BIO209 SUMMARY: CHORDATES

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MODULE ONE: UNIT 1

Animals known as chordates belong to the phylum **Chordata**

A group of animals called chordates belong to the animal phylum Chordata

The group of animals called chordates includes these

- Cephalochordates
- Hemichordates
- Urochordates

NB: Cephalochordates and Urochordates are invertebrates

Hemichordates are vertebrates

Which of the subphylum of the phylum Chordata is considered as a separate phylum?

Hemichordata

There are **3** subphyla in the phylum Chordata

The three chordate subphyla

- Urochordata
- Cephalochordata
- Vertebrata (Hemichordata)

Chordates possess the following (four) features

- Notochord or vertebra column
- Dorsal nerve cord
- Pharyngeal slits

- Post-anal tail

Dorsal nerve cord is otherwise called **spinal cord**

A dorsal fairly rigid rod of vacuolated cells found in Chordates is called notochord or vertebra column

Notochord is a stiff but flexible rod (made up of tightly packed vacuolated cells held in position by a firm sheath)

Notochord is made up of **vacuolated** cells

Vertebrates are known as modern chordates

In vertebrates, the notochord is modified or replaced in the course of development into a bony vertebral column known as the spine or backbone

In the aquatic species (chordates), the notochord or vertebral column helps the animal to swim by flexing its **tail**

The fluid-filled tube of nerve tissue that runs the length of the animal, dorsal to the notochord is called **Dorsal nerve cord**

Dorsal nerve cord is present in chordates throughout embryonic and adult life

In fish and other vertebrates, the nerve cord is represented by the spinal cord

In fishes, the main communications line of the nervous system is **Dorsal nerve cord**

The pharyngeal gill slits are pairs of openings through the pharynx that serve as water exit holes through which water, drawn through the pharynx, is passed out

Invertebrate chordates use **pharyngeal gill** to trap food particles in the water where the animals live

In fishes, the pharyngeal gill develop into **true gills** for breathing

Which of these groups possess true gills for respiration?
Reptiles
Birds
Fish
Mammals (including humans)

In reptiles, birds, and mammals (including humans), the gill slits are vestiges (gone or no longer functional), occurring only in the **embryonic** stage

The part of the animal that extends backward behind the anus is called **Muscular post-anal tail**

Basic/primary features of chordates

- Notochord
- Dorsal nerve cord
- Pharyngeal gill slits
- Muscular post-anal tail
- Blocks of muscle (metameric musculature)
- Triploblastic coelomates
- Bilateral symmetry
- Ventral heart
- Limbs
- Endoskeleton
- Digestive system
- Reproduction
- Excretion

Coelom means “body cavity”

The body structure chordates are made up of three germ layers of embryonic cells

Chordates have **four** of appendages in the form of legs, arms, wings or fins

Inner skeleton is also called **Endoskeleton**

The digestive system of chordates comprises of

- Stomach
- Intestine
- Mouth (tongue and teeth)

Chordates organ of respiration are lungs and gills

The mode of reproduction in phylum Chordata is **sexually**

Chordates reproduce **sexually**

Chordates excrete (get rid of) wastes through kidneys and intestine

Chordates are a group of animals (some invertebrates and all vertebrates) that have a notochord/backbone, dorsal nerve cord/spinal cord, pharyngeal gill slits and post anal tail

Notochord or backbone

Dorsal nerve cord or spinal cord

In vertebrates, notochord is represented by the **backbone** or **vertebral column**

In vertebrates, dorsal nerve cord is replaced by **spinal cord**

Chordates trap food particles from water with the aid of **pharyngeal gill slits**

MODULE ONE: UNIT 2

The phylum Chordata consists of three subphyla:

- Urochordata (tunicates)
- Cephalochordata (lancelets)
- Vertebrata (vertebrates)
- Hemichordata (acorn worms)

Subphyla Urochordata is represented by **tunicates**

Subphyla Cephalochordata is represented by **lancelets**

Subphyla Vertebrata is represented by the **vertebrates**
Subphyla Hemichordata is represented by the **acorn worms**

The hemichordates, urochordates, and cephalochordates (form the **invertebrate** component of the phylum Chordata) are collectively referred to as the protochordates

The phylum Chordata comprised of **four** subphyla

Hemichordates are also called half chordates

Tail chordates are also known as Urochodata or Tunicata

The prefix cephalo means “head”

The prefix uro means “tail”

The prefix hemi means “half”

Vertebrata are chordates with **backbone**

The hemichordates are considered as **half chordates**

The hemichordates are considered as **half chordates** because their chordate features are partial or not well-developed, and they do not have a post-anal tail

The vertebral column (notochord) is composed of bones or cartilages called **vertebrae**

The Urochordata is made of these classes

- **Class** Ascidiacea (sea squirts)
- **Class** Thaliacea (salps)

- **Class** Larvacea (Appendicularia)

(Mnemonic: LAT)

The hemichordata is made of these classes

- **Class** Enteropneusta (acorn worms)
- **Class** Planctosphaeroidea (extinct)
- **Class** Pterobranchia (*Cephalodiscus)*

(Mnemonic: PEP)

Subphylum Cephalochordata (head chordate)
Class Leptocardii (Leptocardia)

The three invertebrate subphyla Hemichordata, Urochordata, Cephalochordata are collectively called protochordates

Subphylum Vertebrata (craniata)
- **Superclass** Agnatha (jawless fish)
- **Class** Cyclostomata (lampreys and hagfishes)
- **Order** Petromyzontia (or *Hyperoartii*)
- **Order** Myxinoidea (or *Hyperotreti*)
- **Class** Ostracodermi (extinct)

- **Superclass** Gnathostomata (jawed vertebrates)
- **Class** Placodermi (armoured fishes, extinct)
- **Class** Chondrichthyes (cartilaginous fish)
- **Subclass** Elasmobranchii
- **Subclass** Holocephali
- **Class** Osteichthyes (bony fish)

