NATIONAL OPEN UNIVERSITY OF NIGERIA

SCHOOL OF SCIENCE AND TECHNOLOGY

COURSE CODE: BIO 209

COURSE TITLE: CHORDATES

COURSE GUIDE

BIO 209
CHORDATES

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INTRODUCTION

BIO 209: Chordates, is a 200 level, first semester, 3- credit unit course designed for students of Biology and related courses. The course, being a three- credit course, is fairly extensive; it has been arranged into 21 study units of 4 modules to carefully and thoroughly take you through the world of chordates. For each unit, you will need at least one hour of study. On completion of the course, including the Tutor-Marked Assignments, you will need not less than 45 hours of study to successfully complete the course. Colourful photographs of some selected animals have been added to enhance your ability to recognise these animals. It will be better to download the course material onto your computer, that way you will have the colours undistorted for better view. It will certainly be an uphill task to expect you to memorise all the characteristic features ascribed to each group of chordates, however, you will be expected to learn the major distinguishing feature(s) of each group. For instance, you cannot afford to recognise birds without associating them with the possession of feathers or mammals with mammary glands. Given that biology is a subject associated with certain special terms, you will need to consult a dictionary, especially a dictionary of biology to aid your understanding of some terms that you may come across in the course of study. As much as possible, we have attempted to define some terms.

WHAT YOU WILL LEARN IN THIS COURSE

This course is all about a group of animals called chordates. You will learn about these animals and the basis for their being called and grouped together as chordates. You will also learn about the invertebrate and vertebrate forms of chordates and the general outline of their classification. By studying chordates, you will be learning about animals around you and those you do see or hear about in distant lands and waters. Indeed, you will be learning about fishes, snakes, crocodiles, lizards (reptiles), frogs, toads (amphibians), doves, pigeons, chickens (birds), goats, sheep, elephants, lions and humans (mammals). In addition, you will learn about their migration from aquatic to terrestrial environments and the adaptations that have accompanied their change of abode. You will have the opportunity to learn about the possible origins of these animals and how they have moved to occupy different ecological niches including their current distribution pattern around the world.

COURSE AIMS

This course aims to provide you with an understanding of the animals called chordates including their possible origin, adaptive radiation and distribution around the world.

COURSE OBJECTIVES

Working through and completing this course should enable you to:

- describe chordates and their characteristic features in general and specific terms
- assign chordates to their respective sub-phyla and classes
- recognise and describe the major groups of chordates especially the vertebrates/vertebrata
- appreciation and understand the evolution, adaptive radiation and zoogeography of chordates.

WORKING THROUGH THIS COURSE

To complete this course successfully, you will be required to read the course units very well and take interest in reading other reference materials recommended, and others you may find. You will never make a good student if you have no interest in reading. After reading through a unit, ensure, through self-assessment, that you understand what you have read. Take nothing less than one hour to study each unit and then attempt to raise questions that you may wish to ask yourself as self-test or keep for the facilitator to assist you. If you spend an hour weekly, then you will need 21 weeks on self-study alone.

THE COURSE MATERIAL

The main components of this course material are:

- The Course Guide
- Study Units
- References/Further Reading
- Tutor-Marked Assignments

STUDY UNITS

BIO 209 comprises 21 study units arranged in four (4) modules as shown below:

MODULE 1 INTRODUCTION TO CHORDATES

Unit 1 General Characteristics of Chordates
Unit 2 Classification of Chordates
Unit 3 Hemichordata
Unit 4 Urochordata
Unit 5 Cephalochordata

MODULE 2 VERTEBRATE CHORDATES (I)

Unit 1 Vertebrata
Unit 2 Gnathostomata
Unit 3 Amphibia
Unit 4 Reptilia
Unit 5 Aves (I)
Unit 6 Aves (II)

MODULE 3 VERTEBRATE CHORDATES (II)

Unit 1 Mammalia
Unit 2 Eutherians: Proboscidea, Sirenia, Carnivora
Unit 3 Eutherians: Edentata, Artiodactyla, Cetacea
Unit 4 Eutherians: Perissodactyla, Chiroptera, Insectivora
Unit 5 Eutherians: Rodentia, Lagomorpha, Primata

MODULE 4 EVOLUTION, ADAPTIVE RADIATION AND ZOOGEOGRAPHY

Unit 1 Evolution of Chordates
Unit 2 Adaptive Radiation of Chordates
Unit 3 Zoogeography of the Nearctic and Neotropical Regions
Unit 4 Zoogeography of the Palaearctic and Afrotropical Regions
Unit 5 Zoogeography of the Oriental and Australasian Regions

Module 1 introduces you to the subject - Chordata by way of giving a general description and classification of this group of animals. Furthermore, the Module, in Units 3-5, takes you into the invertebrate group of chordates. It must be pointed out that although the Hemichordata are today considered as a separate phylum from Chordata, we have included them here as was the old tradition out of sheer interest/completeness of the picture. You will certainly gain better insight on the rudimentary nature of the invertebrate chordates and build up knowledge towards understanding the evolutionary trends that led to the emergence of the more advanced chordates - vertebrates.

Module 2 takes us to the fascinating world of vertebrate chordates. Certainly, you must have at one time or the other in your study of biology, dealt with the vertebrates although not necessary under the topic - chordates. Vertebrates have a well-defined backbone, which may be cartilaginous or bony in nature. Unit 1 describes the vertebrates as a whole and further describes the characteristic of a sub-group - the Agnatha, which comprises vertebrates without jaws. Unit 2 describes the Gnathostomata, which comprises vertebrates with jaws. This unit takes us to the interesting world of fishes (both the cartilaginous and bony fishes). The amphibians are described in Units 3, while Unit 4 gives a description of reptiles. Birds, by virtue of their complexity and diversity, take up Units 5 and 6, which you will certainly find interesting to study.
Module 3 continues with the description of the vertebrates with a focus on mammals. Unit 1 of this Module gives a vivid description of mammals including their subgroups i.e. the Protheria and the Therians; the metatherians, which constitute the primitive therians are also described in this unit. The true therians (Eutheria) take up the rest Units (2-5) in which the various orders of the class are discussed.

Module 4 takes you to the subject of evolution, adaptive radiation and zoogeography, which is all about the origin of vertebrates, how they radiated to occupy the regions of the globe and the current distribution pattern of these animals (vertebrates) over the globe.

Attempts have been made to give you a pictorial representation of some of these animals in order to broaden your understanding and ability to recognise them.

PRESENTATION SCHEDULE

This course (BIO 209), like any other NOUN course, has important time frames for its early and timely completion, together with the submission of your TMAs and attendance at tutorials. Your facilitator is central to all these, hence the need to keep in touch with him/her in order to keep abreast with the stipulated schedules. The TMAs will be posted on the internet for a certain period of time, after which you will not be able to gain access to them or be allowed to submit your assignment after the stipulated time. You must therefore guard against trailing behind in your work.

ASSESSMENT

There are two aspects of assessment for this course. The first is the TMA, which you will do as the course progresses. This is the continuous assessment component of the course and its score value is 30%. The second aspect is the final examination that comes after you have

completed the course; the score value is 70%. You must score at least 40% in the two assessments to pass this course.

TUTOR-MARKED ASSIGNMENT

As was started earlier, the Tutor-Marked Assignment (TMA) accounts for 30% of the total score of the course, so you must pay attention on this arm of the course because you cannot pass the course without the TMA component. In each unit, you have a TMA; your facilitator will tell you which one you will need to submit. However, it is important that you spend time on all the TMAs, whether you need to submit them or not as each is meant to task your understanding on what you have studied in a particular unit. Indeed, the TMAs will assist you in your final examination. You will be working within a time frame to undertake and submit your TMA. Therefore, be in constant touch with your facilitator.

FINAL EXAMINATION AND GRADING

This course will end with a final examination, which has a score value of 70% of the total score for the course. Unlike a TMA that focuses on a particular unit, the final examination is on all the units. Your levels of preparation, especially for a three credit unit course like 'Chordates', will certainly be very high if you must earn a good grade.

COURSE MARKING SCHEME

Assessment	**Marks**
TMAs	30% of selected TMAs
End of course examination	70% of overall course marks
Total	**100% of course mark**

FACILITATORS/TUTORS AND TUTORIALS

You must bear in mind that this is self-help programme. In other words, you are essentially your own teacher; the facilitator simply guides you and this assistance is minimal compared to what you will do by yourself. Your facilitator will mark and make comments on your assignments. Furthermore, he/she will monitor your progress and provide assistance whenever you have any difficulties. The facilitator shall arrange tutorials - an opportunity to meet with your facilitator face to face for interactions on the course. Therefore, you need to be in constant touch with your facilitator by phone or email to know the arrangements concerning tutorials and to seek answers to:

- any part of the study or assigned readings that you do not understand
- any difficulties you might have with TMA

You must never miss any tutorials as it is a rare window, far better than phone calls and emails, to put your questions across to your facilitator and also gain from what others may have to ask. To derive maximum benefit from the course tutorials, you are advised to prepare a question list before attending any given tutorial.

SUMMARY

Upon completing this course, you will be knowledgeable in the subject area of chordates in terms of their characteristic features in general and that of the respective sub-groups. You should be able to distinguish one chordate group from another. In addition, you should be able to:

- explain what chordates are
- describe general chordate features
- attempt to classify chordates at least to the class level
- recognise and describe fishes, amphibians, reptiles, birds, and mammals
- give an account the evolution of chordates
- discuss the adaptive radiation and zoogeography of chordates.

We wish you success as you go through the wonderful world of chordates. Aim high towards an excellent grade in this and other courses and stay alive with the National Open University of Nigeria.

MAIN COURSE

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MODULE 1 INTRODUCTION TO CHORDATES

UNIT 1 GENERAL CHARACTERISTICS OF CHORDATES

CONTENTS

1.0 INTRODUCTION

In this unit, we shall be looking at a group of animals called chordates. Chordates belong to the animal phylum Chordata and include the vertebrates, together with several closely related invertebrates, the urochordates and cephalochordates. Until recently, an invertebrate group, the Hemichordata was placed under the phylum Chordata but is now considered as a separate phylum. However, we shall consider hemichordata here along with the rest invertebrate groups as the case previously.

The three chordate subphyla i.e. Urochordata, Cephalochordata and Vertebrata are so grouped on account of having certain primary features namely:

i) a notochord (a dorsal fairly rigid rod of vacuolated cells) or a vertebral column
ii) a hollow dorsal nerve cord or spinal cord
iii) pharyngeal slits
iv) a post-anal tail.

It must be emphasized that although chordates are said to have these four basic features in common, some of these characteristics may not be

retained throughout the life of an animal but must be present or manifest in an individual at some time during its development.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- describe and recognise chordates by their characteristic features
- distinguish chordates from other animal groups
- have a mental picture of the body structure of chordates.

3.0 MAIN CONTENT

3.1 Characteristics of the Chordates

As was highlighted in the introduction, chordates as a group of animals share some common features which manifest at some stage in their lives. In addition to the four features earlier mentioned (i.e. notochord, hollow dorsal nerve cord, pharyngeal slits and post-anal tail), chordates also exhibit other features presented below.

Basic/primary features of chordates

Notochord: This is a stiff but flexible rod (made up of tightly packed vacuolated cells held in position by a firm sheath). The notochord lies along the inside of the dorsal side of the body and provides structural support. It can be found in its near original form in some invertebrate chordates. In most modern chordates especially the vertebrates, the notochord exists only during development but is modified or replaced in the course of development into a bony vertebral column known as the spine or backbone. In entire aquatic species, the notochord or vertebral column helps the animal to swim by flexing its tail.

Dorsal nerve cord: This is a fluid-filled tube of nerve tissue that runs the length of the animal, dorsal to the notochord. It is present in chordates throughout embryonic and adult life. In fish and other vertebrates, the nerve cord is represented by the spinal cord, which is the main communications line of the nervous system.

Pharyngeal gill slits: The pharynx is the part of the throat immediately behind the mouth down toward the stomach. The pharyngeal gill slits are pairs of openings through the pharynx. The slits serve as water exit holes through which water, drawn through the pharynx, is passed out without it continuing down into the rest of the gastrointestinal tract. Invertebrate chordates use them to trap food particles in the water where the animals live. In fishes, the gill slits have developed into true gills for breathing. In reptiles, birds, and mammals (including humans), the gill

slits are vestiges (gone or no longer functional), occurring only in the embryonic stage**.**

Muscular post-anal tail: It is that part of the animal that extends backward behind the anus. The notochord, nerve cord, and the myotomes (muscles that are supplied by a nerve of the spine) extend to the tail. The tail is found at some time during a chordate's development and may be prominent or vestigial.

Other features of Chordates

Blocks of muscle (metameric musculature): These are muscle blocks on either side of the body that surround the notochord and nerve cord.

Triploblastic coelomates: The body structure is made up of three germ layers (layers of embryonic cells) and a well-developed coelom (body cavity).

Bilateral symmetry: The body of chordate is bilaterally symmetrical i.e. if the body is divided into two halves through a central axis; each side is a mirror of the other.

Ventral heart: The heart of chordates is ventrally located with dorsal and ventral blood vessels and a closed blood system.

Limbs: Chordates generally have four appendages that are in the form of legs, arms, wings or fins**.**

Endoskeleton: Chordates have an inner skeleton.

Digestive system: Chordates have a digestive system of stomach and intestine. Food is taken through the mouth which may have a tongue and teeth. (They eat plants and animals).

Nervous system: Chordates have a brain and nervous system. They have the most well-developed brains and complex nervous systems of all the animal phyla.

Respiration: Chordates take in oxygen and get rid of carbon dioxide through lungs or gills.

Reproduction: Chordates reproduce sexually.

Excretion: Chordates get rid of wastes through kidneys and intestine.

3.2 Body Outline of Chordates

The generalised body structure of a typical chordate is given in Figure 1 below:

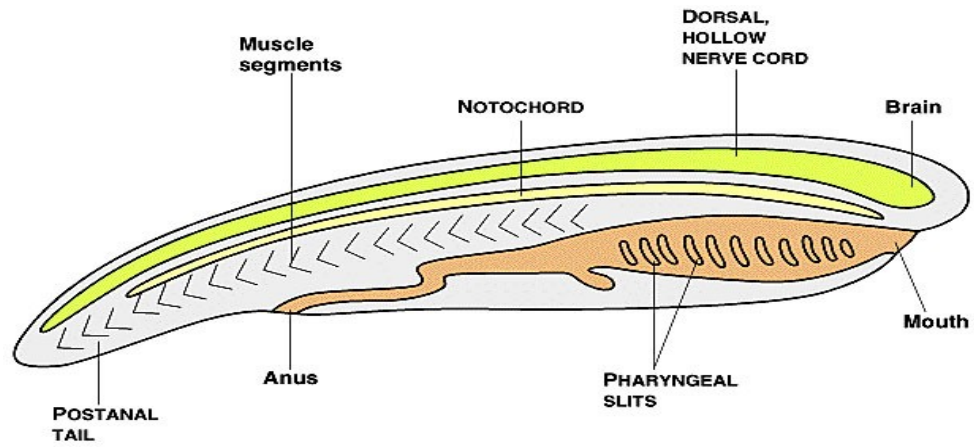

Fig. 1: A Generalised Body Outline of Chordates
Source: www.faculty.evansville.edu/de3/b10802.

As shown in Figure 1 presented above, chordates have four major characteristic features namely, notochord, dorsal nerve cord, post anal tail and pharyngeal slits. These features in their unmodified or modified forms cannot be missed in either the developing or the fully developed stage of a chordate.

4.0 CONCLUSION

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.

5.0 SUMMARY

In this unit, you have learnt about a group of animals called chordates, which included all vertebrates, together with several closely related invertebrates. These animals have the following four primary features that manifest at some stage in their life cycle:

- **A notochord**: A dorsal fairly rigid rod of vacuolated cells, which provides structural support. In vertebrates, it is represented by the backbone.
- **Dorsal nerve cord**: A fluid-filled tube of nerve tissue that runs the length of the animal, dorsal to the notochord. In fish and other vertebrates, the nerve cord is represented by the spinal cord, which is the main communications line of the nervous system.

- **Pharyngeal gill slits**: These are pairs of water-exit openings through the pharynx used in less advanced chordates to trap food particles from the water in which the animals live or for breathing where gills have developed as in fish. In reptiles, birds, and mammals (including humans), the gill slits are vestiges (reduced or no longer functional), occurring only in the embryonic stage.
- **Muscular post-anal tail**: This is the structure that extends backwards from behind the anus. It is that part of the animal behind the anus, which terminates the digestive tract.

6.0 TUTOR-MARKEDASSIGNMENT

i. List the primary features of chordates.
ii. Based on the primary features only, identify and name any five chordates (two must be aquatic) that you come across in your environment. State the visible features that aided your identification.
iii. Study Figure 1 carefully and note the four primary features of chordates. Draw and label the body outline of a generalised chordate.

7.0 REFERENCES/FURTHER READING

Alexander, R. M. (1975). *The Chordates*. Cambridge: Cambridge University Press.

Hickman, C. P., Roberts, L. S. & Larson, A. (1997). *Integrated Principles of Zoology*. London: Win C. Brown Publishers.

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UNIT 2 CLASSIFICATION OF CHORDATES

CONTENTS

1.0 INTRODUCTION

In unit 1, you were introduced to the phylum Chordata by looking at their general features and a generalised body form of the phylum. In this unit, we shall be looking at the component groups that make up the phylum. We shall also examine the subphyla under the phylum Chordata, its classes and their orders. In other words, we shall be looking at the classification of chordates.

The phylum Chordata consists of three subphyla: Urochordata, which is represented by tunicates; Cephalochordata, represented by lancelets and Vertebrata represented by the vertebrates. The fourth subphylum Hemichordata presented by the acorn worms is presently treated as a separate phylum by many authors. In this study however, the subphylum Hemichordata will be treated under the phylum Chordata as was the case previously. This is to broaden the scope of our understanding of the group that was earlier considered as a bridge between the ancestral chordate forms and the present day true chordates starting from the subphylum Urochordata.

In this unit, the hemichordates, urochordates, and cephalochordates therefore form the invertebrate component of the phylum Chordata. Collectively, they are referred to as the protochordates in line with the ancestral/primitive position ascribed to them. In the classification arrangement for the protochordate stated below, we shall limit ourselves to the level of *class* only since the content of our study programme has its focus on the vertebrate component.

2.0 OBJECTIVE

At the end of this unit, you should be able to:

- classify chordates into their various groups and sub-groups.

3.0 MAIN CONTENT

3.1 General Classification of Chordates

The phylum Chordata comprised of four subphyla and each subphylum is comprised of classes. Each class in turn is comprised of orders. As we have highlighted in the introduction above, we shall classify the protochordates to the level of *class* only and attempt to classify the vertebrates a step further down to the level of *order*.

- **Phylum** Chordata
- **Subphylum** Hemichordata (half chordates, currently considered by many authorities as a separate phylum)
- **Subphylum** Urochodata/Tunicata (tail chordates)
- **Subphylum** Cephalochordata (head chordates)
- **Subphylum** Vertebrata (backbone chordates).

As indicated above, 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 urochordates are noted for their tail (uro-) while the cephalochordates show some degree of head (cephalo-) formation. In the vertebrates, the notochord has been replaced by a true backbone/vertebral column, made up of either cartilage or bone.

We shall now examine the various subgroups in each subphylum.

Subphylum	Hemichordata (half chordates)
Class	Enteropneusta (acorn worms)
Class	Planctosphaeroidea (extinct)
Class	Pterobranchia (*Cephalodiscus)*
Subphylum	Urochordata (tail chordates)
Class	Ascidiacea (sea squirts)
Class	Thaliacea (salps)
Class	Larvacea (Appendicularia)
Subphylum	Cephalochordata (tail chordate)
Class	Leptocardii (Leptocardia)

The three invertebrate subphyla (Hemichordata, Urochordata, Cephalochordata) mentioned above are collectively called protochordates because they are considered to be the ancestral stock of the chordates. In other words, they represent the primitive form of chordates.

We shall now look at the classification of the subphylum Vertebrata and the subgroups under it. In the class mammalia, only the major orders will be highlighted.

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).

The classification of the chordates presented above is the traditional form and is the most common that you would find in text books; it is based on gross anatomical and physiological traits that is, individual inherited characteristics, and not phylogenetics. You must note that the subject of classification generally, including that of vertebrates is dynamic and often in a state of flux; continuously changing.

