contract and pull against the roof of the thorax pulling it down wards. This levers the wings upwards. To lower the wings, the depressor muscles contract and pull in a horizontal direction and eventually pull the wings downwards.

In large insects e.g locusts, grasshoppers and dragon flies, the wing flapping is not very rapid. It is between 10-50 times per second. The flight muscles in these insects are attached directly at the base of the wings. They are therefore called direct flight muscles.

The nervous system stimulates these muscles to work antagonistically.

But in small insects, e.g the fruit fly, mosquito and bee, the wings are much smaller and flap at a very high rate eg in bees they flap at 500 times per second, mosquitos 600 times per second.In these insects, the muscles stimulate themselves to work antagonistically. They are attached to the wall and roof of the thorax and not at the base of the wings.They are therefore called indirect flight muscles. In the diptera, the second pair of wings is replaced by halteres. They balance the animal. Butter flies have also got indirect flight muscles (those joined to the thorax and not wings) but has two pairs of wings which move together

Draw and label fig 28.9 and 28.10 from page 150 Introduction to biology

WALKING IN INSECTS:

An insect has six legs, all of them attached to the thorax. Usually when an insect is walking three legs are on the ground and three raised moving forward.

Those on the ground supporting the insect are one and three on one side and the middle one on the other side, forming a tripod. At the joints, each leg has a pair of antagonistic muscles. the flexor muscle contracts as the extensor muscle relaxes and so bends the leg .The the flexor muscle relaxes as the extensor muscle contracts and so straightens the leg.

Draw and label the muscle attachment in arthropod limb from page 149 Introduction to biology.

LOCOMOTION IN FISH.

Fish live and move in water.

Adaptations for living in water:

1. All fish have a streamlined body which reduces water resistance as the fish moves.
2. They possess gills which enable them carry out gaseous exchange.
3. Their body surfaces are smooth, covered with slime, which enables the fish to escape from the enemy in the water easily.
4. Most fish have scales which protect the fish from external abrasion e.g moving sticks in the water. These scales point backwards so as to reduce water resistance to a minimum. Those without scales have tough leatherly skins for the purpose of protection.
5. Fish possess fins which are for balancing and motion in the water.
6. Many fish possess a swim bladder, which is a gas filled structure that enables them to alter their densities according to the depth of the water where they are. Hence, the swim bladder enables the fish to gain bouyancy at any depth.

SWIMMING MOVEMENTS:

The propulsive force that drives the fish through water, comes from blocks of muscles found on either side of the back bone and around the fish. These blocks of muscles are in a zig zag pattern, one behind the other.

When a fish is swimming, muscles blocks contract and relax alternately on each side of the back bone. The contraction and relaxation always begins from the head and continues to end at the tail.(These alternating contractions and relaxations, bend the backbone into a continous series of waves which move rapidly down the fish's length.

At the end of the body, is the tail fin. The side to side movements of this correspond to the muscle contractions. When the blocks of muscle on the left side contract, the tail fin swings to the left. When the ones on the right contract, It is pulled back to the right. As the tail pushes backwards on the water there is a forward force created and so the fish moves forward.

DIAGRAM TO SHOW.

Draw fig 29.3 from page 159 Introduction to biology.

Balance in fish

Fish face three types of instability in water

i) Pitching

This is the forced up and down movement of fish. This is prevented by the paired fins. (Pelvic and Pectoral)

ii) Yawing:

This is the side to side swaying of the fish from a straight course.

iii) Rolling:

This is the turning over movement:

Both (ii) and (iii) above are prevented by the action of the median fins (dorsal and ventral)

Other functions of the paired fins.

i) They are used for upward and downward movements in the water.

ii) Pectoral fins are used as breaks to stop forward movement.

iii) One pectoral fin can be used to act as a pivot so that the fish can make a sharp turn.