- **Class** Amphibia (amphibians)
- **Order** Anura
- **Order** Urodela
- **Order** Gymnophiona/Apoda
- **Class** Reptilia (reptiles)
- **Order** Crocodilia
- **Order** Testudinata
- **Order** Squamata
- **Order** Rhynchocephalia
- **Class** Aves (birds)
- **Subclass** Archaeminthes (extinct)
- **Subclass** Neornithes
- **Superorder** Odontognathae (extinct)
- **Superorder** Palaegnathae
- **Order** Struthioniformes
- **Order** Tinamiformes
- **Superorder** Neognathae
- **Order** Anseriformes (waterfowl)
- **Order** Galliformes (fowl)
- **Order** Charadriiformes (gulls, button-quails)
- **Order** Gaviiformes (loons)
- **Order** Podicipediformes (grebes)
- **Order** Procellariiformes (albatrosses)
- **Order** Sphenisciformes (penguins)
- **Order** Pelecaniformes (pelicans)
- **Order** Phaethontiformes (tropicbirds)
- **Order** Ciconiiformes (storks)
- **Order** Cathartiformes (New World vultures)
- **Order** Phoenicopteriformes (flamingos)

Order Falconiformes (falcons, eagles, hawks)

- **Order** Gruiformes (cranes)

- **Order** Pteroclidiformes (sandgrouse)
- **Order** Columbiformes (doves and pigeons)
- **Order** Psittaciformes (parrots)
- **Order** Cuculiformes (cuckoos and turacos)
- **Order** Opisthocomiformes (hoatzin)
- **Order** Strigiformes (owls)
- **Order** Caprimulgiformes (nightjars)
- **Order** Apodiformes (swifts and hummingbirds)
- **Order** Coraciiformes (kingfishers)
- **Order** Piciformes (woodpeckers)
- **Order** Trogoniformes (trogons)
- **Order** Coliiformes (mousebirds)
- **Order** Passeriformes (passerines)
- **Order** Strigiformes (owls)

- **Class** Mammalia (mammals)
- **Subclass** Prototheria
- **Subclass** Theria
- **Infraclass** Metatheria
- **Infraclass** Eutheria

- **Order** Proboscidea (elephants)
- **Order** Sirenia (manatee, dugong)
- **Order** Carnivora (dogs, cats, lions)
- **Order** Edentata (anteaters, sloth
- **Order** Artiodactyla (cows, sheep, pigs)
- **Order** Cetacea (whales, dolphins)
- **Order** Perissodactyla (horses, zebra)
- **Order** Chiroptera (bats)
- **Order** Insectivora (shrews, moles)
- **Order** Rodentia (rats, mice)
- **Order** Lagormorpha (rabbit, hares)
- **Order** Primates (monkeys, apes, humans)

Agnatha are jawless vertebrates
Gnathostomata are jawed vertebrates

The Gnathostomata are grouped into two
Fishes or Pisces (Placodermi, Chondrichthyes and Osteichthyes)
Tetrapods i.e. animals with four limbs (Amphibia, Reptilia, Aves and Mammalia)

Chondrichthyes are cartilaginous fish
Osteichthyes are bony fish

Chordates have a skull enclosing sensory organs such as the brain, eyes, inner called Craniata

The amphibians, reptiles, birds and mammals are referred to as tetrapods on account of having four limbs

Which subphyla of the phylum chordata have only one class?
Cephalochordata (Leptocardii)

MODULE THREE: UNIT 3

The subphylum Hemichordata has **two** extant (living/existing) classes

The subphylum Hemichordata has the following characteristics:

- Body is divided into three sections- proboscis, collar and trunk
- Body is bilaterally symmetrical

- Primitive notochord is restricted to the proboscis only and thus called stomochord
- Body has more than two cell layers, tissues and organs
- A true coelom (body cavity)
- A straight or U-shaped gut, with an anus
- Nervous system normally diffuse, but variable
- A partially open circulatory system
- Glomerulus as excretory organ
- Reproduction normally sexual
- Feed on fine particles in the water
- Live in marine environments.

The body of hemichordate is divided into three sections - **proboscis, collar and trunk**

In hemichordate, notochord is restricted to the **proboscis** only and thus called stomochord

In hemichordate, notochord is replaced by **stomochord**

Acorn worms belong to the class **Enteropnuesta**

Enteropneusta (acorn worms) are 2 to 2.5m long

The excretory organ of hemichordates is called **Glomerulus**

Proboscis is also known as **Protosome**

Hemichordates have the following classes

Enteroneupsta

Pterobranchia

In the Class Pterobranchia proboscis is modified into a **shield**

Pterobranchia (pterobranchs) are tiny, deep-sea, colonial, moss-like animals

An example of Pterobranchia is ***Rhabdopleura (Cephalodiscus)***

Hemichordates are primitive chordates that live in **marine** environment

Hemichordates are represented by two living classes:

- Enteropneusta (acorn worms)
- Pterobranchia

NB: The third class Planctosphaeroidea is extinct

In Hemichordates, body colonies are interconnected by stems, or stolons

MODULE ONE: UNIT 4

The urochordates are generally called tunicates or tail chordates

Which chordates subphylum represents the most primitive of the true chordate (most advanced amongst the protochordates)?

Urochordates

Urochordates have the following characteristics:

- notochord present only at the developmental tadpole stage; absent in the adult stage thus, adult has no endoskeleton
- hollow nerve cord
- post anal tail
- body wholly covered by a structure called 'tunic' made of secreted protein and cellulose-like material

- body has more than two cell layers and includes tissues and organs - triploblastic
- U-shaped gut
- body without coelomic body cavity
- hermaphroditic with external fertilisation

- nervous system composed of an anterior ganglion from which individual nerves issue arise
- no excretory organs
- a distinct larval stage that undergoes metamorphosis
- gill slits are used to trap food particles during filter feeding
- ventral heart present with incomplete closed circulatory system
- haemocyanin as blood pigment (no hemoglobin)
- no excretory organs
- habitat is marine environment

The body of Tunicates is wholly covered by a structure called 'tunic' made of secreted protein and cellulose-like material