As shown above, two superclasses namely Agnatha (jawless vertebrates) and Gnathostomata (jawed vertebrates) emerged from the subphylum Vertebrata. The Gnathostomata are grouped into two based on the diversity of their habits, form and structure. These include the fishes also known as Pisces (Placodermi, Chondrichthyes and Osteichthyes) and the tetrapods i.e. animals with four limbs (Amphibia, Reptilia, Aves and Mammalia).

The vast majority of chordates have a skull enclosing sensory organs such as the brain, eyes, inner ear, etc. and hence the name Craniata. All craniates, with the exception of one group i.e. the hagfishes; have their notochord modified into a vertebral column or backbone. So while the hagfishes have a cartilaginous skull, they however lack a backbone. That explains why some authors prefer to name the Subphyla, Craniata from which Vertebrata emerges as a superclass.

Based on the classification above, the jawless agnathans are considered as the ancestors of the jawed vertebrates; the cartilaginous fishes (Chondrichthyes) gave rise to the bony fishes (Osteichthyes), which in turn are said to have given rise to the land/terrestrial vertebrates. On land, the amphibians gave rise to the reptiles and the reptiles in turn gave rise to both birds and mammals.

The amphibians, reptiles, birds and mammals are referred to as tetrapods on account of having four limbs. The reptiles and mammals are referred to as amniota because they have an amniotic membrane. So you may find in some texts that classification goes to some extent along the said arrangement.

4.0 CONCLUSION

Chordates are a diverse group of animals comprising invertebrate and vertebrate forms, which are classified into four subphyla namely: Urochodata (tail chordates), Cephalochordata (head chordates) and Vertebrata (backbone chordates). Hemichordata (half chordates, currently considered as a separate phylum),

5.0 SUMMARY

The phylum Chordata is comprised of three subphyla namely, Urochodata, Cephalochordata and Vertebrata. Hemichordata (half chordates) is currently placed as a separate phylum but included in this study in order to broaden your knowledge of what constituted the half chordates. The Urochordata (tail chordates) is made of three classes namely; Ascidiacea, Thaliacea and Larvacea (Appendicularia). The subphylum Cephalochordata (tail chordate) is quite unique in that it has one class – the Leptocardii. The subphylum Vertebrata is comprised of two superclasses namely Agnatha (jawless fish) and Gnathostomata (jawed vertebrates). Agnatha has only one living class - Cyclostomata (lampreys and hagfishes). On the other hand, Gnathostomata is comprised of six classes namely Chondrichthyes (cartilaginous fish), Osteichthyes (bony fish), Amphibia, Reptilia, Aves (birds), and Mammalia.

6.0 TUTOR-MARKED ASSIGNMENT

i. Attempt to classify chordates to subphylum. How many subphyla are there?

ii. Classify the phylum to the level of living superclass/class/infraclass. Do so repeatedly until you are able to classify chordates to that level without any errors.

7.0 REFERENCES/FURTHER READING

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www.en.wikipedia.org/wiki/Chordate.

UNIT 3 HEMICHORDATA

CONTENTS

1.0 INTRODUCTION

In the previous units, we described the hemichordates as half chordates because of the primitive nature of their notochord. That explains why they are excluded from the Phylum Chordata by most authors/taxonomists. However, following the traditional classification, we have included the group amongst the protochordates (i.e. the Hemichordata, Urochordata and Cephalochordata). In this unit, we shall be describing the characteristics of the hemichordates. To aid your understanding of the study, the description of the characteristics of this group of animals shall follow the classification pattern presented in unit 2 of this module. In this respect, we shall describe the subphylum Hemichordata and its two extant (living/existing) classes.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- describe the characteristic features of hemichordates
- distinguish members of the subphylum from other protochordates.

3.0 MAIN CONTENT

3.1 Characteristics of the Subphylum Hemichordata

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.

As we have described above, the hemichordates are distinguished by a tripartite (three parts) division of the body. At the anterior end of the body is a proboscis (pre-oral lobe); behind this are a collar, and lastly a trunk. The hemichordates share some (but not all) of the typical chordate characteristics. They have bronchial openings, or "gill slits," that open into the pharynx; there is a rudimentary structure in the collar region called the stomochord, or a diverticulum (blind sac) that is made up of cells that resemble those found in the notochord but which is not a true notochord. There is a dorsal nerve cord, in addition to a smaller ventral nerve cord. This incompleteness especially on the structure of the notochord accounted for their removal from the true chordates, although they are quite closely related. Indeed, some DNA-based studies of evolution suggest that hemichordates are actually closer to echinoderms than to true chordates. This is supported by the fact that the larvae of at least some hemichordates look very much like those of some echinoderms.

3.2 Characteristics of the Class Enteropneusta (Acorn worms)

The enteropneusts comprised the majority of the hemichordates with more than 70 species. They are the typical acorn worms and very well fit the description of hemichordates above. They have the following characteristics:

Body is divided into three sections - a proboscis, a collar and a trunk (see Figure 2)

- multiple bronchial openings, as many as 200 in some species
- gaseous exchange occurs over the whole body as well as in the pharyngeal slits

- reproduction is normally sexual involving the two opposite sexes and egg fertilisation. However, reproduction can occur as a result of fragmentation of the adult body.
- they live in burrows in the substrate (mud or fine sand) or under rocks, in both shallow and deeper waters
- feeding is either substrate eating or filter feeding.

Enteropneusta (acorn worms) are 2 to 2.5m long; marine in shallow waters, solitary, live in mud or vegetation; filter-feeders. They have well-developed gill slits, and a stomochord. They also have a dorsal strand of nerve cells, believed to be the precursor to the dorsal hollow nerve cord. The enteropneustes are slow burrowers. They use their proboscis to burrow through sediment. Substrate eaters like *Balanoglossus* consume large amounts of mud and or sand and digest out the organic matter within it. They deposit their wastes on the surface just like we see the earthworms do. Their burrows may have several openings at one end. They seldom leave their burrows. The filter feeders have mucous secreting glands and numerous cilia on their proboscis. The proboscis is held out of the burrow entrance and organic particles are caught in the mucous and then swept to the mouth by the beating of the cilia. These species can cover their mouth with their collar and thus avoid eating inorganic or any undesirable materials.

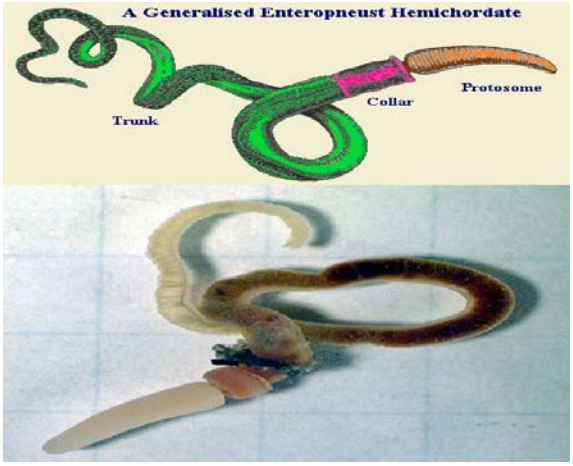

Fig. 2: Typical Enteropneustic Hemichordate (left and right) showing the Basic Body Features: **Proboscis/Protosome** (in which the notochord is encased), Collar and Trunk/Body.
(Note**:** the colours in the image on the left do not represent the real colour of the animal, but are used to emphasize the different body sections).
Source:www.earthlife.net/inverts/hemichordata.html and www.faculty.clintoncc.suny.edu/.

3.3 Characteristics of the Class Pterobranchia

The class is characterised by the following features:

- proboscis is modified into a shield (see Figure 3).
- collar is modified to produce between 1 and 9 pairs of tentacles or lophophore arms with double row of smaller ciliated tentacles (see Figure 3 below)
- trunk is short and sac-like rather than being long and thin (see Figure 3 below)
- asexual reproduction is by budding and is common and often gives rise to colonies starting from a single individual. Sexual reproduction is by the normal method of reproduction as in the enteropneusts with external fertilisation.
- One or no pharyngeal slits
- Protein collagen tube structure houses the organism.

Pterobranchia (pterobranchs) are tiny, deep-sea, colonial, moss-like animals. There is no trace of a dorsal nerve cord or notochord; only one pair of gill slits in species of the genus *Cephalodiscus.* The pterobranchs are an obscure group of animals, which unlike the acorn worms; form colonies in which the individuals are interconnected by stems, or stolons. The individuals or zooids are generally small often less than 1 mm long. The proboscis is not elongated, as in acorn worms, but shield-shaped. The collar bears a pair of branched tentacles that collect small food particles from the water. Most strikingly, almost in all pterobranch species, special glands in the proboscis secrete a collagen material from which a tube casing is made to house the animal (Figure 3 below). The proboscis is also used as an organ of locomotion (just the way a snail uses its foot), both for movement inside and outside the burrow. The tentacles secrete mucus which is driven, along with the food particles trapped in it to the mouth, by the beating of the cilia. The mucus and the accompanying food particles are then digested in the U-shaped digestive tract. The animal's anus is on the animal's back approximately opposite the animal's mouth.

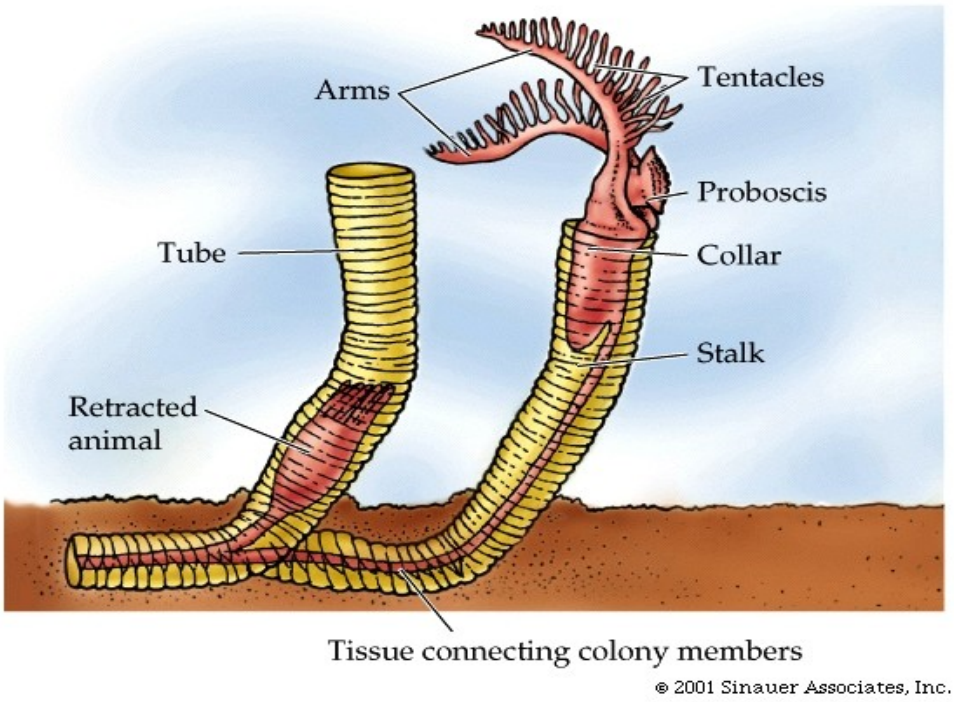

Fig. 3: A Typical Pterobranch - *Rhabdopleura*.

Note that the modified shield-like proboscis, collar bearing a pair of tentacles and the short sac-like trunk. The animal can retract into a tube casing as snails do)
Source: http://bill.srnr.arizona.edu/classes/182/LophTer.jpg

4.0 CONCLUSION

Hemichordates are primitive chordates that live in marine environment. Their body is divided into three sections - proboscis, collar and trunk.

5.0 SUMMARY

In this unit, we have described the hemichordate as a group of primitive chordates on account of their stomochord (primitive notochord) that is restricted to the proboscis only. Their body is divided into three sections viz: proboscis, collar and trunk. Hemichordates are represented by two living classes: Enteropneusta (acorn worms) and Pterobranchia. The third class Planctosphaeroidea is extinct. The enteropneustes are slow mud burrowers that have well-developed gill slits, a stomochord and a dorsal strand of nerve cells, believed to be the precursor to the dorsal hollow nerve cord. The Pterobranchia (pterobranchs) are colonial, moss-like animals showing no trace of a dorsal nerve cord or notochord, and only one pair of gill slits in species of the genus *Cephalodiscus*. Body colonies are interconnected by stems, or stolons. The proboscis is not elongated, as it is in acorn worms, but shield-shaped. The collar bears a

pair of branched tentacles that collect small food particles from water. In most pterobranch species, special glands in the proboscis secrete a collagenous material from which the tube casing, housing the animal is made.

6.0 TUTOR-MARKED ASSIGNMENT

i. Give why hemichordates are considered half/primitive chordates
ii. Describe the basic body structure of hemichordates and show by way of a diagram.

7.0 REFERENCES/FURTHER READING

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Hickman, C. P., Roberts, L. S. & Larson, A. (1997). *Integrated Principles of Zoology.* London: Win C. Brown Publishers.

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http://bill.srnr.arizona.edu/classes/182/LophTer.jpg

http://www.earthlife.net/inverts/hemichordata.html

http://www.ucmp.berkeley.edu/chordata/hemichordata.html

UNIT 4 UROCHORDATA

*C*ONTENTS

1.0 INTRODUCTION

This unit focuses on the urochordates - the tail chordates. They represent the most primitive of the true chordate. In other words, they are the most advanced amongst the protochordates i.e. they are more advanced than the cephalochordates and hemichordates; you would recall that we described the hemichordates as half chordates.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- enumerate the characteristics and describe the urochordates/tunicates.
- have a mental picture of what the urochordates look like.

3.0 MAIN CONTENT

3.1 Characteristics of the Subphylum Urochordata (Tunicata)

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
- **n**o 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.

Urochordates are a medium sized group of marine animals commonly referred to as Sea squirts, Tunicates, Salps or Larvaceans. They are all filter feeders using a basically similar mechanism of pumping water through a perforated pharynx, which collects small particles in a layer of mucus. All the urochordates have an external covering or 'house' called the tunic, which is made of secreted proteins and a polysaccharide much like cellulose. In some cases, this matrix contains living cells that have migrated from the main body of the animal, and even sometimes blood vessels. The animal lives within its ‘house’ permanently in most cases. The 'houses' of the larvaceans are less substantial as new ones are secreted every four hours or so. Although the urochordates are close relatives of the chordates and also of vertebrates such as mammals, they seem to be far less like vertebrates than many of the other invertebrate phyla; i.e. they have no limbs, no brain and except in the larvaceans, the tail is only evident during larval development.

The subphylum is divided into three classes namely: Ascidiacea, Thaliacea and Larvacea.

3.1.1 Characteristics of the Class Ascidiacea

This class is represented by the Sea squirts and they make up the bulk of the species found within the phylum Urochordata.

The class Ascidiacea has the following characteristics:

- notochord and post-anal tail found in the larval stage only (see Figures 4 and 5 below).
- tadpole-like larvae metamorphose into adults
- sessile (non-moving or staying in one place) adults

- marine habitat - most species are common coastal animals occurring in rock pools and out into deeper water to about 400-5,000 m in depth
- solitary or colonial - the colonial species may share a common exhalent siphon.
- translucent or whitish body colour (see Figure 6 below) but some species are much more colourful and can be red, brown, yellow and even blue
- tunic composed mostly of an acellular (not made of cells) matrix of tunicin, a polysaccharide similar to cellulose (there are some living cells of various sorts within this matrix but they are well spaced out)
- pharynx has numerous small pores or slits in its walls for the passage of water
- two openings, an inhalant siphon (where water comes in) and an exhalent siphon (where water goes out)
- hermaphroditic - male and female reproductive organs in each individual
- filter feeders.

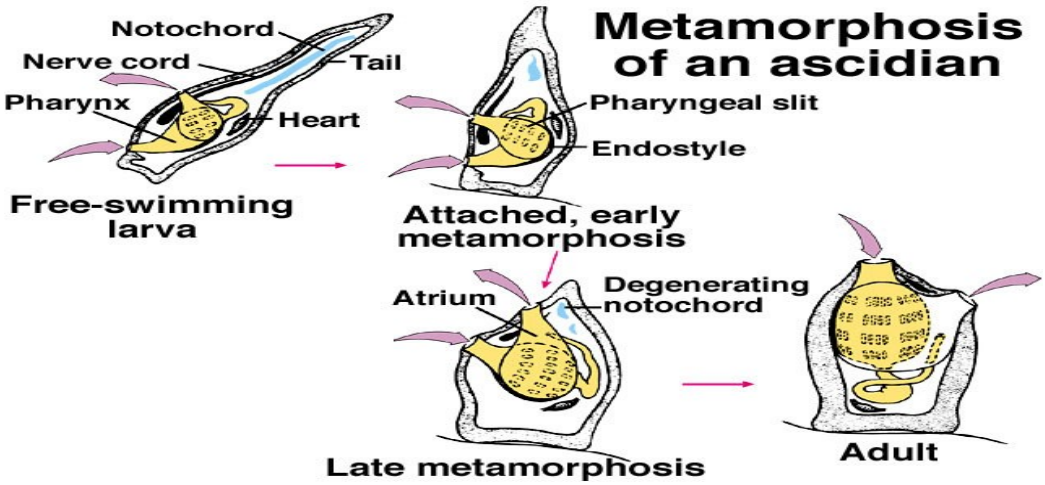

Fig. 4: Life Cycle of Ascidians

Note that the notochord and the tail in the free swimming larva gradually disappear as the animal metamorphoses to the adult stage.

Source: www.faculty.evansville.edu/de3/b10802/: 16th Aug., 2009

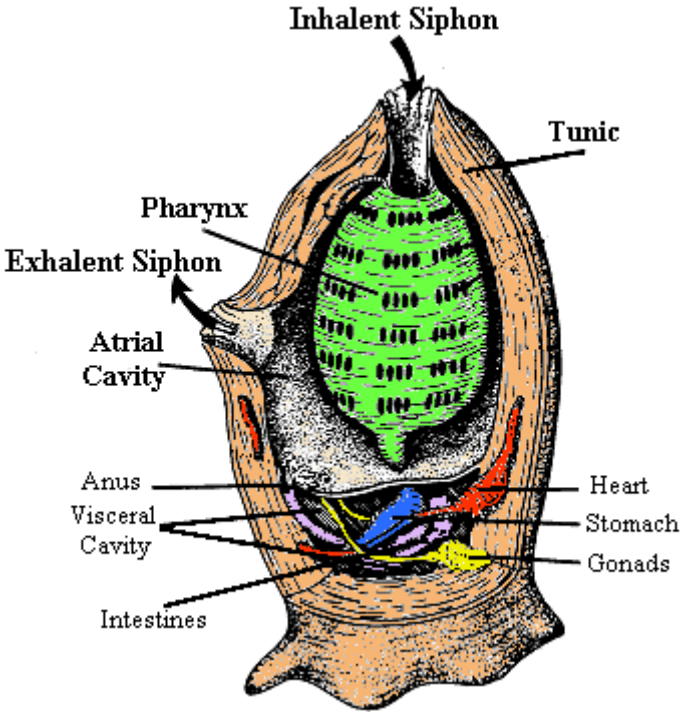

Fig. 5: Anatomy of an Adult Ascidian/Tunicate

Note the absence of the notochord and the tail, the pharynx and the numerous gill slits. The animal is encased in a tunic.

Source: http://www.earthlife.net/inverts/ascidiacea.html

Fig .6: White Colony of Sea Squirts

Such a colony usually has a common exhalent siphon. The inhalant siphons are very visible.

Source: http://www.fotosearch.com/PHD547/aa032112/

The name tunicate arises from the existence of the tunic (external covering or 'house') while Sea squirt arise from the fact that when squeezed, water shoots out of the exhalent siphon. The larvae swim

towards light at the surface of the sea at first then after a short while they reverse direction and swim down towards the sea floor, often in less than one day. Tunicate larvae do not feed and are essentially a dispersal form. They soon find a suitable spot on the sea floor and settle in a head down, tail up position. They attach themselves to the sea floor (substrate) using special adhesive glands in the front of their head and then undergo an amazing metamorphosis during which the post-anal tail and the notochord are lost. The remainder of the body twists through 180 degrees to form a small tunicate. Tunicates feed by drawing water in through the inhalant siphon. This water passes through the pharynx where small particles are trapped before the water leaves the body through the exhalent siphon. The water current is maintained by beating cilia, though they can force water out of the atrial cavity by muscular contraction of the tunic, if frightened. The small particles, plankton and so on, are trapped on a continually moving layer of mucous. This mucous is secreted by special cells and is moved across the surface of the pharynx by the beating of many small cilia, eventually it is passed in the digestive tract where both the particles and it caught up in it are digested.