Hemichordates and Tunicates both live in marine environment

Urochordates are a medium sized group of marine animals commonly referred to as Sea squirts, Tunicates, Salps or Larvaceans

All the urochordates have an external covering or 'house' called the **tunic**, which is made of secreted proteins and a polysaccharide

The 'houses' of the larvaceans (are less substantial as new ones) are secreted every four hours

The subphylum Urochoradta is divided into three classes namely:

- Ascidiacea (Sea squirts)
- Thaliacea
- Larvacea

Sea squirts belong to the class **Ascidiacea**
In the class Ascidiacea, tadpole-like larvae metamorphose into adults

Body colour of species of the class **Ascidiacea** include these

- Translucent or whitish
- Red
- Brown Yellow
- Blue

Ascidians inhale and exhale water through the an organ known as **siphon**

Tunicates feed by drawing water in through the **inhalant siphon**

Siphon is the organ used for feeding and excretion in Tunicates

Salps belong to the class **Thaliacea**

The class Thaliacea has the following features:

- small barrel-shaped animals
- feed as they swim slowing through warm waters
- filter feeders
- inhalant and exhalent siphons at opposite ends of their bodies
- two-generation life cycle - one generation is solitary and the other forms chainlike colonies

Two types of siphon present in Tunacates are:
- Inhalant siphon
- Exahalant/Exhalent siphon

Which of these are among the most advanced invertebrates in the sea and are closely related to vertebrates (animals with backbones)?

Salps

Animals with backbone are called **vertebrates**

Vertebrates are animals with **backbones**

An example of tunicate or urochordate which possess a “barrel-like body” is **salp**

The Larvaceans, are sometimes called the apendicularians

Characteristics of the Class Larvacea (Apendicularia) includes these

- Planktonic (mass of floating organisms)
- Body consists of a basically oval trunk and a relatively long thin tail
- Tail contains the notochord which is retained all through the animals life, unlike the rest of the urochordates where it is lost before maturity, or even during embryogenesis
- Larva metamorphoses to adult
- They secrete a gelatinous 'house' that encases the trunk or body, but not the tail
- Tail has muscle cells attached to it and is used for swimming

A mass of floating organisms in an aquatic environment is called **planktonic**

Larvaceans are small marine chordates with a **tadpole** appearance with the tunicate housing only the trunk but not the tail

Evolution by retaining juvenile traits as an adult is known as **Neoteny**

The trunk of larvaceans are encased in a gelatinous ‘house’

NB: The main difference between larvaceans and other tunicates is their ability to retain the notochord throughout life of the animal

MODULE ONE: UNIT 5

Members of the subphylum Cephalochordata have the following characteristics:

- Notochord: well-developed and persists throughout life of the animal. It runs the length of the animal from the tail to the tip of the nose on the head - a feature that gives subphylum its name (cephalo- meaning head).
- Numerous gill slits over 100 used to trap food particles during filter feeding
- Dorsal nerve cord
- Post-anal tail
- Marine and fish-like in appearance (both ends pointed)

- o normal vertebrate endoskeleton
- External fertilisation
- Some metamerism (body segmentation) in the musculature
- No heart
- Use haemocyanin pigment (no haemoglobin) Closed blood circulatory system.

cephalo- meaning **head**

The subphylum Cephalochordata is represented by one organism *Branchiostoma* commonly called **Amphioxus or lancelets**

Amphioxus means "**sharp at both ends**"

Protochordates that are capable of feeding while they are motionless, moving food-laden water by means of cilia are called **filter feeders**

Amphioxus is 51-76 mm (2-3 in) in length and whitish to creamy yellow or pink

Ampioxus or lancelet belong to the class Branchiostoma (cephalochordate)

Which of these protochordate is fish-like in appearance but without eyes?

Amphioxus

The musculature of the body of lancelet is divided into V-shaped blocks or myotomes

Cephalochordates are the most advanced protochordates showing all the primary chordate features

Amphioxus belong to the class: **Leptocardii/Leptocardia** (small heart)

Leptocardia or Leptocardii means "**small heart**"

The blood of amphioxus is **colorless**

Cephalisation is defined as the development of the **head** in cephalochordates
MODULE TWO: UNIT 1

The vertebrates (animals having backbone) are **advanced chordates**

In vertebrates, notochord is replaced by vertebral column (the backbone)

The chordate subphylum, Vertebrata, is characterised by the following features:

- Notochord is not present in adult; it is replaced by spine of cartilaginous or bony column - the vertebrae/backbone
- A complex brain encased by a cranium, which protects and supports it.
- Well-developed head (cephalisation) with advanced nervous and sensory structures
- Most have two pairs of appendages: one pair of pectoral and one pair of pelvic appendages
- Bony and/or cartilage endoskeleton for structural support and or locomotion.
- True body cavity – the coelom
- Males and females are separate and distinct
- Gill slits are few in number, when present
- Modes of feeding: herbivores, carnivores, omnivores, filter feeders, parasites.
- Well-developed ventral heart with 2-4 chambers
- Closed circulatory system with haemoglobin as the respiratory pigment in the blood
- Variety of habitats including freshwater, salt water, terrestrial.
- Specialised epidermal structures in the form of scales, feathers, hair, fur, spines.
- True kidneys.
- Efficient respiratory system of gills or lungs.
- Body is bilaterally symmetrical and of three parts - head (with internal skeleton the cranium), trunk and post-anal tail.

The brain of a vertebrate is encased in a **cranium** or **skull**
The protective cover which encases the brain of vertebrates is known as skull or cranium
Body of vertebrates are divided into head, trunk and (post-anal) tail

Segments arranged or form notochord is known as **somites**

Members of the superclass Anatha have the following features:

- Lack jaws hence the name agnatha (without jaw)
- Vertebral spine is cartilaginous
- Head with a cranium that encases a brain
- Mouth is generally round/ circular
- No scales or exoskeleton

Characteristics of the Class Cyclostomata (lampreys and hagfishes)

- eel-like in shape
- lack jaws but have rows of horny teeth that move in circular motion and give the mouth a circular shape - hence the name cyclostomata. In the absence of a jaw, the mouth cannot close and is always open such that water constantly cycles through it.
- prey/parasitise on fishes
- lack exoskeleton/scales
- notochord persists in adults
- marine habitat with size of 10-90cm in length

Cylcostomata are marine vertebrates (animals) with **circular mouth shape**

Cyclo means **circular**
Stomata means **mouth**

The name cyclostomata means **round/circular mouth**

The class Cyclostomata consists of two orders

Petromyzontia (or Hyperoartii)

Myxinoidea (or Hyperotreti)

The Petromyzontes are characterised by the following features:

- Soft body without scales
- Pineal (cone-like) eyes
- Lack bone
- Endoskeleton made of cartilage
- Seven gill pouches open directly to exterior
- Circular sucking mouth used in parasitising other fishes
- Lack paired fins but have fin rays
- Single dorsal nasal opening on top of the head
- Cartilaginous braincase
- Ammocoetes larva metamorphoses to adult

Lampreys (*Petromyzon marinus)* belong to the order **Petromyzontia**

Order: Myxinoidea (or Hyperotreti) e.g. hagfishes- *Bdellostoma* and *Myxine* spp

Hagfishes belong to order **Myxinoidea**

The hagfishes are characterised by the following features:

- Circular mouth fitted with rasping tongue surrounded by short tentacles
- Gill pouches joined to a common external opening on either side
- Nasal opening at the tip of the snout rather than on top of the head as in the lampreys
- Exclusively marine
- Elongate (eel-like) body
- Scale less body
- Many mucous glands present for anti-predator defense
- Unsupported fin rays

Characteristics of the Class Ostracodermi (Extinct)

- Small fish-like animals (only few centimeters long)
- Bottom dwellers, poor swimmers
- Rudimentary fins and bony armor
- No lower jaw
- No teeth
- Filter feeders or deposit feeders
- Marine

The Ostracoderms are **extinct vertebrates**

The Three Types of Ostracoderms

- Arapsid
- Heterostracan
- Ousostracan

Vertebrates are chordates with a well defined **backbone** (cartilaginous or bony)

Vertebrates have **two pairs of appendages** (1 pair of pectoral and 1 pair of pelvic appendages)

Vertebrates have **2-4** chambered heart

Agnatha means **jawless** or **without jaw**
Gnathostomata means **jawed**

Gnathostomata are **jaw-bearing animals** or **jawed vertebrates**

Examples of Gnathostomes are Human, fish, dogs, cows, goats, cats etc

Gnathostomes are characterised by:

- A vertically biting device called jaws
- Paired appendages
- Interventrals and basiventrals in the backbone

- Gill arches
- Horizontal semicircular canal in the inner ear
- Teeth - modified dermal scales
- Paired nasal sacs

The Gnathostomata or gnathostomes have **vertical biting teeth**

The gnathostomes include these:

SHARKS, RAYS, CHIMAERAS, RAY-FINNED FISHES, LOBE-FINNED FISHES AND LAND VERTEBRATES INCLUDING HUMANS

All these are classes of the superclass Gnathostomata

- Placodermi
- Chondrichthyes (Cartilaginous fish)
- Osteichthyes (Bony fish)

The cartilaginous fishes have the following characteristics:

- internal skeleton is composed of cartilage (rather than bone)
- body scales are placoid (tooth-like) with a bony base
- jaws suspended by two gill arches
- swim bladder or lung absent; have oil-filled liver to provide buoyancy
- claspers (modified pelvic fins) present in males for internal fertilisation
- notochord present in the young and gradually replaced by a backbone of cartilage in adult
- ventral mouth
- gills not covered by operculum
- fleshy pectoral and pelvic fins

Members of the class Chondrichthyes have a backbone that is made of **cartilage**

Characteristics of the Class Osteichthyes (Bony fish)

Members of this class have the following characteristics:

- Bony endoskeleton
- body covered by cycloid scales (thin and round bony scales)
- paired pectoral and pelvic fins supported by bony rays
- bilaterally symmetrical tail fin
- visceral cleft as separate gill openings covered by a bony flap – the operculum

The class Chondrichthyes is divided into two extant subclasses:

Subclass: Elasmobranchii (sharks, rays and skates)
Subclass: Holocephali (chimaera, sometimes called ghost sharks)

Chimaera is also called **ghost shark**

The Osteichthyes include two major subclasses

- Actinopterygii
- Sarcopterygii

An example of Osteichthyes is **Tilapia tilapia** (Tilapia fish)

Fishes are aquatic chordates throughout their life

The subclass of Gnathostomata that is extint is Plercodemi

Placodermi are armoured **fishes or extinct**

Chondrichthyes are **cartilaginous fish**

Amphibians are animals that live in **water** and on **land** (dual habitation)

- Amphi - meaning **both** ○ Bios - meaning **life**

The amphibians are characterised by the following features:

- Moist and glandular skin
- Complex life cycles (eggs, tadpole/juveniles, adults through metamorhosis)
- Non-amniotic eggs
- Eggs lack a shell instead surrounded
- Three-chambered heart
- No external ear
- Cold-blooded animals
- Two pairs of pentadactyl (five digits) limbs

The amniotic membrane surrounds or protects the **embryo**
The skin of amphibians is **moist and glandular**

Amphibians absorbs water and oxygen from the surrounding atmosphere through their moist scale-less skin

The period in which amphibians become inactive when conditions are unfavorable for survival is called **estivation**

The life cycle of most amphibians begins in **water**

The eggs of amphibians hatch into **tadpoles** (larvae)

The tadpoles changes from plant-eating (herbivorous) to meat eaters (carnivorous) animals

Amphibians reach full adulthood at 3 - 4 years

The class Amphibia is comprised of three orders which include these

- Gymnophiona (caecilians)
- Urodela (urodeles - newts and salamanders ○ Anura (anurans - frogs and toads)

Anura are amphibians without tail

Urodels are amphibians with true tail

The largest group of living amphibians is the **urodels**

Members of the order Urodela have the following characteristics

- Lack true tail in the adult stage ○ Hind limbs are longer than front limbs ○ Live in aquatic environment ○ Larval forms are called tadpoles ○ External gills in the larvae