3.1.2 Characteristics of the Class Thaliacea (salps)

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 chain-like colonies.

The class contains about 70 species. Filter feeding has to do with drawing current of water in through their inhalant siphon and out through the exhalant/exhalent siphon. Between the two siphons, the water passes through the many pore or slats of the enlarged pharynx which occupies most of the body cavity. The water current is driven by beating cilia. Small particles of plankton are collected on a film of mucus which continuously passes across the pharynx. This mucus is secreted by special cells and is kept moving by the beating of numerous small cilia until it is swept into the digestive tract. Salps belong to the same group as sea squirts (tunicates or urochordates). Although they may not look it, salps are among the most advanced invertebrates in the sea and are closely related to vertebrates (animals with backbones).

Fig. .7: **Salp (see the barrel-like body) Source**: Peter Parks © 2001 by Image Quest 3-D http://beyond.australianmuseum. net.au/holoplankton/ holoplankton04.htm&h

3.1.3 Characteristics of the Class Larvacea (Apendicularia)

The Larvaceans, sometimes called the apendicularians, are small animals and are quite different in form to the rest of the Urochordata. They have the following features:

- 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
- their larva like that of tunicates - metamorphoses to adult
- they secrete a gelatinous 'house' that encases the trunk or body, but not the tail
- the tail has muscle cells attached to it and is used for swimming.

Fig. 8: A Typical Larvacean with a Tadpole Appearance showing the Gelatinous 'House' Encasing the trunk or body, but not the tail
Note: At times, this tiny pelagic (open sea) tunicate can be among the more abundant gelatinous animals in offshore waters, but most people have no idea of its presence. The colour and density of the house are the same as sea water and hence difficult to be seen.
Source: David Wrobel: http://jellieszone.com/oikopleura.htm

4.0 CONCLUSION

The larvaceans are small marine chordates with a tadpole appearance and with the tunicate housing only the trunk but not the tail.

5.0 SUMMARY

The larvaceans are urochordates that have the following characteristics:

- lanktonic - mass of floating organisms
- body consists of an oval trunk and a relatively long thin tail that houses the notochord throughout life of the animal
- only the trunk is encased in a tunicate (the gelatinous 'house').

6.0 TUTOR-MARKED ASSIGNMENT

i. Attempt to draw a diagram of a typical larvacean.
ii. What is it that distinguishes the larval and adult stages of the larvacean from that of other urochordates?

7.0 REFERENCES/FURTHER READING

Alexander, R. M. (1975). *The Chordates.* Cambridge: Cambridge University Press.

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http://www.fotosearch.com/PHD547/aa032112/

http://www.earthlife.net/inverts/ascidiacea.html

http://www.faculty.evansville.edu/de3/b10802/

UNIT 5 CEPHALOCHORDATA

CONTENTS

1.0 INTRODUCTION

In this unit, we shall be looking at a group of marine protochordates –the cephalochordates. The cephalochordates are the most advanced protochordates, clearly showing the four primary features of chordates (notochord, dorsal nerve cord, pharyngeal gill slits and post anal tail) throughout their life. They are the closest to the vertebrates.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- describe the features of cephalochordates
- distinguish the cephalochordates from other protochordates.

3.0 MAIN CONTENT

3.1 Characteristics of the Subphylum Cephalochordata (Amphioxus or Sea lancelets e.g. *Branchiostoma*)

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)
- no normal vertebrate endoskeleton

- external fertilisation
- some metamerism (body segmentation) in the musculature
- no heart
- use haemocyanin pigment (no haemoglobin)
- closed blood circulatory system.

The subphylum Cephalochordata is usually represented by one organism *Branchiostoma* commonly called Amphioxus (which means "sharp at both ends") or lancelets. Cephalochordates are like vertebrates in having the derived feature of an elongated body as adults, but are still (primitively) filter feeders; that is, they feed while motionless, moving food-laden water by means of cilia on their gill bars.

Amphioxus is 51-76 mm (2-3 in) in length and whitish to creamy yellow, sometimes with a tint of pink. It lives on seashores throughout the temperate zone. Amphioxus shows some cephalisation, in that the primary feeding structures are concentrated at the anterior end, and it has a light sensitive pigment spot on the anterior end that may be used for orienting it toward light.

Amphioxus is fish-like in appearance but without eyes. It has a laterally compressed dorsal fin.

There are about 25 species of cephalochordates inhabiting shallow tropical and temperate oceans; they spend much of their time buried in the sand of ocean beds.

Lancelets have a notochord - a flexible rod of cells supporting the body. The rest of the skeleton is made up of small, flexible rods between the gill slits and supporting the mouth bristles. A dorsal nerve cord runs along the top of the notochord. They have blood vessels but no heart. The pharynx is perforated by over 100 pharyngeal slits or "gill slits", which are used to strain food particles out of the water. The musculature of the body is divided up into V-shaped blocks or myotomes, and there is a post-anal tail (see Figure .9 below). All of these features are shared with vertebrates. On the other hand, cephalochordates lack features found in most or all true vertebrates; the brain is very small and poorly developed and the sense organs are also poorly developed, and there are no true vertebrae (bone in spinal column).

Class: Leptocardii/Leptocardia (small heart).

- No true heart. Heart is represented only by a simple pulsating vessel.
- The blood is colorless
- No brain, renal organs, and limbs.

- Backbone is represented only by a simple, unsegmented notochord.

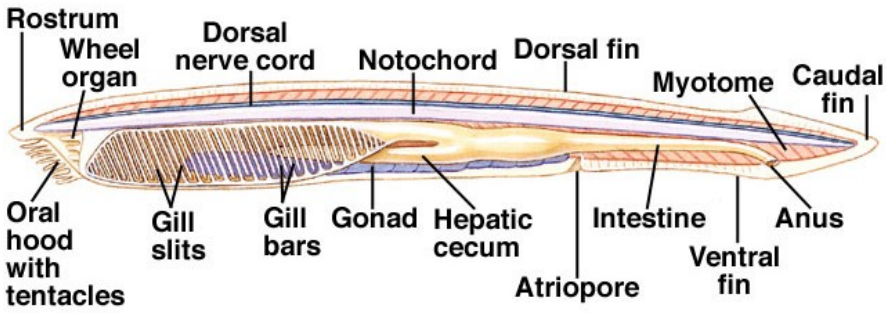

Fig. 9: Anatomy of the Cephalochordate *Amphioxus*
(see the notochord and the dorsal nerve cord stretching the whole length of the animal. See also the gill slits and the post-anal tail. These primary chordate features remain through the life of the animal).
Source: www.faculty.evansville.edu/de3/b10802/: 16th Aug., 2009

Fig. 10: Cephalochordate showing Body Metamerism (segmentation) in the Musculature
Source: www.faculty.evansville.edu/de3/b10802/: 16th Aug., 2009

4.0 CONCLUSION

Cephalochordates are the most advanced protochordates showing all the primary chordate features namely a notochord, dorsal nerve cord, pharyngeal gill slits and post-anal tail.

5.0 SUMMARY

The subphylum Cephalochordata is comprised of small marine organisms that exhibit the basic chordate features throughout their life. They have a well-defined notochord, numerous gill slits, dorsal nerve

cord and post-anal tail. They exhibit well-defined body segmentation and cephalisation.

6.0 TUTOR-MARKED ASSIGNMENT

i. State the characteristic features of cephalochordates.
ii. Give reasons these animals are called cephalochordates?
iii. The cephalochordates, like other protochordates, are marine organisms and are not easy to come by. You are therefore not in a position to have samples that you could see or handle. Therefore, like in previous exercises, take a careful look at Figure 9 above. Take note of the four primary features of chordates in it. Close your book or the page you are on and attempt to draw and label the figure of the body outline of a cephalochordate. Thereafter, assess yourself to see if your diagram and labelling were correct. If not, repeat the exercise until you get it right. Compare the said figure and that of the generalised chordate in Figure 1 of unit 1 above. What conclusions can you draw of the cephalochordates in this regard?

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http://www.faculty.clintoncc.suny.edu/.

MODULE 2 VERTEBRATE CHORDATES (I)

UNIT 1 VERTEBRATA

CONTENTS

1.0 INTRODUCTION

In module 1, we discussed the ancestral chordates called the protochordates, comprising the Hemichordata, Urochodata and the Cephalochodata. You will recall that the major structural support of this group of animals (protochordates) is the notochord, which manifests at some stage or throughout their life. In this module, we shall be looking at the characteristic features of the advanced chordates – the vertebrates. You will also recall that we said that a major departure of the vertebrates from their ancestral stock was the replacement of the notochord with a vertebral column (the backbone) from which the name of the subphylum is derived. The vertebral column may be cartilaginous in nature as is the case in some fishes or bony as in most vertebrates. Unlike the protochordates, vertebrates are the ones we oftentimes come across more or less on a daily basis. Indeed, in most homes, some of these animals are part of the family. Such animals include dogs, cats, horses, chickens, pigeons, etc. It must be emphasised that we humans are chordates.

In describing the characteristic features of the vertebrates, we shall again follow the pattern we adopted for the protochordates by following the classification outline that was presented earlier in module 1, unit 2. In this unit, we shall describe the subphylum Vertebrata in general and go further to consider one of the three superclasses (Agnatha) and the two classes (Cyclostomata, Ostracodermi) in the superclass.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- recognise and describe vertebrates by their basic characteristic features
- assign vertebrates to their various groups.

3.0 MAIN CONTENT

3.1 Characteristics of the Subphylum Vertebrata

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

Basic 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.

Other features

- 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.
- Variety of feeding strategies: 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.

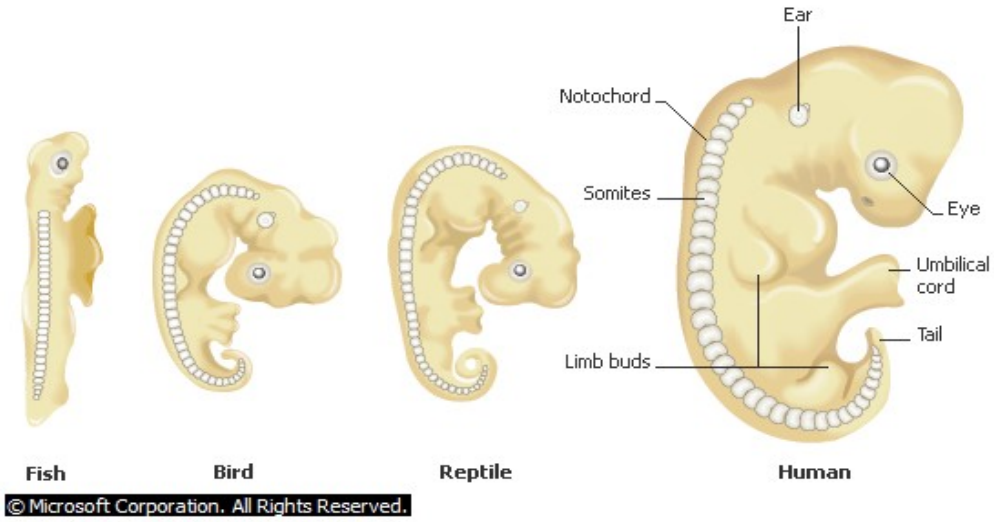

Fig.1: Vertebrate Embryos
Source**:** Microsoft ® Encarta ® 2009. © 1993-2008 Microsoft Corporation.

Vertebrates that evolved from fish pass through similar embryonic stages. A flexible notochord develops in the back and blocks of tissue called somites form along each side of it. These somites will become major structures, such as muscle, vertebrae, connective tissue, and, later, the larger glands of the body. Just above the notochord lies a hollow nerve cord.

3.1.1 Characteristics of the Superclass Agnatha

Members of the superclass have the following features:

- lack jaws hence the name agnatha (without jaw)
- vertebral spine is cartilaginous in nature
- head with a cranium that encases a brain
- mouth is generally round/ circular
- no scales or exoskeleton.

3.1.1.1 Characteristics of the Class Cyclostomata (lampreys and hagfishes)

The class cyclostomata derived its name by having a round or circular mouth. The class is characterised by the following features:

- 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.

The cyclostomes are very unique among vertebrates because of their semi-parasitic nature. The lampreys, with the exception of some small freshwater forms, attach themselves to other fishes using their suctorial mouth and then rasp off the flesh by means of the horny teeth carried by the highly-developed tongue. The hagfishes are capable of boring their way right into the body of their prey, devouring all the soft parts and leaving the skin behind as an ordinary empty shell, held by the bones. In large numbers, lampreys can cause great damage to fisheries especially fishes caught by hooks or nets as they eat up their flesh leaving them as empty shells as described above.

The class Cyclostomata consists of two orders: Petromyzontia (or Hyperoartii) and the Myxinoidea (or Hyperotreti).

Order: Petromyzontia (or Hyperoartii). E.g. lampreys - *Petromyzon marinus.*

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.

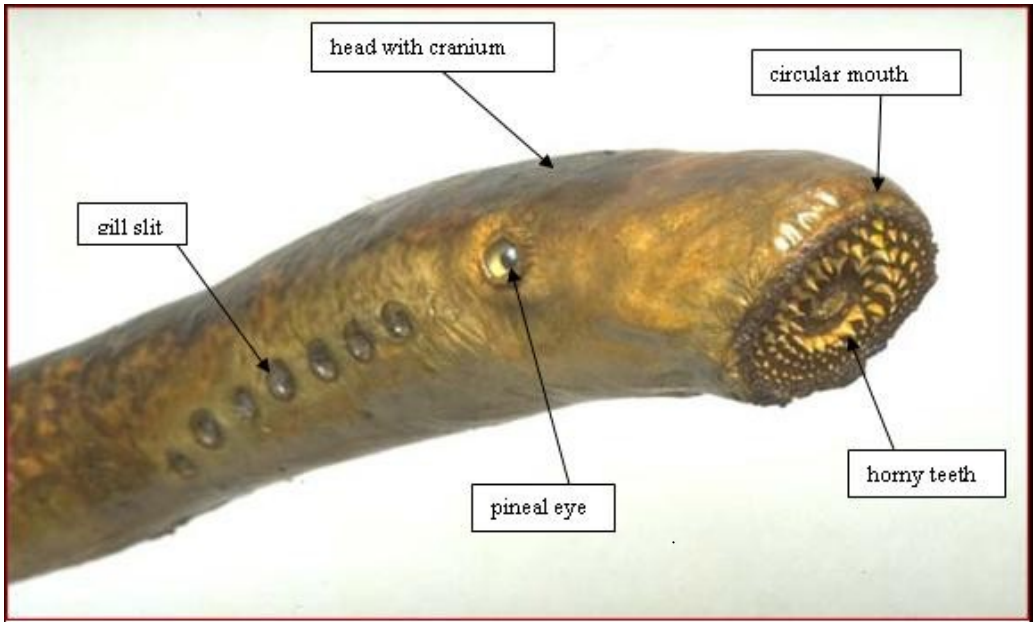

Fig. 2. A Cyclostome - Sea Lamprey

Note the circular mouth with horny teeth, head with cranium, pineal eyes and seven gill slits; modified by labeling.

Source: http://paxarcana.files.wordpress.com/2008/11/sea_lamprey.jpg
Order: Myxinoidea (or Hyperotreti) e.g. hagfishes- *Bdellostoma* and *Myxine* spp.

The hagfishes are characterised by the following features:

- circular mouth fitted with rasping tongue surrounded by short tentacles (see Figure 3)
- 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
- scaleless body
- many mucous glands present for anti-predator defense
- unsupported fin rays.

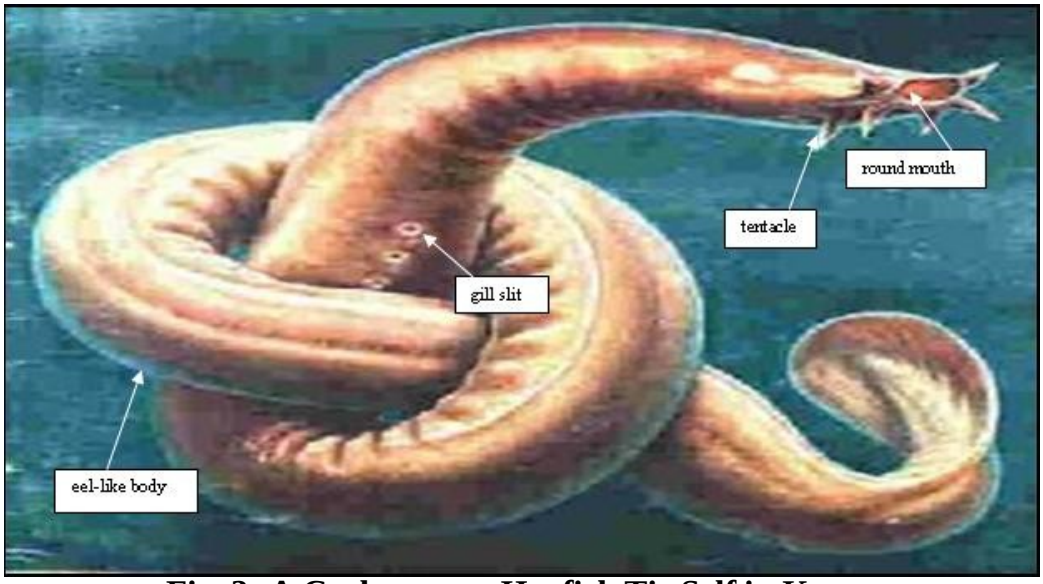

Fig. 3: A Cyclostome - Hagfish Tie Self in Knot

(see mouth with tentacle and gill pouches, elongate and scaleless body): (modified by labelling)
Source**:** http://en.wikipedia.org/wiki/Agnatha (Acessed 9th February, 2012)

3.1.1.2 Characteristics of the Class Ostracodermi (Extinct)

This class is extinct but had the following characteristics:

- 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.

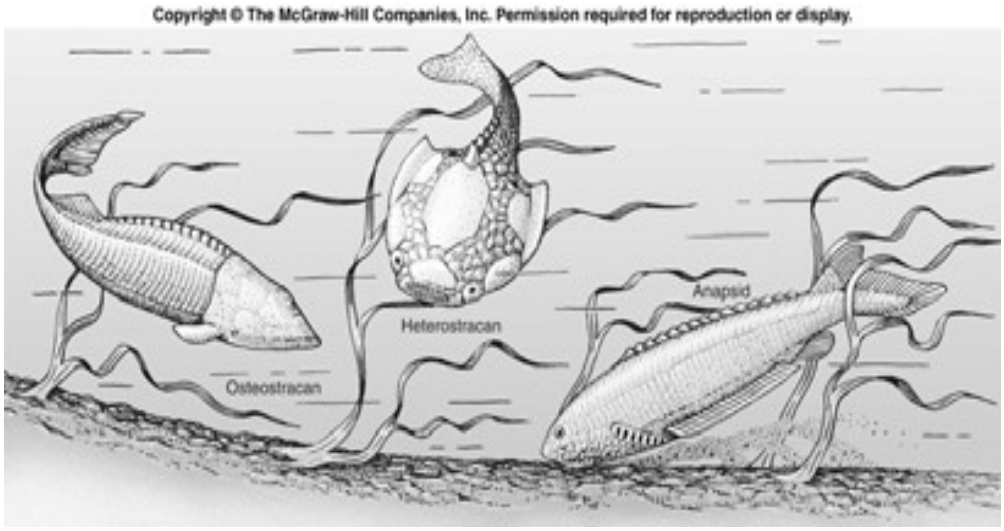

Fig. 4: The **Three Types of Ostracoderms**
Source**:** www.itech.pjc.edu/rthrasher/accessed.

4.0 CONCLUSION

Vertebrates are chordates with a well defined backbone (cartilaginous or bony), complex brain encased by a cranium, well developed head (cephalisation) with advanced nervous and sensory structures, and two pairs of appendages (1 pair of pectoral and 1 pair of pelvic appendages).