Frogs and toads belong to the order **Anura**

Frogs adapt to drier habitats than toads because they have **drier skin that is warty**

Toads have **drier and warty skin** while frogs have **smooth skin**

Frogs have longer and well-pronounced webbed feet (that facilitate movement in water) than toads and are often in or near water

The largest frog is called the **West African Goliath frog**

Frogs and toads feed on insects and other invertebrates

The order Urodela is characterised by the following features:

- A long true tail hence the name "Urodela" meaning "evident/visible tail" ○ The adults are shaped like eels ○ Lack a tympanum (external ear drum)
- They have small and underdeveloped legs adapted to walking rather than jumping or hopping
- Legs almost equal in size
- They breathe through external gills as well as lungs

Urodela mean **evident or visible tail**

The adult urodels spend most of their life time on **land**

The largest (amphibian) urodel is called the **giant salamander of Japan**

The **red-spotted Newt** lives in ponds and streams in the eastern and central United States

After reaching adulthood, skin of **red-spotted Newt** turns olive with red from bright reddish-orange

Caecilians/Apoda belong to the order **Gymnophiona**

Members of the order Gymniphiona have the following characteristics:

- Lack legs hence the name Apoda (dig burrow by ramming its bony head through the soft dirt)
- Worm-like in shape – body is ringed/marked by rings

- Usually terrestrial
- Practically blind
- Tail absent or greatly reduced
- No middle ear apparatus
- Sensory tentacles on head

Internal fertilisation

Caecilian is wormlike amphibian with no limbs

The untrained eye may mistaken which amphibian for a snake (reptile) or earthworm?

Caecilian

- Anura are amphibians without tails in the adult stage
- Urodela are amphibians with tails (true tails)
- Gymnophiona are worm-like amphibians without legs

MODULE TWO: UNIT 4

Reptiles lay their eggs on **land**

Amphibian eggs are laid in **water**

The embryo in the eggs of reptiles is protected by a thin membrane called **amniotic membrane**

The amniotic membrane protects the **embryo**

Amniotic membrane finds its genesis in **reptiles**

Reptiles are animals which include lizards, wall geckos, crocodiles, snakes and tortoises

Reptiles are characterised by the following features:

- Dry skin with keratinised epidermal horny scales
- Bony endoskeleton
- Two pairs of pentadactyl (five digits) limbs with true claws (if limbs are present)
- No external ear
- Fertilisation is internal and fertilised eggs laid (oviparous) on land or eggs retained internally until hatching (ovoviviparous)
- Amniotic egg with leathery shell
- Cold blooded (poikilothermic/exothermic)
- Gut and the ducts of the urinary and reproductive system open into a posterior chamber called the cloaca

Cold blooded animals are also called **poikilothermic or ectothermic**
Warm blooded animals are called **exothermic**

Ecto meaning "inner"
Exo meaning "outer"
Themic meaning "temperature"

Reptiles regulate their body temperature either by basking in the sun (warming) hiding under cover to keep cool

Reptiles lay amniotic eggs that have **a leathery shell** that prevents rapid water loss

The Class Reptilia is composed of four orders namely

- Crocodilia (crocodiles and alligators)
- Testudinata (turtles)
- Squamata (lizards and snakes)
- Rhynchocephalia (Tuataras)

The crocodilians (Crocodiles and alligators) have the following features:

- Have a long snout
- Four well-developed limbs
  A muscular tail used to propel them through the water
- Lay eggs in large mounded nests or in cavities dug in the soil
- Carnivorous on fish, amphibians, reptiles, birds, and mammals

A crocodile has a very long, narrow, V-shaped snout, while the alligator's snout is wider and U-shaped

A crocodile's upper and lower jaws (teeth) are exposed such that even when the mouth is the bottom teeth are visible while an alligator's teeth don't show when its mouth is closed

The order Testudinata (Turtles and tortoises) is characterised by the following features:

- Shell or carapace
- No teeth but have a sharp-edged beak
- Oviparous and fertilisation internal
- No temporal opening in the skull behind the eye

A condition in which Testudinates (turtles and tortoise) lack temporal opening in the skull behind the eye is called **Anapsis**

The shell of testudinata is covered with **scutes**

The shell of turtle/tortoise consists of the top shell called carapace and a bottom shell known as plastron

The shell of Testidunata (turtle/tortoise) comprised a **carapace** and **plastron**

Turtles/tortoises are long-lived animals from 20 to over 100 years

The Latin word-root "test" means ‘shell’

"Testudines" is Latin for turtle

Lizards and snakes belong to the order **Squamata**

Characteristics of the Order Squamata (Lizards and snakes)

- Transverse vent or cloacal opening
- Skull that is more moveable (or kinetic) than other reptile orders
- Paired copulatory organs called hemipenes
- Body covered in scales
- Periodically shed their skin (a process known as ecdysis/moulting)
- Carnivorous or omnivorous
- Variety of habitats (aquatic, terrestrial, or arboreal)
- Lay eggs; others bear live young (ovoviviparous)

The Order Squamata (meaning scaled reptiles) is the largest order of reptiles with over 6,000 living species

The Order Squamata is the most diverse of the reptile orders, containing 96% of the reptile species

A process of periodical shedding of the skin by order squamata is known as **ecdysis** or **moulting**

Lacertilia (lizards)
Serpentes (snakes)

In order squamata, the ability to lose the tail when attacked by predators is known as **caudal autotomy**

Difference Between Snakes and Lizards

Snakes (Serpentes) lack limbs while lizards (Lacertilia) are characterised by four limbs

- All snakes lack external ear opening while lizards have visible ear openings
- Snakes have an elongate body while lizards have long slender bodies
- Snakes lack eyelids while lizards have movable eyelids

Monitor lizards are oviparous (egg layers)

Wall geckos make a variety of noises

The name gecko is derived from a Malay word, gecko – which imitates their cry

Chameleons belong to the family Chamaeleonidae

Chameleons are distinctive and highly specialized group of lizards which have parrot-like **zygodactylous** feet