5.0 SUMMARY

We have described vertebrates as advanced chordates with the following characteristics:

- well-defined backbone (cartilaginous or bony)
- complex brain encased by a cranium
- well-developed head with advanced nervous and sensory structures
- two pairs of appendages (1 pair of pectoral and 1 pair of pelvic appendages)
- true body cavity – the coelom
- males and females are separate and distinct
- gill slits are few, when present
- variety of feeding strategies: herbivores, carnivores, omnivores, filter feeders, parasites
- well-developed ventral heart with 2-4 chambers
- closed circulatory system with hemoglobin as 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.

Similarly, we described the vertebrate superclass - Agnatha with the following features:

- lack jaws hence the name agnatha (without jaw)
- vertebral spine is cartilaginous in nature
- head with a cranium that encases a brain
- mouth is generally round/ circular (cyclostomata)
- no body scales or exoskeleton.

6.0 TUTOR-MARKED ASSIGNMENT

i. Now that you have learned about vertebrates, take a walk around your home, office, school etc and look out for animals that fit the description of vertebrates. Name each and state against it any characteristic features of vertebrates.

ii. Why are you not likely to see members of the superclass Agnatha around you?

7.0 REFERENCES/FURTHER READING

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http://paxarcana.files.wordpress.com/2008/11/sea_lamprey.jpg

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www.itech.pjc.edu/rthrasher/.

UNIT 2 GNATHOSTOMATA

CONTENTS

1.0 INTRODUCTION

In unit 1 of this Module, we described the Superclass Agnatha as chordates without jaws. In this unit and subsequent ones, we shall be introducing you to a diverse group of vertebrates under the superclass Gnathostomata, which contains vertebrates with jaws. Human, fish, dogs, cows, goats, cats and other vertebrates we see most often, have jaws; human and these animals are therefore gnathostomes. We shall therefore be examining a complex yet exciting group of animals that we consume as food, keep as pets, exploit for services or view as wild animals, etc. Our starting point is the fishes, which we all know dwell in water.

2.0 OBJECTIVE

At the end of this unit, you should be able to:

- describe the vertebrates with jaws i.e. the superclass Gnathostomata and its classes.

3.0 MAIN CONTENT

3.1 Characteristic of the Superclass Gnathostomata (jaw-bearing animals)

Gnathostomes are characterised by:

- a vertically biting device called jaws (primitively made up of two endoskeletal elements, the palatoquadrate and Meckelian cartilage, and a number of dermal elements called teeth, sometimes attached to large dermal bones)
- paired appendages (paired pectoral and pelvic fins) supported by an internal skeleton, which supports more efficient locomotion
- interventrals and basiventrals in the backbone. These are the elements of the backbone, which lie under the notochord, and match the basidorsals and interdorsals respectively.
- gill arches, which support/hold the gills, lie internally to the gills and branchial blood vessels, unlike the gill arches of all jawless craniates, which are external to the gills and blood vessels
- a horizontal semicircular canal in the inner ear
- teeth - modified dermal scales
- paired nasal sacs.

The Gnathostomata or gnathostomes differ from all other craniates or vertebrates in having a vertically biting device, the jaws, which consist of an endoskeletal mandibular arch and a variety of exoskeletal grasping, crushing, or shearing organs, i.e. the teeth, and jaw bones. The gnathostomes include sharks, rays, chimaeras, ray-finned fishes, lobe-finned fishes and land vertebrates including humans.

3.1.1 Characteristics of the Class Placodermi (Extinct)

The class Placodermi is regarded as the first set of fish with jaws but are now extinct.

The members of this class had the following characteristics:

- well-developed fins and armour plating (see Figure 4)
- dermal armour consisting of head armour and thoracic armour. In the thoracic armour, the foremost dermal plates form a complete "ring" around the body and always include at least one median dorsal plate (see Figure .5 below).
- inhabit both freshwater and marine environment
- bottom dwellers.
- large size (up to 10 m)

- lower jaw and teeth present
- scavengers or predators.

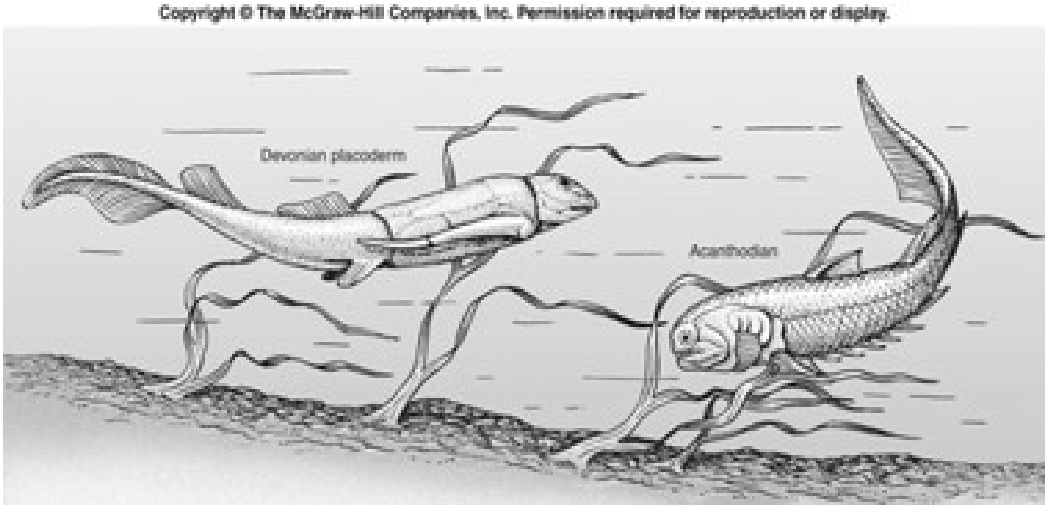

Fig. 4: A Typical Outlook of Placorderms
Source: www.itech.pjc.edu/rthrasher/ (Accessed 17th Aug. 2009)

3.1.2 Characteristics of the Class Chondrichthyes (Cartilaginous 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.

The class Chondrichthyes is divided into two extant subclasses:

Subclass: Elasmobranchii (sharks, rays and skates)
Subclass: Holocephali (chimaera, sometimes called ghost sharks).
Members of the class Chondrichthyes have a backbone that is made of cartilage. They are they not the fishes you come across often because of their marine.

3.1.3 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 Osteichthyes are characterised by endochondral ("spongy") bone in the endoskeleton, dermal fin rays made up by lepidotrichiae (modified, tile-shaped scales), and three pairs of tooth-bearing dermal bones lining the jaws (dentary, premaxillary and maxillary). The Osteichthyes include two major subclasses, the Actinopterygii and the Sarcopterygii.

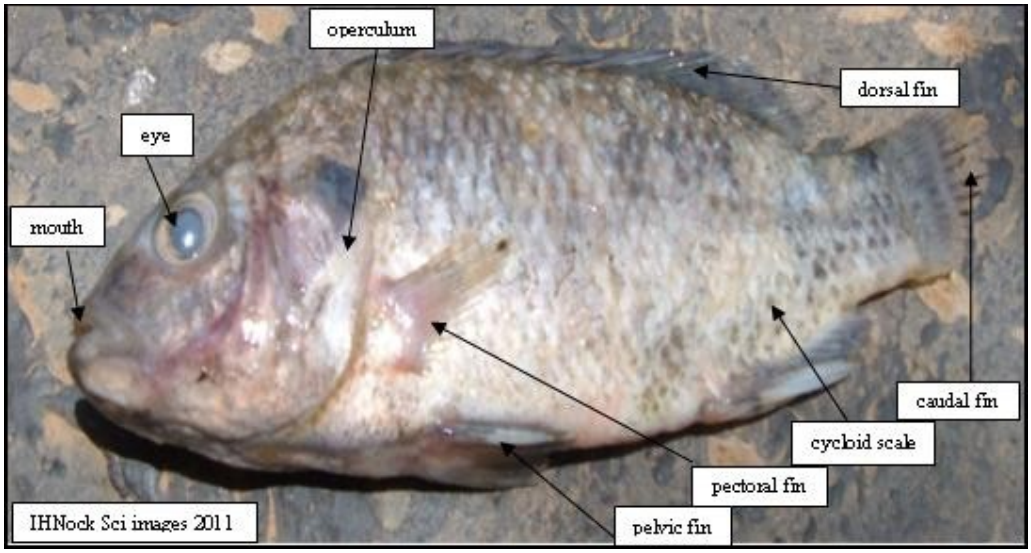

Fig. 5: Typical Tilapia Fish (see the cycloid body scales, the operculum, pectoral and pelvic fins)
Source: I.H.Nock Science images, 2011

4.0 CONCLUSION

Gnathostomes are a diverse group of vertebrates with jaws.

5.0 SUMMARY

We have described the Gnathostomes as vertebrates characterised by:

- a vertically biting device called jaws, and which is primitively made up by two endoskeletal elements, the palatoquadrate (dorsal component of the mandibular arch) and Meckelian (ventral component) cartilage, and a number of dermal elements called teeth, sometimes attached to large dermal bones
- paired appendages (paired pectoral and pelvic fins) supported by an internal skeleton which supports more efficient locomotion
- interventrals and basiventrals in the backbone. These are the elements of the backbone, which lie under the notochord, and match the basidorsals and interdorsals respectively.
- gill arches which support/hold the gills lie internally to the gills and branchial blood vessels, unlike the gill arches of all jawless craniates, which are external to the gills and blood vessels
- a horizontal semicircular canal in the inner ear
- teeth - modified dermal scales
- more proficient predators than the jawless fish
- paired nasal sacs.

We also described three classes of fishes namely:

i) placodermi (extinct) as gnothostomes with well developed fins and armour plating, which consist of head and thoracic armours
ii) chondrichyes as having cartilaginous endoskeleton
iii) osteichthyes with bony endoskeleton.

6.0 TUTOR-MARKED ASSIGNMENT

i. State three major characteristic features of gnathostomes.
ii. What is the main distinguishing feature of each of the three fish classes?
iii. Obtain fish from the market and attempt to classify them as either cartilaginous or bony fish. Describe features that aided your identification/categorisation.

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Alexander, R.M. (1975). *The Chordates.* Cambridge: Cambridge University Press.

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Philippe janvier: http://www.tolweb.org/Gnathostomata/14843

UNIT 3 AMPHIBIA

CONTENTS

1.0 INTRODUCTION

In the last two units, we examined the characteristics of fishes, which are aquatic throughout their life. In this unit, we shall be looking at animals that exhibit dual habitation of being able to live in both water and on land. These are the amphibians (amphi - meaning both, bios - meaning life). They exhibit ability to colonise land from water. Accordingly, you will find that respiration by gills in water is being supported by moist skin and not too efficient lung system for life on land.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- describe the characteristic features of the class Amphibia and the respective orders
- recognise the animals called amphibians.

3.0 MAIN CONTENT

3.1 Characteristics of the Class Amphibia

The amphibians are characterised by the following features:

- moist, glandular skin that lacks the keratinised scales of reptiles
- complex life cycles (eggs, tadpole/juveniles, adults through metamorhosis)

- non-amniotic eggs (they lack the amniotic membrane that surrounds the embryo)
- eggs lack a shell instead surrounded by several gelatinous layers
- gills at the larval stage and lungs at the adult stage. In many amphibians, the skin is also important in gas exchange
- two pairs of pentadactyl (five digits) limbs
- cold-blooded animals (they do not have a constant body temperature but instead take on the temperature of their environment)
- three-chambered heart
- no external ear.

The moist, scale-less skin of amphibians absorbs water and oxygen from the surrounding atmosphere, but that also makes them vulnerable to dehydration (loss of bodily fluids). Without moist conditions, their skin dries out and they die. That explains why amphibians are most often found near ponds, marshlands, swamps, and other areas where moisture is available. Some amphibians become inactive when conditions are unfavourable for survival. This period of inactivity is called estivation when it occurs during hot, dry weather and hibernation when it occurs in response to cold temperatures. Activity resumes when favourable conditions return.

The thin skin of amphibians contains many glands; among them is the poison gland that protects certain species against predators. The poison from the glands of the brightly coloured poison-dart frog is particularly toxic and is used by South American Indians to coat the tips of their arrows. Some amphibians protect themselves from enemies by changing colour to blend in with their surroundings i.e. they camouflage.

The life cycle of most amphibians begins in water when the female lays eggs that are fertilised outside of her body. The eggs then hatch into larvae (known as tadpoles), that breathe through external gills. The larvae grow flat tails and feed on vegetation. During a process called metamorphosis, physical changes occur and external gills give way to lungs. The tadpoles also change from plant-eating (herbivorous) to meat eaters (carnivorous) animals. Amphibians usually reach full adulthood at three to four years.

The class Amphibia is comprised of three orders which include the Gymnophiona (caecilians), Urodela (urodeles - newts and salamanders) and Anura (anurans - frogs and toads).

3.1.1 Characteristics of the Order Anura (Amphibians without tail)

The anurans are the largest group of living amphibians, comprising about 3,000 species. This order is made of the most common amphibians that we come across in our environment. They include the frogs and toads.

Members of this order have the following characteristics:

- lack true tail in the adult stage
- hind limbs are longer than front limbs; and by this they are well adapted for hopping, jumping and swimming
- live in aquatic environment, although some are well adapted to drier habitats
- larval forms are called tadpoles, the adults lack true teeth and are usually herbivorous, and develop hind limbs before front limbs (which is the opposite of Urodela larvae)
- external gills in the larvae give way to internal gills with opercular chambers that allow water to flow over the internal gills, before exiting through a spiracle.

Frogs and toads differ; toads have drier skin that is warty (which enables them adapt to drier habitats) in comparison to the smooth skin of frogs. Frogs also have longer and well-pronounced webbed feet (that facilitate movement in water) than toads and are often in or near water. Frogs range in size, the smallest measuring about 1 inch (2.5 centimeters) and the largest (the West African Goliath frog) measuring more than 1 foot (about 30 centimeters). To a large extent, toads are the ones we see hopping around our surroundings especially during the rains. They are more tolerant to dry conditions than frogs, which are often in water or not too far from a water source. Frogs and toads live mainly on a diet of insects and other invertebrates. The largest frogs and toads also eat small mammals, birds, fish, and other amphibians**.**

Fig..6: A: North American Bullfrog

(Named for the sound of its deep croak, is the largest frog in the United States – see the well pronounced webbed hind limb that typifies frog life in water. **B**: Typical toad in Nigeria; this toad was found in a riparian forest (along of a river in Katsina), northern Nigeria. It finds habitation in the moist soil covered by leaves).

Source: **A**: Michael P. Gadomski/Photo Researchers, Inc. Microsoft ® Encarta ® 2009. © 1993-2008 Microsoft Corporation. **B:** I.H.Nock Science images

3.1.2 Characteristics of the Order Urodela (Evident/visible tail)

Members of this order (Urodela) are amphibians that have a visible tail. Indeed, you could mistake them for reptiles on account of this. Members include the newts and salamanders.

The order 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.

Urodeles are usually found in or near water and often reside in moist soil under rocks or logs. The adults usually spend most of their time on land and have a diet consisting of insects and worms and burrow in mud at the bottom of marshes. They range in size from approximately 10 cm (4 in) to the largest of all amphibians that is the giant salamander of Japan, which grows to more than 1.5 m (about 5 ft).

Fig. 7: Mud Puppies – *Necturus* (unusual type of salamander)
Source: Jack Dermid/Bruce Coleman, Inc. Microsoft ® Encarta ® 2009.

Like most adult amphibians, mud puppies have lungs. But unlike most mature amphibians, they also have external gills to breathe under water.

Fig. 8: The Red-Spotted Newt
Source**:** S. R. Maglione/Photo Researchers, Inc. Microsoft ® Encarta ® 2009**.** © 1993-2008 Microsoft Corporation

The red-spotted Newt, lives in ponds and streams in the eastern and central United States. In its larval stage, shown here, its skin is a bright reddish-orange. After reaching adulthood, its skin turns olive with red spots. Note that this amphibian can easily be mistaken for a reptile.

3.1.3 Characteristics of the Order Gymnophiona (Caecilians/Apoda e.g. *Ichthyophis, Typhlonectes*)

Members of the order 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

Fig. 9: The Caecilian (wormlike amphibian with no limbs)
The untrained eye may mistaken this amphibian for a snake (reptile) or earthworm.
Source: http://en.wikipedia.org/wiki/Caecilian

Members of this order are look like worms**,** blind and legless amphibians that are shaped like worms. They burrow in moist soil in tropical habitats of Africa and South America, feeding on soil invertebrates such as worms and insects. Some caecilians live in moist soil that is rich in decayed plant matter. They also live in leaf litter. Other caecilians live in water all or most of the time. The burrowing movements of land-dwelling caecilians turn soil and thus keep it in good condition.

4.0 CONCLUSION

Amphibians are vertebrates that live both on land and in water.

5.0 SUMMARY

In this unit, we have described amphibians as vertebrates and gnathostomes with the following features:

- moist and glandular skin
- complex life cycles
- eggs without shell and amniotic membrane surrounded by several gelatinous layers.
- gills at the larval stage and lungs at the adult stage for respiration. In many amphibians, the skin aids gas exchange.
- cold-blooded.

We also described three orders in the class Amphibia:

i) Anura - as amphibians without tails in the adult stage
ii) Urodela - as amphibians with tails
iii) Gymnophiona - worm-like and without legs.

6.0 TUTOR-MARKED ASSIGNMENT

i. Look around your environment for animals you consider as amphibians. Give reasons for listing each as an amphibian.
ii. With reasons, attempt to place each amphibian identified in your environment in its appropriate class.

7.0 REFERENCES/FURTHER READING

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UNIT 4 REPTILIA

CONTENTS

1.0 INTRODUCTION

In this unit, we shall be looking at a group of vertebrate gnathostomes called reptiles, which unlike the amphibians have successfully found colonised land. This is supported by their dry skin which prevents loss of water from their body. Some reptiles live in water but return to land to lay eggs, unlike the amphibians whose eggs are laid in water; reptile eggs have a shell/thick membranous covering that also protects against desiccation. Furthermore, unlike the situation in amphibians, the embryo in the eggs of reptiles is protected by a thin membrane called the amniotic membrane. So we can rightly say that the amniotic membrane finds its genesis in reptiles. The ability of reptiles to colonise land is also supported by efficient lungs at the adult stage, which enhance respiration as against the use of gills and moist skin as obtains in many amphibians. Reptiles are animals we see quite often – the most common being the lizards. Others include wall geckos, crocodiles, snakes and tortoises.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- identify reptiles by their characteristic features
- distinguish reptiles from the urodelans (amphibians).

3.0 MAIN CONTENT

3.1 Characteristics of the Class Reptilia (Lizards, crocodiles, snakes, tortoises, turtles)

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 (see Figure 2.10)
- cold blooded (poikilothermic/exothermic)
- gut and the ducts of the urinary and reproductive system open into a posterior chamber called the cloaca.

There are about 6,550 living species of reptiles worldwide; they live in a wide range of habitats, including forests, swamps, grasslands, deserts, oceans, and mountains. The name "reptile" is generally applied to any of a group of ectothermic (cold-blooded i.e. need an "outside" source of heat to generate adequate body heat) vertebrates in the Class Reptilia. Reptiles must regulate their body temperature by behaviour, either by basking in the sun to keep warm or by hiding under cover to keep cool. Some reptiles (such as lizards) look superficially similar to the tailed amphibians (newts and salamanders). However, reptiles have dry and not moist skin. They are covered in scales or a shell. If they have legs, they have true claws on their toes. Reptiles can be far from water sources because their skin retains water better than that of amphibians. Reptiles lay amniotic eggs that have a leathery shell that prevents rapid water loss.

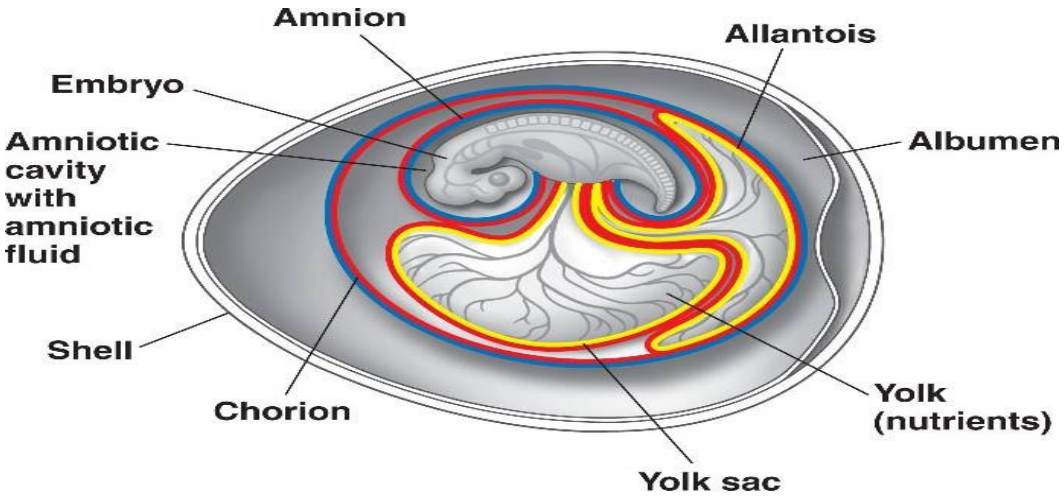

Fig. 10: Typical Amniotic Egg (see the amniotic membrane encasing the embryo in amniotic fluid)

Source: www.nicerweb.com/bio1152/Locked/media/ch47/amniotic.htm (12th January, 2012)

The Class Reptilia is composed of four orders namely Order Crocodilia (crocodiles and alligators), Order Testudinata (turtles), Order Squamata (lizards and snakes) and Order Rhynchocephalia (Tuataras).

3.1.1 Characteristics of Order Crocodilia (Crocodiles and alligators)

The crocodilians 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.

Fig. 11: Crocodiles and Alligators
Source: Microsoft ® Encarta ® 2009. © 1993-2008 Microsoft Corporation.

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 are nearly the same width, so the teeth are exposed all along the jaw line in an interlocking pattern, such that even when the mouth is the bottom teeth are visible (**A**). An alligator's teeth don't show when its mouth is closed (**B**).

3.1.2 Characteristics of Order Testudinata (Turtles and tortoises)

The order is characterised by the following features:

- shell or carapace formed from the fusion of vertebrae and ribs with dermal bones
- no teeth but have a sharp-edged beak, called a tomium used as cutting edges to bite off chunks of food
- oviparous and fertilisation internal and accomplished by a penis which is an outgrowth of the cloacal wall. Eggs are buried in a nest and left to incubate and hatch.
- no temporal opening in the skull behind the eye, a condition known as anapsis. This feature is unique among living reptiles.

Fig. 12: **A Young Turtle** (as it emerges from its hiding place on the sea floor)
Source: Jozon Michel/Agency Hoa Qui/Phototake NYC. Microsoft ® Encarta ® 2009. © 1993-2008 Microsoft Corporation

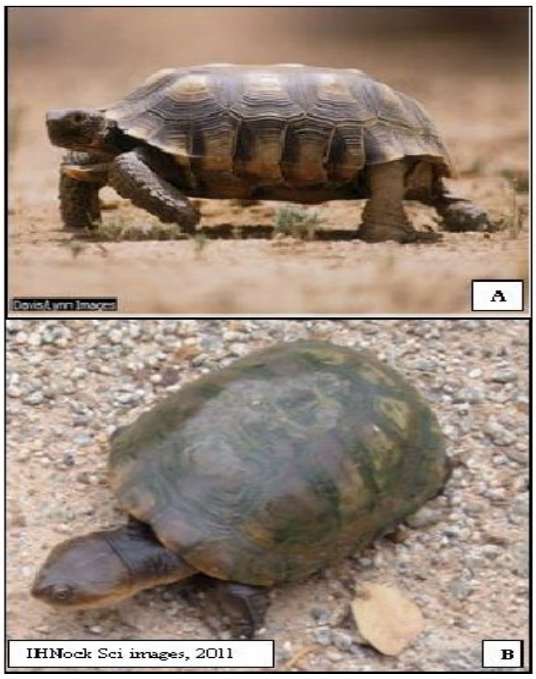

Fig. 13: A: The Desert Tortoise, *Gopherus agassizii* (is found in deserts throughout the southwest United States and northwest Mexico.)
B: **A Common Tortoise from a Pond in Northern Nigeria**
Source: **A**: Davis/Lynn Images. Microsoft ® Encarta ® 2009. © 1993-2008. Microsoft Corporation. All rights reserved. **B:** I.H.Nock Science images, 2011

The shell of testudinata is covered with scutes. No other vertebrate has the hard shell that surrounds and protects the organs of turtles/tortoise.

The shell of turtle/tortoise consists of two basic parts, the top shell which is referred to as a carapace, and a bottom shell that is known as a plastron. The two parts of the shell are connected on each side by a portion of the shell known as the bridge. The ribs and vertebrae of turtle/tortoise, with the exception of the neck and tail, are fused to form the carapace. Because of the fusion, you cannot see a clearly defined vertebrae/backbone as is the case in other vertebrates we have studied so far. The shell is not an exoskeleton as some people mistakenly assert, but a modified ribcage and part of the vertebral column. It cannot be "taken off". Because of the shell, the pectoral and pelvic girdles are uniquely located within the ribcage. The limb bones are also modified to accommodate the shell. Turtles/tortoises are long-lived animals. Some live from 20 to over 100 years, depending on species. Some species only eat animal matter while others eat both plants and animals. The Latin word-root "test" is synonymous for shell, and the order name "Testudines" is Latin for turtle. Tortoises are considered as turtles that inhabit land and have un-webbed feet unlike the water turtle that live most of the lives in water and have webbed feet. Both lay eggs on land. The two are thus distinguished by their habitat i.e. land turtle or water turtle. However, the Americans make no such distinctions as the word turtle refers to both, whether on land or water.

3.1.3 Characteristics of the Order Squamata (Lizards and snakes)

The order is characterised by the following features:

- 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. It is the most diverse of the reptile orders, containing 96% of the reptile species. In other words, these are the reptiles you come across often. They are represented by the Lacertilia (lizards) and the Serpentes (snakes). Members of this huge order are found worldwide, except in Antarctica and on a few very remote islands. Many squamates have loss or reduction of limbs and the ability to lose the tail (caudal autotomy), especially when attacked by predators, as is the case with wall geckos. Snakes (Serpentes) lack

limbs; however, some species have vestigial (degenerate or functionless) limbs in the form of small spurs (e.g. the rubber boa). All snakes lack eyelids and external ear opening (some burrowing lizards lack ear openings as well). Snakes have an elongate body (some lizard species are limbless and have long slender bodies). On the other hand, lizards (Lacertilia) are characterised by four limbs (some lizards species that lack limbs), visible ear openings, and movable eyelids. These three characters alone readily distinguish lizards from snakes.

Fig. 14: The Racerunner Lizard *Cnemidophurus* Native of North and South America (See the colourful scaly body, pairs of pentadactyl limbs, post anal tail). **B: Common Male *Agama*Llizard found in most parts of Nigeria**

Source**: A:** Larry Miller/Photo Researchers, Inc. Microsoft ® Encarta ® 2009**.** © 1993-2008 Microsoft Corporation (modified by labeling). **B**: I.H.Nock Science images, 2011

Fig. 15: A: Monitor Lizard B: Wall Gecko (Shedding its skin – moulting/ecdysis)
Source: I.H.Nock Sci images, 2011

Monitor lizards are large reptiles (some are small as 20 cm long). They have a long neck, powerful tails and claws, and well developed limbs. Most species are terrestrial but some aquatic species are also known. They are mostly carnivorous although some eat fruit. Monitor lizards are oviparous, laying 7-37 eggs which are buried in soil or protect in a hollow tree stump. Wall geckos are amazing reptiles. They have a specialised toe pads that enable them to run across walls, ceilings and even glass windows. Wall geckos can make a variety of noises. Indeed, the name gecko is derived from a Malay word, gecko – which imitates their cry. Wall geckos can lick with their tongue; they are able to lose their tail when they are grabbed.

Fig. 16: Chameleon
Source**:** I.H.Nock Sci images, 2012

Chameleons (family Chamaeleonidae) are a distinctive and highly specialized group of lizards. They have parrot-like zygodactylous feet (two pairs of toes which the second and third toes face forward and the first and fourth toes face backward), mobile and stereoscopic eyes (with three dimensional effect), a very long, highly modified, and rapidly extrudable tongues, prehensile tail, crests or horns on head, and the ability of some to change color.

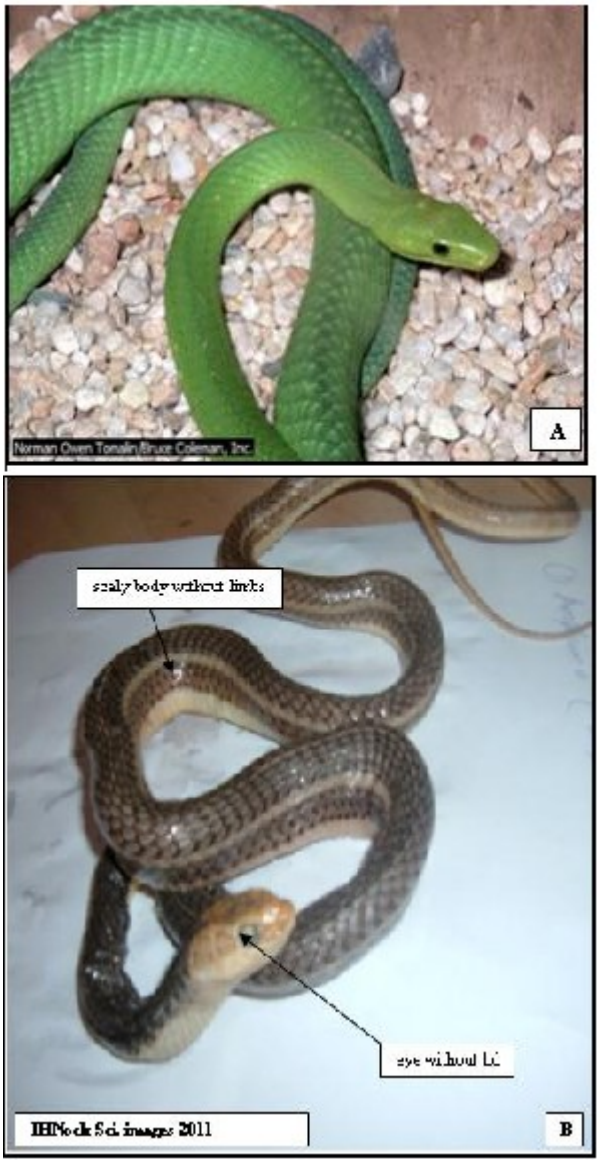

Fig. 17: **A: Green Mamba, a Member of the Cobra** Family **B: Preserved Specimen of the Striped Olympic Snake in the Museum of Natural History, Department of Biological Sciences, Ahmadu Bello University, Zaria, Nigeria**

Source**: A:** Norman Owen Tomalin/Bruce Coleman, Inc Microsoft ® Encarta ® 2009. © 1993-2008 Microsoft Corporation (modified by labeling). **B**: I. H. Nock Science images, 2011

The Green Mamba (Figure 17) lives in Africa and is one of the world's fastest-moving snakes. The snake is popularly known as the 'Green snake' and is able to conceal self among green leaves. Note the scaly body, and the absence of limbs, ear opening and eye lids associated with snakes generally.

3.1.4 Characteristics of the Order Rhynchocephalia (Tuatara)

Members of this order are characterised by the following features:

- a scaly loose skin which may be soft to touch
- a spiny back
- a third primitive, light-sensitive eye above the brain
- live in burrows and are nocturnal, hunting at night just outside their burrow entrance
- they feed on worms, lizards, millipedes and small seabirds.

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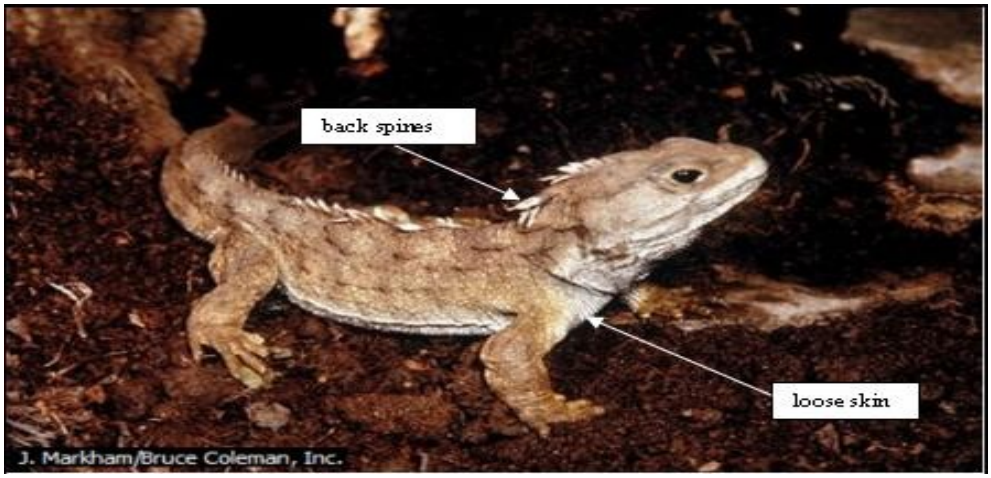

Fig. 18: The Tuatara, *Sphenodon punctatus* (See the scaly loose skin and spiny back)
Source: J. Markham/Bruce Coleman, Inc.Microsoft ® Encarta ® 2009. © 1993-2008 Microsoft Corporation. (modified by labeling)

Tuatara means "spiny back". Tuataras are reptiles but they are very different from lizards, snakes, and crocodiles. Tuataras have a primitive body structure that supports the theory that they are one of the oldest and most un-evolved species, having hardly changed in the past 220 million years. The order has only two living species in New Zealand. They are solitary, nocturnal hunters of insects and small vertebrates. Tuataras grow to 60 centimeters (24 inches) in length. They may live more than 50 years; their eggs must incubate for 15 months before hatching—longer than for any other reptile.

4.0 CONCLUSION

Reptiles are vertebrates with jaws (gnathostomes) that have dry skin with keratinised epidermal horny scales.

5.0 SUMMARY

We have described reptiles as vertebrate gnathostomes with 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 on land or eggs retained internally until hatching
- amniotic egg with leathery shell
- cold blooded (poikilothermic/exothermic)
- gut and the ducts of the urinary and reproductive organs empty into a posterior chamber called the cloaca.

We also described three orders in the class namely:

- Crocodilia with a long snout
- Testudinata with a shell or carapace
- Squamata with scaly body
- Tuatara with "spiny back".

6.0 TUTOR-MARKED ASSIGNMENT

i. Take a walk around your surroundings to locate a lizard; do this in the early hours of the day when it is just getting warm, you are likely to find lizards basking in the sun on account of their cold blooded nature and thus not too active to move away from you. Take a critical look at the skin of the lizard. Compare and contrast it with the skin of the Tuatara and members of order Urodela (salamander and newt – Amphibia, Unit 3).

ii. How would you differentiate a crocodile from an alligator?

iii. What are the basic features that differentiate lizards from snakes.

iv. Give reasons why reptiles are better equipped for life on land than amphibians.

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UNIT 5 AVES

CONTENTS

1.0 INTRODUCTION

This unit focuses on birds (Aves), which are very familiar vertebrates that we come across virtually every day. Birds represent a major departure from the reptiles as the body scales have been replaced by feathers; this is a major characteristic feature of the class. Indeed, any animal you see with feathers is undoubtedly a bird. They include the doves and pigeons on your roof and on trees around your homes, to the chickens and turkeys you eat as delicacies, to the big ostriches that cannot fly. Birds are better equipped to live on land than the reptiles. Unlike the reptiles, they are warm blooded animals, have more efficient lungs with pouches for gaseous exchange coupled with a heart of four chambers. Most birds fly but a few such as penguins and ostriches have lost their ability to fly (though their ancestors did fly). Birds also have a large-yolked egg encased in a hard calcareous shell that can withstand desiccation.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- describe birds by their characteristic features
- describe the subclass Archaeonithes and Neornithes.

3.0 MAIN CONTENT

3.1 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.

It is interesting to note that birds are the only vertebrates with feathers. So any animal you see with feathers is undoubtedly a bird. Birds are said to have come from a common ancestor (monophyletic lineage) and are thus related through that common origin. 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, a lightweight but strong skeleton and forelimbs modified as wings. Birds also have unique digestive and respiratory systems. Some birds, especially parrots, are among the most intelligent animal species; a number of bird species have manufacturing skills and ability to tools, and many social species exhibit cultural transmission of knowledge across generations.

Adaptation to flight in birds is facilitated by light body weight (a consequence of the absence of teeth and ultra-light bones and air sacs), high body temperature, improved blood circulation, high metabolism, and acute vision (that enables avoidance of danger such as tree branches at high speed).

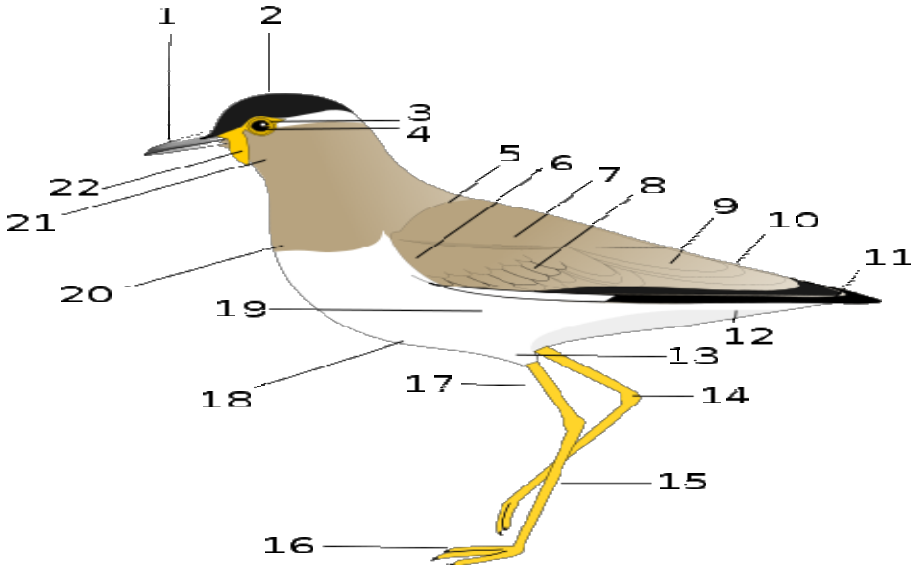

Fig. 19 : External Morphology of a Bird (*Vanellus malabaricus*) :
1. Beak; 2. Head; 3. Iris; 4. Pupil; 5. Mantle; 6. Lesser coverts; 7. Scapulars; 8. Coverts; 9. Tertials; 10. Rump; 11. Primaries; 12. Vent; 13. Thigh; 14. Tibio-tarsal articulation; 15. Tarsus; 16. Feet; 17. Tibia; 18 Belly; 19. Flanks; 20. Breast; 21. Throat; 22. Wattle
Source: L. Shyamal 2007:
http://en.wikipedia.org/wiki/File:Birdmorphology.svg

The class Aves is comprised of two subclasses namely Archaeonithes (extinct ancient birds) and Neornithes (recent birds). So it is right to say that all living birds belong to the subclass Neornithes, which is further divided into three Superorders namely Odontognathae (extinct), Paleognathae and Neognathae.

3.1.2 Characteristics of the Subclass Archaeonithes

Members of this subclass are extinct ancient birds. They were characterised by having clawed wings, a reptilian style ribcage without a large carina and the presence of a long, bony tail. The known members of the group were *Archaeopteryx* and *Archaeornis*.