One of the world's fastest-moving snakes is the **Green Mamba** or **Green snake**

Characteristics of the Order Rhynchocephalia (Tuatara)

- A scaly loose and soft skin
- A spiny back
- A third primitive, light-sensitive eye above the brain
- Live in burrows and are nocturnal
- They feed on worms, lizards, millipedes and small seabirds

Tuatara means "spiny back"

The eggs of Tautara incubate for 15 months before hatching

MODULE TWO: UNIT 5

Birds are also called **Aves**

The body scales of birds have been replaced by **feathers**

Animals with feathers are called **birds**

An animal with a feather is a **bird**

Birds are better equipped to live on land than the reptiles

Unlike the reptiles, birds are warm blooded animals

Aves have a heart of four chambers (Four-chambered heart)

Most birds fly (TRUE)

Penguins and ostriches have lost their ability to fly (though their ancestors did fly)

Birds have a large-yolked egg encased in a hard calcareous shell that can withstand d esiccation

NB: Class Amphibia and Reptilia are poikilothermic i.e cold-blooded

Characteristics of the Class Aves (Birds)

- Body covered with feathers composed mainly of keratin (they are the only animals that have feathers)
- Strong bony endoskeleton
- Bones with large air spaces
- Forelimbs modified as wings for flight (some have lost ability to fly)
  Bipedal- two legs for locomotion (lower part of legs has scales)
- Toothless horny beak; use gizzard to grind food
- Warm-blooded animals (body temperature is internally regulated; endothermic/ homeothermic)
- Efficient lungs with pouches for gas exchange
- Heart of four chambers
- Internal fertilisation
- Hard-calcareous shelled eggs with large yolk

Warm-blooded animals are also called **endothermic** or **homeothermic**

Cold-blooded animals are otherwise known as **exothermic** or **poikilothermic** Birds

or Aves are the only vertebrates with **feathers**

- Modern birds have traits related to high metabolism

- Ability to fly
- A beak with no teeth
- Laying of hard-shelled amniotic eggs
- A four-chambered heart
- Light weight but strong skeleton
- Forelimbs modified as wings
- Birds also have unique digestive and respiratory systems

All these are adaptations or adaptive features for birds

- Light body weight
- High body temperature
- Improved blood circulation
- High metabolism
- Acute vision

Adaptation to flight in birds that enables avoidance of danger such as tree branches at high speed is **acute vision**

The class Aves is comprised of two subclasses namely

- Archaeonithes (extinct ancient birds)
- Neornithes (recent birds)

All living birds belong to the subclass **Neornithes**

All these are superoders of subclass Neornithes

- Paleognathae
- Odontognathae (extinct)
- Neognathae

(Mnemonic: **PON)**

Members of the subclass **Archaeonithes** are (extinct) characterised by having **clawed wings**, **reptilian style ribcage** and **bony long tail**

Archaeonithes are identified withclawed wings, reptilian style ribcage and bony long tail

Archaeopteryx and *Archaeornis* belong to the subclass **Archaeonithes**

Members of the superorder odontognothae (modern birds) are known for having **teeth-like** structures

The superorder Palaeognathae derived its name from 'paleognath', the ancient Greek word for "old jaws"

Ratites are birds (of superorder Palaeognathae) which have lost ability to **fly**

Tinamous are birds that can **fly**

The order Struthioniformes comprised of birds called ratites which are large flightless birds

The Ratites have a simplified wing bone structure, strong legs, and no feather vanes

Examples of ratites (large flightless birds) are the following

- Rhea
- Cassowaries
- Ostriches
- Kiwis
- Emus

(Mnemonic: R COKE)

Kiwis (*Apteryx*) are flightless birds endemic to New Zealand

The national symbol of New Zealand is represented by a ratite (flightless bird) called **Kiwi**

Kiwi is the national of New Zealand

The smallest living ratites that lays the largest egg is known as Kiwi

The Ostrich is the largest living species of bird and lays the largest egg of any living bird

The Ostrich (*Struthio*) is a large flightless bird native to Africa

The Emu is the largest extant bird native to Australia

The following are facts about Cassowaries

- Cassowaries are shy birds of the deep forests of Australia and Papua Guinea
- Females Cassowaries are bigger and more brightly colored than males
- The Cassowaries are the world's most dangerous birds
- They are quick to disappear long before they are seen
- A cassowary has three-toed feet and sharp claws
- Cassowaries kick humans and animals with their enormously powerful legs
- They can jump up to 1.5 m
- Hey are good swimmers

The world's most dangerous bird (ratite) is Cassowaries

The Tinamous are a family flight birds found in Central and South America Birds

are the only vertebrates that have feathers

MODULE TWO: UNIT 6

The superorder Neognathae comprises 27 orders which have a total of nearly 10,000 species

Owls belong to the order **Strigiformes**

The bird that has human appearance is known as **Owls**

The following are characteristics of Owls

- Owls have human appearance

- Upright posture
- Large rounded head
- Large eyes that face forward
- Most birds have eyes on the sides of their heads
- All owls are carnivores (meat-eaters)
- Hooked beak for tearing flesh
- Most owls are nocturnal (active at night and asleep by day)
- Low-light eyes
- Acute hearing

Fowls belong to the order Galliformes

All these are considered as Galliformes (fowls)

- Quails
- Turkeys
- Chickens

Falcons belong to the order **Falconiformes**

Doves and pigeons belong to the order **Columbiformes**

Parrots belong to the order **Psittaciformes**

Parrots have zygodactyl feet - two toes on each foot face forward and two face backward

Parrots are zygodactylous birds

Penguins belong to the order **Sphenisciformes**

Penguins are a group of aquatic, flightless birds that live in the southern hemisphere

Kingfishers and allies belong to the order **Coraciiformes**
All these are true of Kingfishers

- Syndactyl feet (three forward pointing toes) and
- They have long pointed bills
- They are carnivorous
- Most species are found in the old world and australia
- There are about 90 species of kingfisher
- All have large heads, long, sharp, pointed beaks, short legs, and stubby tails
  They consume a wide range of prey including fish

Woodpeckers belong to the order **Piciformes**

- They are medium-sized, hole-nesting land birds
- They have short and strong bill
- Zygodactylous
- Tail have stiffened feathers
- Piciformes are good fliers
- They are poor at walking
- Their eggs are incubated by both sexes
- They are non-migratory

NB: Beak is also called as **Bill**

Waterfowls belong to the order **Anseriformes**

They are strong swimmers

They serve as delicacy to man

They are raised as poultry for meat and eggs

They have webbed feet well suited for efficient swimming (some have subsequently become mainly terrestrial)

Waterfowls include all these

- Shorebirds or waders
- Gulls
- Seabirds (albatross)
- Pelicans

(Mnemonic: SGSP)

Birds used by humans for game are called **fowls**

Flamingos belong to the order **Phoenicopteriformes**

Flamingos have the following characteristic

- They are found in Americas and Old World
- They have long leg, neck and bent bills
- Body color is pink, white, or red
- They are found in tropical fresh and salt water lagoons and lakes
- Flamingos often stand on one leg while resting
- They are filter feeders (uniquely adapted to feed on algae and small shellfish)
- Flamingos live in large flocks

The superorder **Neognathae** is comprised of a diverse group of modern birds

The only vertebrates endowed with feathers are called **Birds**

Birds which have wings modified into flippers are called **Penguins**

The following are characteristic feature of members of the class Aves

- Body covered with feathers composed mainly of keratin (the only animals that have feathers)
- Strong bony endoskeleton (bones have air spaces)
- Forelimbs modified as wings for flight (some have lost ability to fly)
- Bipedal- two legs for locomotion (upper part of legs has scales)
- Toothless horny beak; use gizzard to grind food
- Warm-blooded animals (body temperature is internally regulated; endothermic/ homeothermic)
- Efficient lungs with pouches for gaseous exchange
- Heart of four chambers
- Internal fertilisation
- Hard-calcareous shelled eggs with yolk

MODULE 3: UNIT 1

Mammals are recognized for having **mammary glands**

In female mammals**, mammary glands** are responsible for the production of milk for the newborn

The class Mammalia has the following characteristics

- Mammary glands
- Hairy skin with keratin
- A single jaw bone on either side
- Four-chambered heart
- Muscular diaphragm
- Bony endoskeleton
- Two pairs of pentadactyl limbs
- Outer ear lobe (pinna)
- Warm-blooded (endothermic/homoeothermic

- Viviparous; a few are oviparous
- Teeth
- Internal fertilisation
- Well developed brain encased in a skull

Depending on how they are born, mammals are divided into three main categories **Monotremes, Marsupials** and **Placentals** Monotremes are known as egg layers

The largest group of mammals is called **placentals**

The placentals use a **placenta** during **gestation**

The mammalian **brain** regulates endothermic and circulatory systems

Mammals are divided into two subclasses:

Subclass Prototheria

The monotremes are found in Australia and Papua New Guinea.

Platypus babies feed on milk from the mother and is born blind and hairless

A young or offspring of Platypus is called **puggle** (**echidna)**

The subclass Theria is divided into two infraclasses **Metatheria** and **Eutheria**

The following are (Metatheria) Marsupials

 Possum Kangaroo Opossum Koala

(Mnemonic: PKOK)

Marsupium means **pouch** (built-in baby carrier)

The young of metatherians is called **joey**

A newborn kangaroo stays in its mother's pouch for about **six months** where it feeds on her milk

Koala babies are born with eyes closed and have no ears or fur (body hair)

Koala babies stay inside a pouch on the mother's abdomen for about **seven months**

Kangaroos are found in Australia and Papua New Guinea

Opossums are marsupials found in North and South America

Possums are native to Australia, New Guinea, Sulawesi, New Zealand and China

Koalas are naturally found in Australia

NB: Mersupials are naturally absent in Nigeria

Opossums (*Didelphimorphia*) make up the largest order of marsupials in the Western Hemisphere

The word *opossum* means "white dog" or "white beast/ animal"

A **marsupial** is an animal with a pouch, like a kangaroo or a koala

The koala is a mammal (other than primates) that has fingerprints very similar to human fingerprints

Infraclass Eutheria are mammals that have **placentals**

Eutherians are also known as the placentals (reproductive structure)

The period of development of the embryo in eutherians is called **gestation period**

The gestation period in whale is two years (twenty-four months)
The gestation period in mouse **21** days

The gestation period in human is **nine** months

Gestation period in elephant is **22** months

Mammals are vertebrates that have mammary glands for feeding their young or offspring

Reptiles and protherians have related characteristic features

MODULE THREE: UNIT 2

Elephants belong to the order **Proboscidea**

Elephants are members of the mammalian order **Proboscidea** well known for having: Trunks, tusks and loose skin

The young of an elephant is called **calf**

The Savanna Elephant ***(Loxodonta africana***) is the largest of the three species of elephants

Elephants are the largest land animals

The female elephant carries her young in her womb for 22 months (gestation period).

Fully-grown **elephants** have no natural enemies other than humans (TRUE)

Manatees and dugongs belong to the order **Sirenia**

Characteristics of the Order Sirenia

- Aquatic habitat
- Finlike forelimbs

-
-

Vestigial hind limbs
Tails elongated to caudal fins

West Indian manatee and Indian dugong are commonly called the **sea cows**

These are examples of Carnivorous animals or Carnivores

- Dogs
- Cats
- Lions
- Bears
- Raccoons
- Seals

Members of order Carnivora are known to have sharp canine and molar teeth for ripping flesh in common

The young of a dog or cat is called a **puppy**

The young of a lion is called a **cub**

Carnivora means 'flesh devourer" or "flesh eater" or meat-eating animal

Carnivorans have teeth, claws, and binocular vision adapted for catching and eating other animals

Members of the order Carnivora have sharp canine and molar teeth for tearing flesh

MODULE THREE: UNIT 3

Characteristics of Order Edentata (armadillos, sloths)