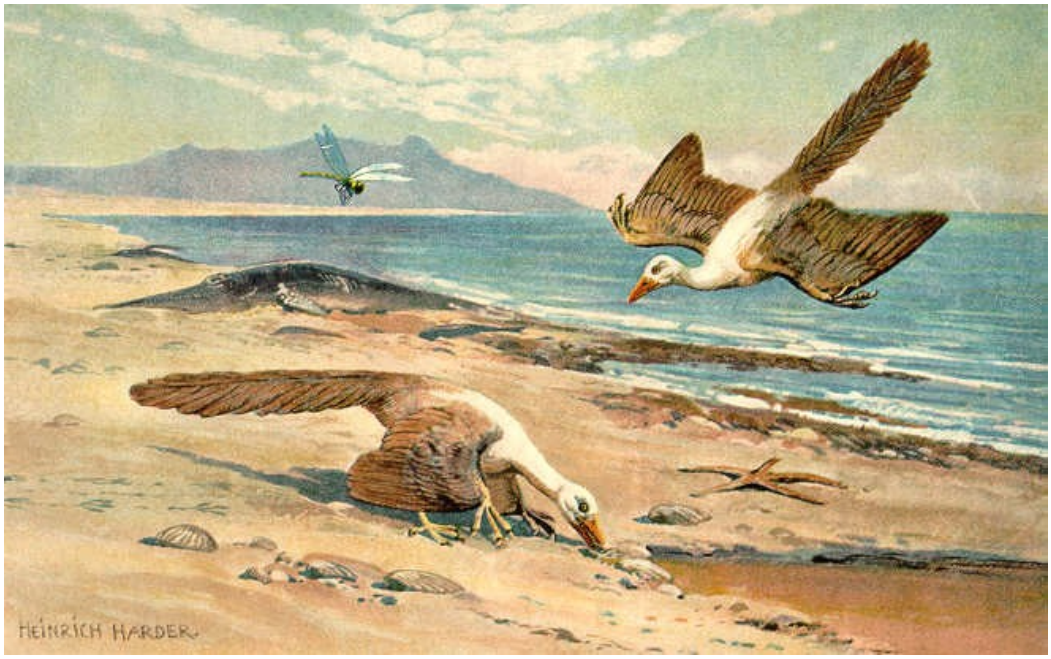

Fig. 20: *Archaeopteryx* (now extinct - see the characteristic clawed wings and long tail)
Source: http://en.wikipedia.org/wiki/File:Archeopteryx_color.jpg (accessed 30th December, 2011)

Characteristics of the Class Subclass Neornithes

Let us now look at the neornithes, which represent all the living birds we see today. In this subclass, there are three superorders namely Odontognathae (extinct), Paleognathae and Neognathae. We shall now look at the Superorders under the subclass and attempt to bring to you pictorial representations.

Superorder Odontognathae

Members of this superorder though considered as modern birds, on account of their anatomy are however extinct. As the name implies, they had teeth-like structures as shown in the Figure below.

Unlike the Archaeornithes described above, the Odontognathae had short tails with a well- developed carina for flight muscle attachment and the wings are generally without claws (though some modern birds such as the kiwis have claws). The brain of the Odontognathae appears to be somewhat simpler than those of modern birds.

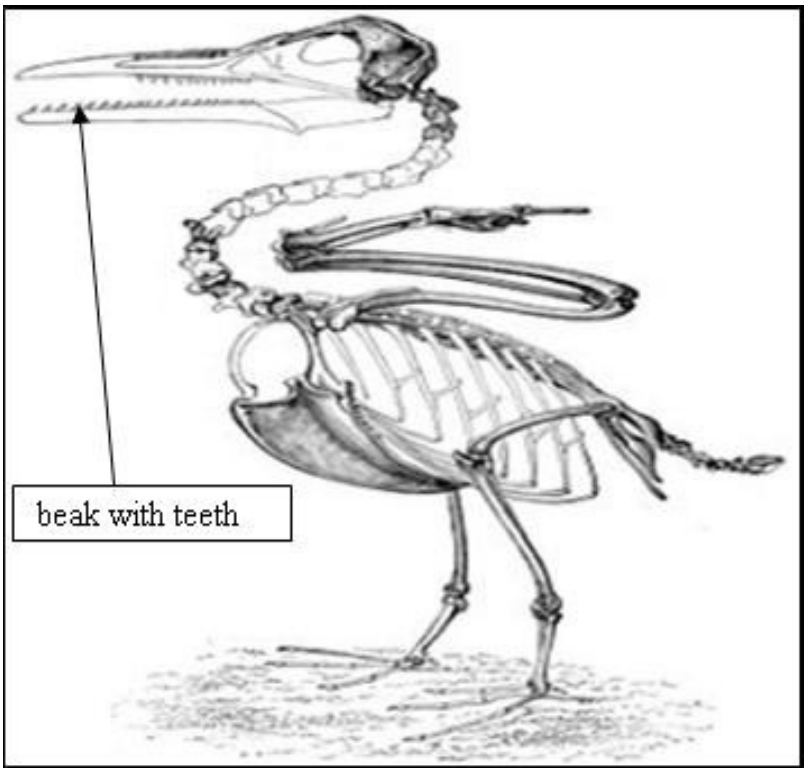

Fig. 21: **A Skeleton of Odontognathae** (see beak with teeth that characterised the extinct superorder)
Source: http://en.wikipedia.org/wiki/Odontognathae (modified by labeling)

Superoder: Palaeognathae

The superorder Palaeognathae derived its name from 'paleognath', the ancient Greek word for "old jaws" in reference to the skeletal anatomy of the palate of the bird, which is described as more primitive and reptilian than of other birds. In other words, the superorder represents birds with primitive jaws, which are more like reptilian jaws. In this superorder we have ratites, which have lost ability to fly and the Tinamous that can fly.

We shall now take a close look at the orders under this superorder by way of brief description and pictorial presentation.

Order: Struthioniformes (Ostriches, Emus, Kiwis)

The order Struthioniformes comprised of birds called ratites, which are large flightless birds; these are birds that have lost their ability to fly and have a flat breastbone. The Ratites have a simplified wing bone structure, strong legs, and no feather vanes, making it unnecessary to oil the feathers. Consequently, they have no preen gland that contains

preening oil. This group is composed of ostriches, rhea, cassowaries, emus and kiwis.

Fig..22: A: Kiwi *B*: Ostrich resting on the Ground at Jos Wildlife Park

Source**: A:***http://*en.wikipedia.org/wiki/Palaeognathae. **B:** I. H. Nock Science images, 2008

Kiwis (*Apteryx*) are flightless birds endemic to New Zealand. Kiwi is a national symbol of New Zealand. Just about the size of a domestic chicken, kiwi are by far the smallest living ratites and lay the largest eggs in relation to their body size of any species of bird in the world. The Ostrich (*Struthio*) is one of two species of large flightless birds native to Africa, the only living member(s) of the genus *Struthio*. The

bird is distinctive in its appearance, with a long neck and long legs and the ability to run at maximum speeds of about 70 km per hour, the top land speed of any bird. The Ostrich is the largest living species of bird and lays the largest egg of any living bird.

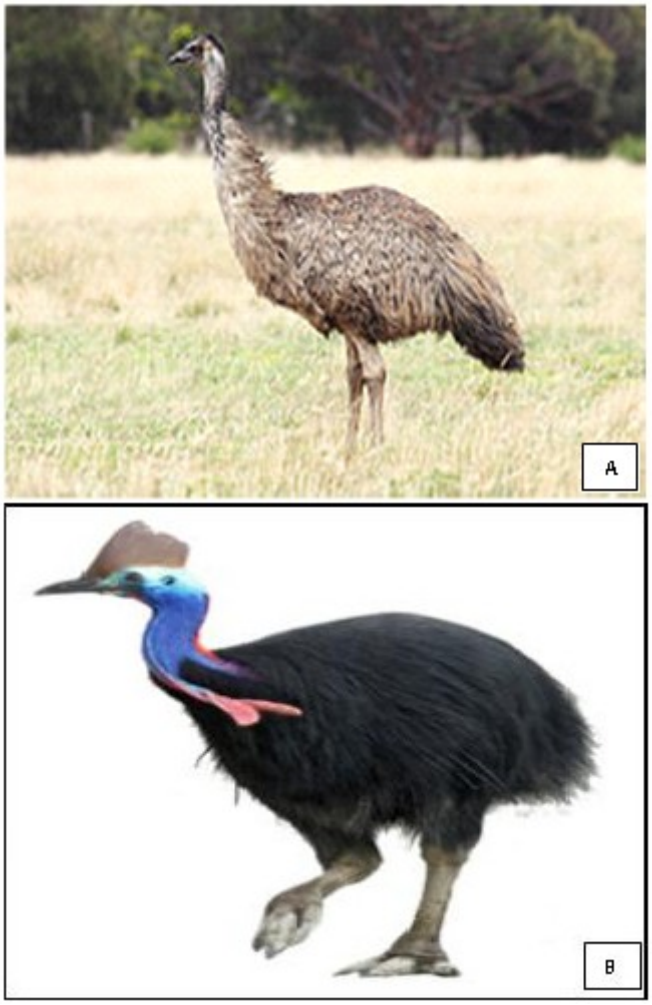

Fig. .23: A: Emu (*Dromaius*) **B: Cassowary**
Source**:** http://en.wikipedia.org/wiki/Emu **B:** http://en.wikipedia.org/wiki/Cassowary

The Emu is the largest bird native to Australia and the only extant member of the genus *Dromaius*. It is the second-largest extant bird in the world by height, after its ratite relative, the ostrich. The soft-feathered, brown, flightless birds reach up to 2 m (6.6 ft) in height. They have long thin necks and legs. Emus can travel great distances at a fast, economical trot and, if necessary, can sprint at 50 km/h (31 mph) for some distance at a time. Cassowaries are not well known birds as they are usually shy birds of the deep forests of Australia and Papua New Guinea. They are quick to disappear long before they are seen. Females are bigger and more brightly colored. Adult Southern Cassowaries are

1.5 to 1.8 m tall, although some females may reach 2 m and weigh 58.5 kg. A cassowary's three-toed feet have sharp claws and the bird is fearsome since cassowaries sometimes kick humans and animals with their enormously powerful legs. Indeed, according to the Guinness Book of Records, 'the Cassowaries are the world's most dangerous birds', capable of dealing fatal blows. They are very unpredictable, aggressive creatures, especially if wounded or cornered. Cassowaries can run up to 50 km/h through the dense forest. They can jump up to 1.5 m and they are good swimmers, crossing wide rivers and swimming in the sea as well. They are certainly a delight to watch.

Order: Tinamiformes (Tinamous)

The Tinamous are a family found in Central and South America. One of the most ancient living groups of bird, they are related to the ratites. Generally ground dwelling, they are found in a range of habitats and can fly and have a keeled breastbone (shaped like a wishbone). Although they look similar to other ground-dwelling birds like quail and grouse.

Fig. 24: Great Tinamou
Source**:** http://en.wikipedia.org/wiki/Tinamiformes

4.0 CONCLUSION

Birds are the only vertebrates that have feathers.

5.0 SUMMARY

We have in this unit learnt about birds, which we described as vertebrates endowed with feathers. We described them with the following characteristics:

- body covered with feathers (the only animals that have feathers)
- strong bony endoskeleton with large air spaces
- forelimbs modified as wings for flight (some have lost the ability to fly)
- bipedal- two legs for locomotion (lower part of legs has scales)
- toothless horny beak and gizzard to grind food
- warm blooded animals
- efficient lungs with pouches for gaseous exchange
- heart of four chambers
- internal fertilisation
- hard-calcareous shelled eggs with yolk.

6.0 TUTOR -MARKED ASSIGNMENT

i. See the TMA in Unit 6 below.

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UNIT 6 AVES II

CONTENTS

1.0 INTRODUCTION

We shall continue with our study of birds by looking at the biggest superorder i.e. Neognathae. In view of the large number of orders in this superorder, we shall give a description and pictorial presentation of a selected few, especially of those we have in our environment or those that are common elsewhere.

2.0 OBJECTIVE

At the end of this unit, you should be able to:

- recognise and describe some members of the superorder Neognathae

3.0 MAIN CONTENT

3.1 Characteristics of the Avian Superorder Neognathae

The superorder Neognathae comprises 27 orders which have a total of nearly 10,000 species. The Neognathae have undergone adaptive radiation to produce the staggering diversity of form (especially of the bill and feet), function, and behaviour that we see today. Most of the birds you see often are indeed members of Neognathae.

Let us now take a brief description together with pictorial presentation of some of the selected orders.

Order: Strigiformes (owls)

Owls are easy to recognise. They have an almost human appearance, with an upright posture, large rounded head, and large eyes that face forward (most birds have eyes on the sides of their heads). All owls are

carnivores (meat-eaters), and several adaptations make them effective hunters, including a hooked beak for tearing flesh and strong feet tipped with sharp talons (claws). The toes can be used in a two-forward, two-backward arrangement for a good grip on prey (most birds have three toes pointing forward and one pointing backward). Feathers are unusually soft, allowing for silent flight, so owls can hear their prey and approach it without warning. Most owls are nocturnal, active at night and asleep by day. Adaptations for night hunting include eyes that can see in low-light conditions and very acute hearing. The eyes are enclosed in a ring of bone and cannot move freely, so owls must turn the entire head to look sideways.

Fig. 25: Eurasian Scops Owl
Source**:** John Chellman/Animals Animals. Microsoft ® Encarta ® 2009. ©1993-2008, Microsoft Corporation

The Eurasian scops owl ranges from southern Europe through East Asia. It is a small medium-sized, “eared” and nocturnal owl that feeds mostly on insects.

Order: Galliformes (fowl)

Galliformes are medium to large in size, with a stocky body, small head, and short wings. Members of the order are quite familiar to us as it comprises the birds we keep and also eat as meat. These birds include chickens, turkeys and quails. Quails are the smallest species, weighing less than 20 grams and measuring just 12 to 15 cm. The wild turkey

weighs 8 to 10 kg, and the domesticated turkey bred for eating can weigh up to 20 kg. Galliformes have short bills that usually curve downward to assist in pecking plant material from the ground. Their feet are big and strong - so strong that they can move heavy branches or stone. Some galliform tails are one-third the size of their total body length. Both sexes are often brown or black, but the males of a few species are incredibly colorful.

Fig. 26: A: Domestic Birds (*Gallus* – chicken and *Meleagris* - turkey-black spotted white).**B: Brown Quail** (*Coturnix*) See body of birds covered with feathers and forelimbs modified to wings.
Source: **A:** I.H.Nock Science images, 2009. **B:** http://en.wikipedia.org/wiki/Quail

Fowl is a word for birds in general but usually refers to birds belonging to one of two biological orders, namely the gamefowl or landfowl (Galliformes) and the waterfowl (Anseriformes), which are closely

related. Many birds that are eaten by humans are fowl, including poultry such as chickens or turkeys, game birds such as pheasants or partridges, other wildfowl like guineafowl or peafowl, and waterfowl such as ducks or geese. Quail is a collective name for several genera of mid-sized birds generally considered in the order Galliformes. Many of the common larger species are farm-raised for table food or egg consumption as is the case in Nigeria, where meat and eggs of quails are sought after as delicacies especially by the health conscious class.

Order: Falconiformes (Falcon)

Falconiformes have a sharply hooked beak with a cere (soft mass) on the proximo-dorsal surface, housing the nostrils. Their wings are long and fairly broad, suitable for soaring flight, with the outer 4–6 primaries emarginated. Falconiformes have strong legs and feet with raptorial claws and an opposable hind claw. Almost all falconiformes are carnivorous, hunting by sight during the day or at twilight. They are exceptionally long-lived, and most have low reproductive rates.

Fig. 27: Brown-Falcon
Source:http://en.wikipedia.org/wiki/File:Brown-Falcon,-Vic,-3.1.2008.jpg

Order: Columbiformes (doves and pigeons)

This is a very familiar order with members such as the pigeons and doves. These birds are compact with broad, rounded, powerful wings; short bills; short legs; and short necks. Males tend to be slightly larger than females in size. In most species, males and females are similarly coloured, although there are a few tropical species whose males are much more colourful than females. Many pigeon and dove species are grey, brown, or cream in colour. However, some tropical species may be green, red, purple, pink, blue, or orange.

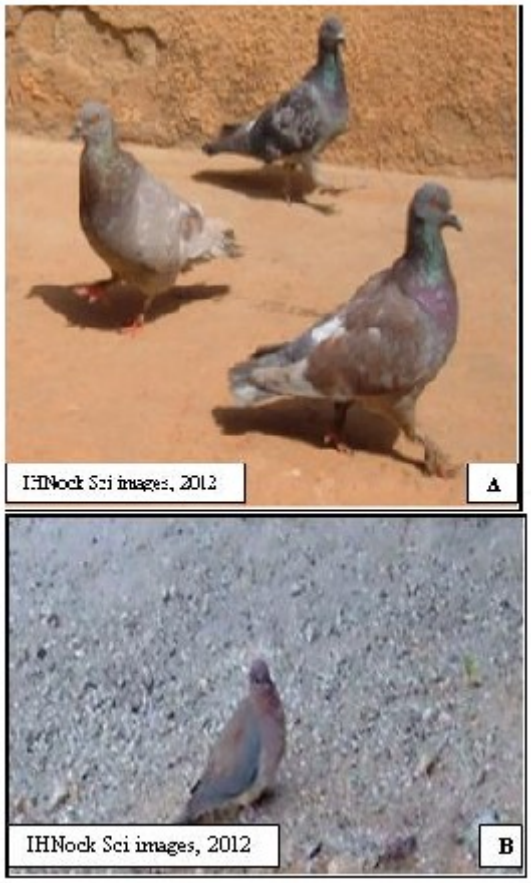

Fig. 28: A: Domestic pigeons B: Dove
Source: I.H.Nock Science images, 2012

Order: Psittaciformes (parrots and allies)

Parrots are very familiar birds on account of their brightly colored plumage (feathers), intelligence, and the ability of some species to imitate human voices, which enhances their popularity as pets. Most have green feathers, and many parrots are blue, red, and yellow. Parrots have large heads, short necks, and curved beaks. They use their hooked beaks to crack nuts and grab branches. This birds use their beaks and

feet to pick up food and carry it their mouths. Parrots have zygodactyl feet - two toes on each foot face forward and two face backward

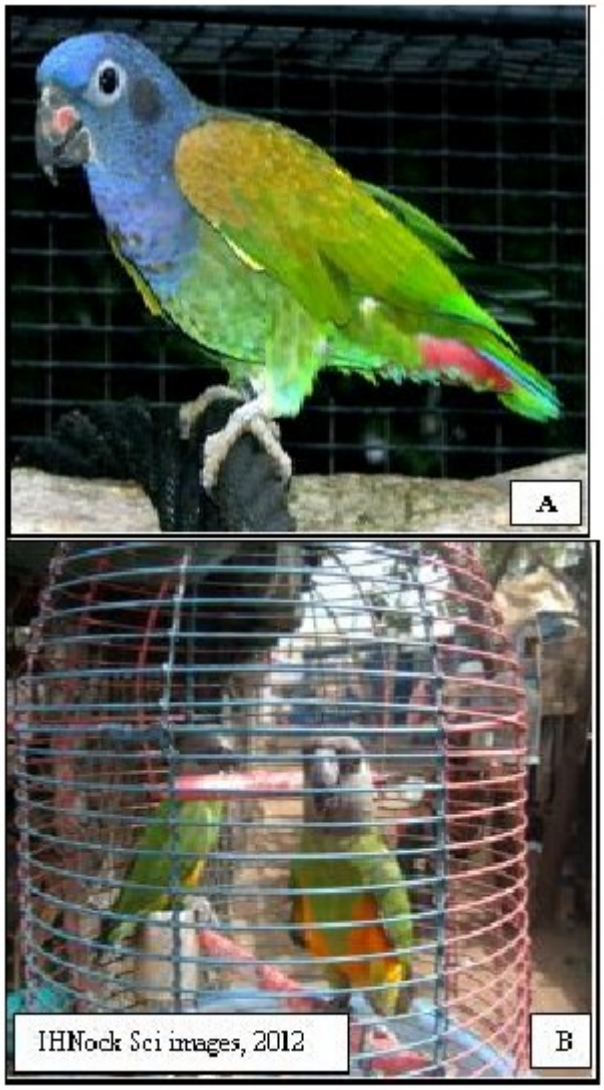

Fig. 29: A: Blue-Headed Parrot (*Pionus menstruus*). **B: Grey-Headed Parrot** (caged and kept as pet in many homes in Nigeria)
Source**: A:** http://upload.wikimedia.org/wikipedia/commons/2/21/Pionus_menstruus_-in_captivity.jpg **B:** IHNock Sci images, 2012

Order: Sphenisciformes (penguins)

Penguins are a group of aquatic, flightless birds living almost exclusively in the southern hemisphere, especially in Antarctica. Highly adapted for life in the water, penguins have counter shaded dark and white plumage, and their wings have become flippers. Most penguins feed on krill, fish, squid, and other forms of sealife caught while swimming underwater. They spend about half of their life on land and

half in the oceans. Although all penguin species are native to the southern hemisphere, they are not found only in cold climates, such as Antarctica. In fact, only a few species of penguin live so far south. Several species are found in the temperate zone, and one species, the Galápagos Penguin, lives near the equator. Penguins always return to their ancestral nesting sites to lay eggs and rear their young. The emperor penguin, the largest of the penguins, lays its single egg during the coldest time of the Antarctic year, when temperatures drop as low as -62°C (-80°F). The egg is incubated on top of the bird's feet, protected by abdominal folds of skin. Young chicks remain under these abdominal folds until they are able to regulate their own body temperature.

Fig. 30: **A: Emperor Penguin** ((*Aptenodytes)* keeping its young warm **B: Two King Penguins** and **One Gentoo Penguin walking on a Beach on South Georgia, British overseas territory**
Source**:** Doug Allan/Oxford Scientific Films. Microsoft ® Encarta ® 2009. © 1993-2008 Microsoft Corporation. **B:** http://en.wikipedia.org/wiki/Penguin (accessed 12 December, 2011).

Order: Coraciiformes (kingfishers and allies)

Coraciiformes are a fairly large order characterised by syndactyl feet (three forward pointing toes) and long, pointed bills. Birds in the order are usually colorful, have one mate partner (monogamous) and nest in cavities. Their young are helpless and depend on the parent for food (altricial) and retain waxy sheaths on their feathers until just before fledging. Most birds in this order are carnivorous.

Fig. 31: Azure Kingfisher
Source: http://en.wikipedia.org/wiki/kingfisher

Kingfishers are a group of small to medium-sized brightly coloured birds in the order Coraciiformes. They have a cosmopolitan distribution, with most species being found in the Old World and Australia. There are roughly 90 species of kingfisher. All have large heads, long, sharp, pointed beaks, short legs, and stubby tails. Most species have bright plumage with little differences between the sexes. Most species are tropical in distribution, while the majorities are found only in forests. They consume a wide range of prey including fish, from where they derive their name, on account of their ability to catch fish by a swift dive. It is a delight to watch the kingfisher swooping down to catch fish. Like other members of their order they nest in cavities, usually tunnels dug into the natural or artificial banks in the ground.

Order: Piciformes (woodpeckers and allies)

The piciformes are small to medium-sized, hole-nesting land birds. The bill is short to medium-long, straight, and strong, and the wings are of medium length and rounded. The legs are short and strong, with the strong toes arranged in a zygodactylous (yoke) pattern, with two toes forward and two toes back. The tail may have stiffened feathers. The

plumage is frequently brightly coloured and boldly patterned. Piciformes are good fliers and can easily perch and climb, but are poor at walking. Most species feed on insects. The eggs are incubated by both sexes, and both parents care for the unfeathered young, which remain in the nests. Except for a few species of woodpeckers, the piciformes are non-migratory.

Fig. 31: A: Woodpecker resting after Foraging B: Holes in a Tree made by Woodpecker

Source: http://en.wikipedia.org/wiki/Woodpecker

Members of this order have strong bills (same as beaks) for drilling and drumming on trees and long sticky tongues for extracting food. Woodpecker bills are typically long, sharp and strong with chisel-like tip; the tip is kept sharp by the pecking/hammering action on wood. The long sticky tongues armed with bristles, aid these birds in grabbing and extracting insects deep within in hole of a tree.

Order: Anseriformes (waterfowl)

Members of this order are strong swimmers with medium to large bodies. They are an important food source for humans, and continue to be hunted as game, or raised as poultry for meat and eggs. A well known member of this order is the domestic duck, which is sometimes kept as a pet. Some definitions of the term 'waterfowl' include the saltwater shorebirds or waders, gulls, pelicans, and herons, as well as seabirds such as the albatross; but 'fowl' especially refers to birds used by humans for game. All species in the order are highly adapted for an aquatic existence at the water surface. They have webbed feet well suited for efficient swimming (although some have subsequently become mainly terrestrial).

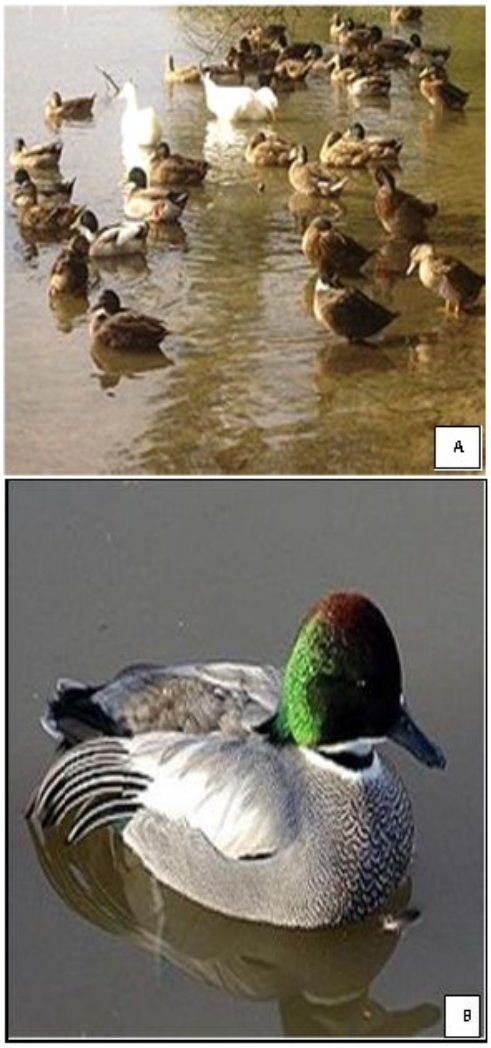

Fig. 32: Ducks at a Lake B: Duck Swimming
Source : http://en.wikipedia.org/wiki/Duck
Ducks are mostly aquatic birds, mostly smaller than the swans and geese, and may be found in both freshwater and sea water.

Order: Phoenicopteriformes (flamingos)

Fig. 33: A Flamingo (see the typical long legs)
Source**:** I.H.Nock Science images, 2012

Notes: Flamingos or flamingoes are a type of wading bird found in the Americas and in the Old World. Flamingos are 3-5 feet tall and have long legs, long necks, and long, bent bills. Most species are pink, white, or red and are found in tropical fresh and salt water lagoons and lakes. Flamingos often stand on one leg while resting. They are filter feeders and are uniquely adapted to feed on algae and small shellfish. Flamingos have two rows of lamellae or comb-like bristles that line the inside of their bills. They also have bristles on their tongues that help filter food out of the water. Flamingos live in large flocks that can include thousands of birds.

4.0 CONCLUSION

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

5.0 SUMMARY

We have, in this unit, learnt about birds, which we described as the only vertebrates endowed with feathers. We described them with the following characteristics:

- 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.

6.0 TUTOR-MARKED ASSIGNMENT

i. Within a radius of 50 metres around your home/office, take an inventory of the birds you can see. State how many you can identify by name and those you cannot.

ii. Visit a nearby market and also make a list of birds sold there. Note the shape and size of their beaks and attempt to relate this to the food they eat.

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MODULE 3 VERTEBRATE CHORDATES (II)

UNIT 1 MAMMALIA

CONTENTS

1.0 INTRODUCTION

We shall be considering a highly diverse but yet interesting group of vertebrates called mammals in this unit. This is where we humans find a place among the vertebrates. Mammals, as we shall be considering shortly, are so termed on account of having mammary glands (modified sweat glands) in females that produce milk for the newborn. It is from these glands that the whole group takes its name 'Mammals'. As we journey into the world of mammals, we shall see that indeed mammals are part of the beauty and diversity of life that make this world so good to live in.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- describe the characteristic features of mammals
- distinguish mammals from other vertebrates.

3.0 MAIN CONTENT

3.1 Characteristics of Mammals

The class Mammalia has the following characteristics:

Main mammalian features:

- **Mammary glands** in females for milk production for the newborn. This milk is produced by modified sweat glands called 'mammary' glands. It is from these glands that the whole group takes its name, 'Mammals'.
- **Hairy skin with keratin** (for insulation) with sebaceous and sweat glands. All mammals have some hair at least at the beginning of their lives - baby whales and dolphins are born with a moustache.
- **A single jaw bone on either side**. In all other vertebrates, there are more than one bones on each side of the jaw.
- **Four-chambered heart** with the main artery leaving the heart curves to the left becoming the aortic arch. (In birds, it curves to the right and in all other vertebrates there are more than one main artery leaving the heart).
- **Muscular diaphragm** separates the thoracic cavity from the abdominal cavity.

Other mammalian features include:

- bony endoskeleton
- two pairs of pentadactyl limbs
- outer ear lobe (pinna) plus middle and inner ears - three middle ear bones (the stapes or stirrup, incus or anvil and the malleus or hammer)
- warm-blooded (endothermic/homoeothermic - heat energy generated from within to maintain a constant high body temperature)
- seven cervical vertebrae (neck bones) are present in most mammals
- viviparous; a few are oviparous
- teeth (where present) are imbedded in jaw and in a variety of forms for different functions (heterodontic)
- internal fertilisation
- well developed brain encased in a skull.

Mammals are divided into three main categories depending on how they are born. These categories are monotremes, marsupials, and placentals.

Except for the five species of monotremes (which lay eggs), all mammal species give birth to live young. Most mammals also possess specialised teeth, and the largest group of mammals i.e. the placentals, use a placenta during gestation. The mammalian brain regulates endothermic and circulatory systems, including a four-chambered heart. Mammals have a buccal cavity (the mouth cavity) with a false palate as roof, which means that the nostrils do not lead directly into the mouth. Effectively, this means that if your mouth is full of food you can still breathe, but a reptile has to breathe around food. The body temperature of mammals is maintained at a constant level, meaning that mammals are endothermic i.e. they generate heat within their bodies metabolically and also have special cooling mechanisms. This does not however imply that all mammals maintain the same body temperature. There are approximately 5,400 species of mammals, distributed in about 1,200 genera, 153 families, and 29 orders (though this varies by classification scheme). Mammals range in size from the 30-40-mm (1.2-1.6 in) bumblebee bat to the 33 m (110 ft) blue whale.

Mammals are divided into two subclasses:

Subclass Prototheria: (monotremes: platypuses and echidnas)

Members of this subclass are extinct except the order Monotremata, which is represented by the duck-billed platypus (flat footed) and the echidnas - spiny anteaters. This group of mammals can be described as having transited from the reptiles as they exhibit some reptilian features as we shall highlight below.

The monotremes (as members are generally referred to) have the following characteristics:

- shelled eggs like reptiles
- single opening – the cloaca (like reptiles) for both urine/faeces discharge and copulation
- testes are not in scrotum but retained in body cavity
- penis lies within the cloaca and although homeothermic, their body temperature is low, from 30-33°C, so also is the basal metabolic rate
- mammary glands (though not truly mammary glands), that produce a fatty sweat (milk) from glands in the skin. The milk collects and drips down tufts of hair into the offspring's mouth.

The monotremes are found in Australia and Papua New Guinea. The duck-billed platypus is semi-aquatic, lives in and around rivers and lakes in Tasmania and other parts of eastern Australia. The female platypus lays eggs in dug holes (burrows) by the bank of rivers. The animal keeps

the eggs and the emerged young warm by curling around them. After hatching from eggs, platypus babies feed on milk from the mother. The spiny anteater lives on land and lays a single egg in a temporary pouch formed on the female's belly. The egg has a leathery shell. The egg hatches in 10 days and the baby echidna is born blind and hairless. It gets milk from a gland within the mother's pouch. In a few weeks, the baby (called a puggle) develops sharp spines, and must leave the pouch. The body of the spiny anteaters, with the exception of the underside, face and legs, is covered with cream coloured spines as seen in the plate below. These spines, which reach 50 mm in length, are in fact modified hairs. Like the hedgehog, the animal roll into ball form when disturbed.

Fig. 33: A: The Duck-Billed Platypus (*Ornithorhynchus)* **B: Spiny Anteater** (*Tacchyglossus)* [note the body spines] Source: A: Tom McHugh/Photo Researchers, Inc. and Kathie Atkinson/Oxford Scientific Films, **B:** http://www.parks.tas.gov.au/?base=4796

Subclass Theria (Live-bearing mammals)

Members of this subclass, unlike the monotremes described above, do not lay eggs but give birth to live babies. This means that there is a period of development for the embryo in the mother before birth. So we can look at the therians as more advanced mammals than the prototherians.

The therians are further divided into two infraclasses namely – Metatheria and Eutheria.

Infraclass Metatheria Marsupials (kangaroo, opossum, koala, possum)

The metatherians i.e. the marsupials have a pouch (marsupium) i.e. a built-in baby carrier, where the embryo completes its development.

The young of metatherians is called joey and is born during the early stage of development (just after a month) akin to premature birth. Under this condition, the joey cannot survive on their own and so must be kept in a pouch (marsupium - from which the group derives its name) situated on the mother's belly. When delivered, the newly born joey crawls up to the mother's pouch and clings on to a nipple from where it feeds until it fully develops. Members include the kangaroos, opossums, possums and koalas. A newborn kangaroo stays in its mother's pouch for about six months, where it feeds on her milk; this is the stage we often see on TV or photographs as shown below. Koala babies are born with eyes closed and have no ears or fur (body hair) so they stay inside a pouch on the mother's abdomen for about seven months while they grow fur and their eyes and ears develop. We can rightly say that the attempt by the metatherians to have their embryos develop within the mother before birth was only partial as the young are born in the early stage of development. The nutritive link between the mother and developing embryo was not supportive enough to allow the embryo to develop fully. Kangaroos are found in Australia and Papua New Guinea. Opossums are marsupials found in North and South America. Possums are medium-sized arboreal marsupial species native to Australia, New Guinea, and Sulawesi (one of the four larger Sunda Islands of Indonesia) and introduced to New Zealand and China. Koalas are naturally found in Australia. All these animals are not native to us here in Nigeria.

Fig. 34: A: Female Kangaroo with Newborn Kangaroo (joey) in Mother's Pouch. B: Young Kangaroo feeding on its Mother's Milk by placing its Head inside Her Pouch.
Source**:** Corbis/© Microsoft Corporation.and Buddy Mays/Corbis
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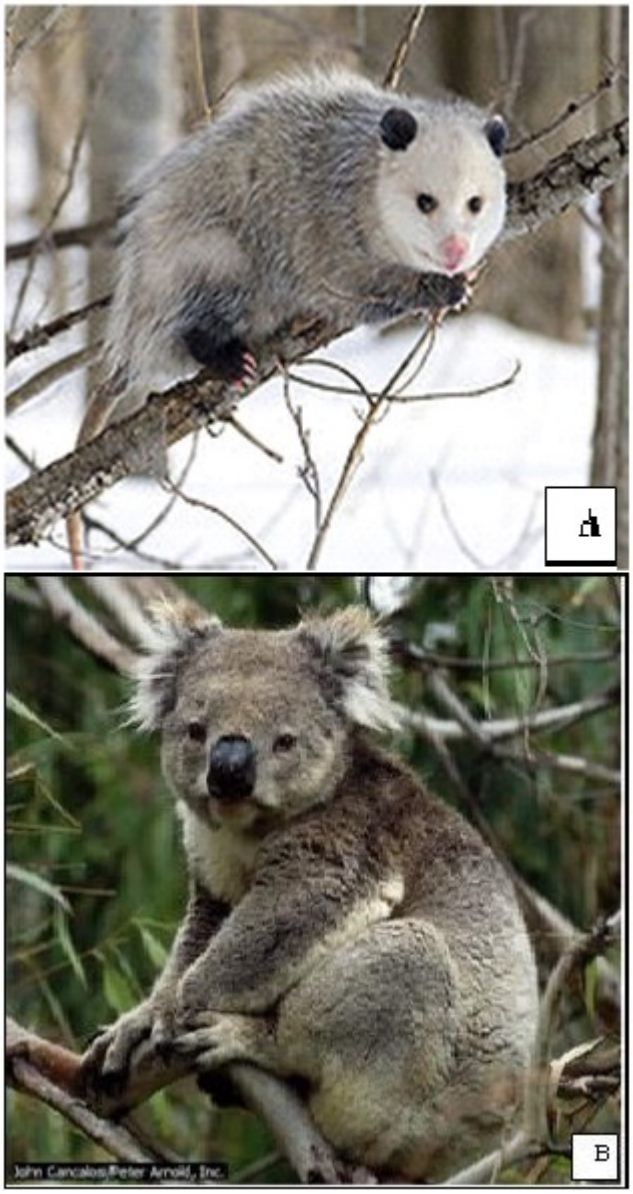

Fig. 35: **A: Virginia Opossum** (*Didelphis virginiana)* **B: Koala** (Koala is in danger of becoming extinct - see Daily Trust Newspaper, Nigeria, 13th November, 2009, p. 36).
Source: **A**: http://en.wikipedia.org/wiki/Opossum **B**: Pat and Tom Leeson/Photo Researchers, Inc. and John Cancalosi/Peter Arnold, Inc. Microsoft ® Encarta ® 2009. © 1993-2008 Microsoft Corporation

Opossums (*Didelphimorphia*) make up the largest order of marsupials in the Western Hemisphere. The word *opossum* means "white dog" or "white beast/ animal". The koala has large, sharp claws used in climbing tree trunks. The Virginia opossum is North America's only marsupial. A marsupial is an animal with a pouch, like a kangaroo or a koala. The opossum has been around for at least 70 million years and is one of Earth's oldest surviving mammals.

The opossum is about the size of a large house cat. It has a triangular head and a long pointed nose. It has grayish fur everywhere but on its ears, feet and tail. Its tail is prehensile. A prehensile tail is adapted for grasping and wrapping around things like tree limbs. The opossum can hang from its tail for a short time. Some people think opossums hang from their tails and sleep, but they do not. Their tails are not strong enough to hold them for that.

The koala's five fingers include two opposable thumbs, providing better gripping ability. The first two fingers are positioned in apposition on the front paws, and the first three fingers for the hind paws. The koala is one of the few mammals (other than primates) that have fingerprints very similar to human fingerprints.

Infraclass Eutheria (placentals)

This group of mammals, also known as the placentals, is characterised by having a placenta - a reproductive structure, which is housed in the uterus of the female by which the developing embryo connects to the mother to get nutritive support.

The offspring of eutherians receives all its nutritional needs through the placenta that links it to the mother to develop into a fully developed organism before birth. The period of development (gestation period) varies with the species of mammal but undoubtedly longer than in the metatherians that we have just described above. For example, the gestation period in the whale is two years, in the mouse 21 days, and in humans nine months. These mammals are the most abundant and diverse of the class representing 94% of the species of mammals. They include those animals we come across or are with us in and around our homes; humans are eutherians.

4.0 CONCLUSION

Mammals are vertebrates that have mammary glands for feeding their young, which may come from shelled eggs as monotremes, or borne live but prematurely as in metatherians, or fully developed through placental support as in eutherians. They have true hairs and nails, and constant body temperature.

5.0 SUMMARY

In this study, we have described mammals as vertebrates with the following main characteristics:

- mammary glands
- hairy skin with keratin
- a single jaw bone on either side
- four-chambered heart
- muscular diaphragm**.**

We also saw that mammals are grouped into two subclasses namely Prototheria and Theiria.

We described the prototherians (monotremes) as mammals with the following features:

- shelled eggs like reptiles
- single opening – the cloaca (like reptiles) for both urine/faeces discharge and copulation,
- testes are not in scrotum but retained in body cavity
- penis lies within the cloaca
- homeothermic though body temperature is maintained at low temperature of 30-33°C so also is the basal metabolic rate
- mammary glands (though not truly mammary glands), that produce a fatty sweat (milk) from glands in the skin. The milk collects and drips down tufts of hair into the offspring's mouth.

We treated the therians under two groups namely, the metatherians and the eutherians.

The metatherians were described as therians with a pouch (marsupium) i.e. a built-in baby carrier, where the embryo completes its development after it has been delivered in the very early stage of development. The pouch is like an incubator where premature babies are kept to fully develop. Animals in this group include kankaroos and opossums, which are found in the Australian sub-continent. Finally, we described the Eutherians as mammals that have a placenta - a reproductive structure, which is housed in the uterus of the female by which the developing embryo has a nutritive connection to the mother. These animals include cows, dogs, cats and humans.

6.0 TUTOR-MARKED ASSIGNMENT

i. Identify and list mammals you see in your immediate environment.
ii. Describe the characteristic features of any named mammal on your list.
iii. What will you consider as the major single difference between the prototherians and the therians?

iv. Compare and contrast the characteristic features of reptiles and protherians.
v. What is the significance of the pouch in the life of metatherians? Which medical equipment in hospital that can be equated with the pouch?
vi. Unlike in the metatherians, the young of the eutherians is fully developed at birth. Explain.