They have reduced or no teeth

They lack enamel (the hard thin calcium-containing covering of the crown of a tooth)

- They have heavily clawed forelimbs for burrowing

The sloths are generally known as lazy animals on account of their sluggish movement.
The slowest mammal is called **sloth**

Mammalian order Artiodactyla include: sheep, pigs, cattle, deer, antelopes, giraffes, hippopotamus with **even number of toes**

Artiodactyla means "even-toed"

Members of the order Cetacea (whales and dolphins) have the following characteristic:

- They are aquatic
- Have blowholes on their heads
- Have flipper-like forelimbs
- Hind limbs are vestigial
- Tails are elongated to flukes (like a caudal fin)

Order Perissodactyla (e.g. horses, zebras, rhinoceroses, tapirs) have hooves with **odd number** of toes

-
-

Members of the order Perissodactyla have odd number of toes (odd-toed)

Bats belong to the order **Chiroptera**
The bat is the only mammal naturally capable of true and sustained flight Which mammal is capable of true flight?
Bats

All these are mammals capable of true flight

Bats

Flying squirrels

- Gliding possums,
- Colugos

Characteristics of the Order Insectivora (e.g. hedgehogs, moles, shrews)

- They feeds on insects
- They are mostly nocturnal
- Majority are terrestrial
- They ave plantigrade or partially plantigrade feet

Insectivora means “insect eater” or insect eating animals

Moles have polydactyl hands also known as a **prepollex**
Moles are found in Australia and South Africa

MODULE THREE: UNIT 5

These are examples of rodents (Order Rodentia)

- Mice

- Rats
- Squirrels
- Marmots
- Capybara
- Beavers
- Porcupines
- Hamsters
- Guinea pigs

Rodentia is an order of mammals characterised by:

- They have two continuously-growing sharp incisors
  They have no canine teeth
  Diastema (space/gap between teeth)

What percent of mammal species are rodents?
40%

The capybara is hunted for meat and skin

The **capybara** (*Hydrochoerus hydrochaeris*) is the largest extant rodent in the world (weighing up to 91 kg)

Beavers are the second-largest rodent in the world (after the capybara)

Porcupines are the third largest of the rodents (63-91 cm long; 5.4-16 kg), behind the capybara and the beaver

Porcupines (spined pigs) are rodents with a coat of sharp spines, or quills, which the animal uses for **defense** or **camouflage** from predators

The common porcupine is an **herbivore**

-
-

In **Nigeria**, the meat of porcupines is eaten as a delicacy (bush meat)

The Order Lagomorpha include the following

- Rabbits
- Hares
- Pikas

Rabbits belong to the order **Lagomorpha**

Characteristics of the Order Lagomorpha

- Four continuously-growing chisel-like incisors for gnawing
  Diastema (space/gap between the teeth)
  Wholly herbivorous
- Strong hind legs for running and jumping

The difference between Hare and Rabbit

- Hares are normally wild and have relatively longer ears than rabbits
- Hares are larger than rabbits
- Hares are born with fur on the body and with open eyes while rabbits give birth to hairless offspring with closed eyes

Humans, monkeys and apes belong to the order **Primata**

Hares are normally wild and have relatively longer ears than rabbits and usually larger than rabbits

Characteristics of the Order Primata (e.g. monkeys, apes, humans)

- They highly developed cerebral cortex
- They have thumbs that are opposable to varying degrees
- They have forward facing eyes
- They are omnivorous

These are Apes (and do not have tails unlike monkeys)

- Gorillas
- Chimpanzees
- Gibbons

Apes are larger than monkeys, do not have tails and have arms longer than legs

The human body contains **206** bones of various shapes and sizes

Tetrapods are animals with **four** limbs (Amphibia, Reptilia, Aves and Mammalia)

The **hagfishes** are capable of boring the body of their prey, devouring all the soft parts and leaving the skin behind as an ordinary empty shell, held by the bones

The largest (of the order **Sphenisciformes)** penguin is called **emperor penguin**

The **anurans** are the largest group of living amphibians, comprising about 3,000 species

Emu is the largest bird

Zygodactylous birds are birds with **two toes forward** and **two toes back** The

Ostrich is the only bird that has didactyl foot

MODULE FOUR: UNIT 1

It is believed that chordates originated from **invertebrates**

Evolution refers to the change in the genetic make-up of a population of organisms from one generation to another leading to the emergence of a new organism (species)

According to the **theory of evolution**, all known species of organisms descended from a common ancestor (or ancestral gene pool)

Inheritable materials that are passed on from generation to generation giving an organism its inherited traits are called **genes**

Traits are inherited characteristics

Mutation is the random changes in genes or the transfer of genes between populations and between species

Evolution: Change in genetic make-up (new organism is formed)

Mutation: Random changes in genes

Genetic recombination increases variation between organisms

A process that causes helpful traits (those that increase the chance of survival and reproduction) to become more common in a population and causes harmful traits to become more rare or even die off is called **Natural selection**

An independent process that produces random changes in the frequency of traits in a population is called **Genetic drift**

In a population, the number of individuals capable of breeding is called **effective population size**

Population bottlenecks are a process where the population shrinks temporarily and therefore loses genetic variation) result in a more uniform population It is believed that chordates originated from **invertebrates**

It was falsely claimed that chordates evolved from **hemichordates**

Chordates having a single common ancestor are termed **monophyletic**

The most celebrated hypothesis on the evolution of chordates is that proposed by **Garstang**

In hemichordates, the stomochord (replacement for notochord) is restricted to the **proboscis** region

Adult urochordates feed using a 'pharyngeal basket'

Tunicates have an unusual heart which pumps by 'wringing out'

Hagfishes are deep-water marine scavengers that burrow into the mud, sticking their heads out until they detect waterborne odors of food such as decaying flesh

Tetrapods are **4-legged** (ancestor to all modern land) vertebrates

The most celebrated example of adaptive radiation was reported by **Charles Darwin**

General adaptation, Environmental change and Archipelagoes make up what is called **adaptive radiation**