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UNIT 2 EUTHERIANS: PROBOSCIDEA, SIRENIA, CARNIVORA

CONTENTS

1.0 INTRODUCTION

In the first unit of this module, we introduced you to the Class Mammalia. We described the characteristic features of the class and its two subclasses i.e. Prototheria and Theria. Under the subclass Theria, we described the two infraclasses Metatheria and Eutheria. The eutherians were described as mammals with placenta – a nutritive support link between mother and embryo; with such a nutritive support, the gestation period in eutherians is long enough to allow the embryo to develop fully before birth. In this unit, we shall focus our attention on the various orders in Eutheria by highlighting the various characteristic features that distinguish one order from the other.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- describe three eutherian orders namely Proboscidea, Sirenia and Carnivora
- distinguish and recognise members of these orders.

3.0 MAIN CONTENT

3.1 Characteristics of Order Proboscidea (e.g. elephant)

Most members of this order are extinct. The last living proboscideans are the elephants, the only extant members of the family Elephantidae. They include *Elephas* (Asian elephants) and *Loxodonta* (African elephants).

Members of this mammalian order are well known for having:

- Trunks, tusks and loose skin

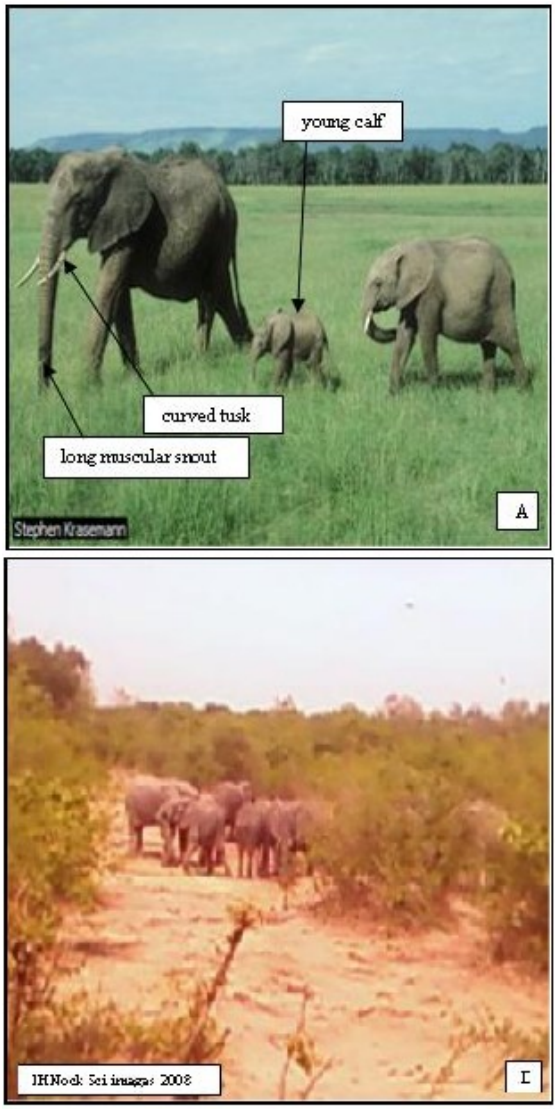

Fig. 36: **A**: **Female Savanna Elephant *(Loxodonta*) with her Calf.** The Savanna Elephant ***(Loxodonta africana***) is the largest of the three species of elephants. It lives in grasslands and drier woodlands throughout Kenya, Tanzania, Botswana, Zimbabwe, Namibia, Nigeria, and South Africa. **B: A Herd of Wild African Elephants** at Yankari National Park, Bauchi State, Nigeria.
Source: **A:** Oxford Scientific Films/Courtesy of Hollywood Edge and Stephen Krasemann. Microsoft ® Encarta ® 2009. © 1993-2008 Microsoft Corporation (modified by labeling). **B**: I.H.Nock Science images, 2009

A well known member of this group is the elephant, an animal we are all familiar with in zoos, and wild life parks. Elephants are huge mammals characterised by a long muscular snout and two long, curved tusks. They are highly intelligent and strong. Elephants are the largest land animals and are among the longest lived, with life spans of 60 years or more. The female elephant carries her young in her womb for 22 months (gestation period). Generally healthy, full-grown elephants have no natural enemies other than humans. African elephants live in grassy regions south of the Sahara Desert. They are dark grey in colour with the bull (male) standing about 3.4 m (11 ft) tall and weighing about 5.4 metric tons, while the cow (female) stands 2.8 m (9 ft) tall and weighs about 3.6 metric tons. They have no sweat glands and that explains why they like to cool off by rolling in ponds and streams. The mud that dries on their skin provides protection from the sun.

3.2 Characteristics of the Order Sirenia (e.g. manatees, dugongs)

The eutherians in this order are characterised by the following features:

- aquatic habitat
- finlike forelimbs
- vestigial hind limbs
- tails elongated to caudal fins.

Fig. 37: **A**:**Manatee B**: **Dugong** – the sea-cow (See animal feeding on sea grass)
Source: **A:** http://en.wikipedia.org/wiki/Manatee **B**: *http://*en.wikipedia.org/wiki/Dugong

Manatees (*Trichechus*) are aquatic eutherians that feed on aquatic plants. They look like whales but are actually relatives of elephants. Manatees are found in shallow coastal waters and rivers in the southeast United States, the Caribbean, northeast South America and West Africa. The dugongs are found in Indian and western Pacific Oceans. West Indian manatee and Indian dugong are commonly called the sea cows. These aquatic eutherians are not within our waters and thus, not on the list of animals we are familiar with.

3.3 Characteristics of Order Carnivora (e.g. dogs, cats, lions, bears, raccoons, seals)

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

Fig. 38: A: Female Cat Breastfeeding Her Puppies B: Dogs (right)
Source**:** I.H.Nock Science images, 2009

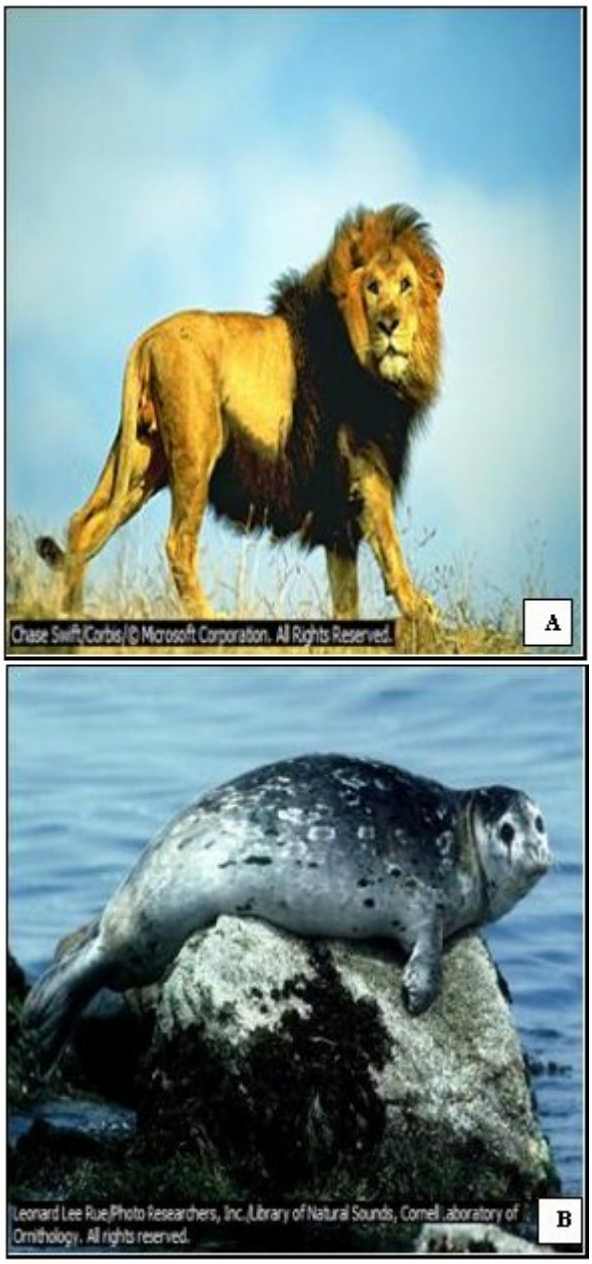

Fig. 39: A: Lion B: Harbour Seal (Harbour seals live on the coastline in many different parts of the world. They grow to be about 6 feet (about 2 metres) long).
Source: **A:** Chase Swift/Corbis/© Microsoft Corporation, Microsoft Corporation Microsoft ® Encarta ® 2009. © 1993-2008. **B:** Leonard Lee Rue/Photo Researchers, Inc./Library of Natural Sounds, Cornell Laboratory of Ornithology

The diverse order Carnivora (flesh devourer) includes over 260 species of placental mammals. Members of this order formally referred to as carnivorans, while the word "carnivore" (often popularly applied to members of the group) can also refer to any meat-eating animal.

Carnivorans are the most diverse in size of any mammalian order, ranging from the least weasel (*Mustela nivalis*), as little as 25 g to the polar bear (*Ursus maritimus*), which can weigh up to 1,000 kg, to the southern elephant seal (*Mirounga leonina*), whose adult males weigh up to 5,000 kg. Apparently, one may not easily figure out what these animals have in common that warrants grouping them together. Think of it, the aquatic seal does not have any noticeable semblance with the land animals such as dogs, cats or the lion, but are described as carnivorans on account of their flesh-eating habit, which is supported by the nature of their dentition dominated by sharp canines and molars for tearing flesh.

There is need to point out that the carnivorous nature of some of these animals has changed over time from being exclusively obligate carnivores as in lions and polar bears, to being omnivores as in domestic cats and dogs. Some, such as the giant pandas, are almost exclusively herbivores but will take fish, eggs and insects when available. Carnivorans have teeth, claws, and binocular vision adapted for catching and eating other animals.

4.0 CONCLUSION

Eutherians of the order Proboscidea have trunks, tusks and loose skin, the order Sirenia are aquatic with finlike forelimbs, non-functional hind limbs and tails elongated to form caudal fins, while members of the order Carnivora have sharp canine and molar teeth for tearing flesh.

5.0 SUMMAY

In this unit, we have examined eutherian orders: Proboscidea, Sirenia and Carnivora. We described the members of the order Proboscidea, represented by the elephants, as eutherians with trunks, tusks and loose skin.

The order Sirenia represented by the manatees and dugongs were described as eutherians with:

- aquatic habitat
- finlike forelimbs
- vestigial hind limbs
- tails elongated to caudal fins.

The last order described in this unit was Carnivora, which is quite a diverse group with eutherians such as dogs, cats, lions and the aquatic seals. They are known to have sharp canine and molar teeth for ripping flesh.

6.0 TUTOR-MARKED ASSIGNMENT

i. Describe the characteristic features of the order Proboscidea, Sirenia and Carnivora.
ii. Take a critical look at the teeth of a dog or cat and that of goats or sheep or any herbivore around you. Which are the dominant teeth in each group of these animals and why?
iii. Take a critical look at the pictures of the lion and the habour seal in Plate 4 above. Give reasons for their classification under the same order?

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UNIT 3 EUTHERIANS: EDENTATA, ARTIODACTYLA, CETACEA

CONTENTS

1.0 INTRODUCTION

In this unit, we shall be looking at three additional orders of the eutherian mammals namely, Edentata, Artiodactyla and Cetacea. We shall, as we have treated other orders above, describe the characteristic feature of each order.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- describe the three eutherian orders of Edentata**,** Artiodactyla and Cetacea
- distinguish and recognise members of each order by their characteristic features.

3.0 MAIN CONTENT

3.1 Characteristics of Order Edentata (armadillos, sloths)

Members of this eutherian order are known to:

- have reduced or no teeth
- lack enamel (the hard thin calcium-containing covering of the crown of a tooth)
- have heavily clawed forelimbs for burrowing.

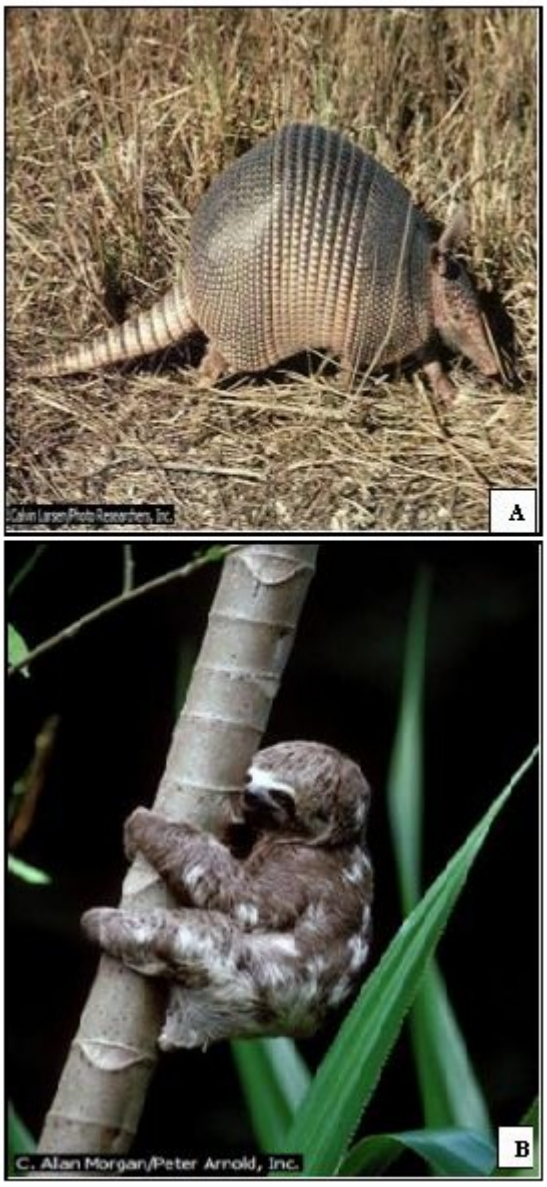

Fig. 40: A: Armadillo B: Pale-throated three-toed Sloth
Source**: A:** Calvin Larsen/Photo Researchers, Inc. Microsoft ® Encarta ® 2009. © 1993-2008 Microsoft Corporation. **B:** C. Allan Morgan/Peter Arnold, Inc, Microsoft ® Encarta ® 2009. © 1993-2008 Microsoft Corporation

All Armadillos are hard bone-plated animals. The hard armour-plated carapace which covers their bodies may just be one-solid armour in some while in others; the armour is constructed of hinged bands, which allow the creature to roll into a ball. Most are about the size of a cat but the giant armadillo reaches 0.9 m (3 ft) in length and can weigh 59kg (130 lbs).

Armadillos are found in the southern part of the United States and in Central and South America. The sloths are generally known as lazy animals on account of their sluggish movement. Indeed, they are the

slowest mammals. A sloth spends most of its days alone, hanging upside down from tree branches, feasting on leaves. On account of its sedentary habit, algae grow in its fur and this helps the animal to camouflage from its predators such as birds. The pale-throated three-toed sloth, *Bradypus variegatus*, with its black face and white band across the forehead, is found in Honduras and Argentina.

3.2 Characteristics of the Order Artiodactyla (e.g. sheep, pigs, cattle, deer, antelopes, giraffes, hippopotamus)

Members of this order have:

- hooves with even number of toes (e.g., 2, 4)
- a bone in the ankle joint (astragalus) with a double-pulley structure that gives the foot greater flexibility.

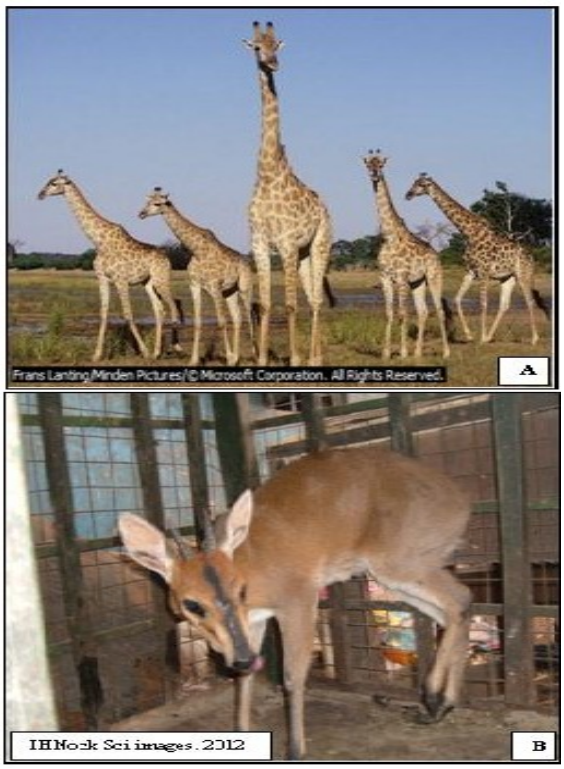

Fig. 41: **A Giraffes** - the tallest land animals, with some growing as tall as 6 m (20 ft). **B:** A **Deer** (caged for sale along the Kaduna-Zaria expressway)
Source: **A:** Frans Lanting/Minden Pictures/© Microsoft Corporation. Microsoft ® Encarta ® 2009. © 1993-2008 Microsoft Corporation and www.uen.org/utahlink/activities/view_activity.
B: I. H. Nock Science images, 2012

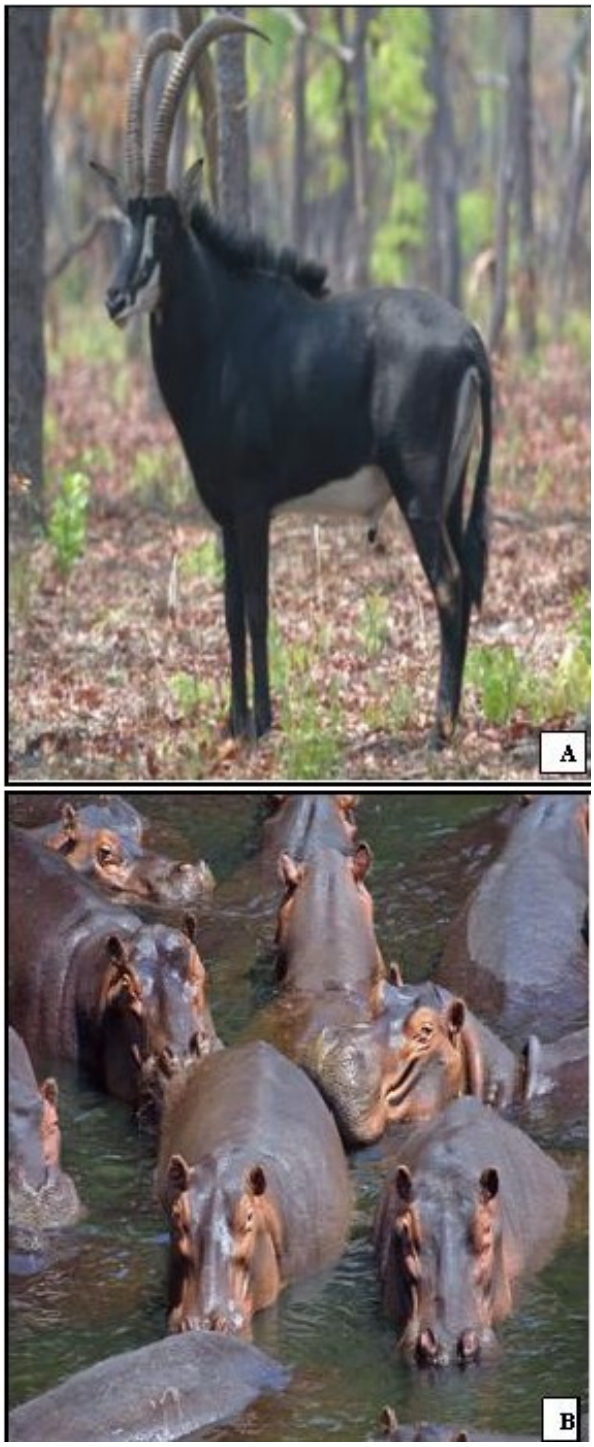

Fig. 42: **A: Sable Antelope Bull among Trees in African savanna. B:** Hippopotamus in water
Source: A http:/en.wikipidia.org/wiki/antelope (accessed 15th January, 2012) **B:** http:/en.wikipidia.org/wiki/File:Hippo_pod_edit.jpg.(accessed 15th January, 2012)

The artiodactyls are a large and remarkably diverse group of mammals. The majority live in relatively open habitats, such as plains and savannahs, but others dwell in forests, and one group is semi-aquatic.

Within this order are some of the fastest-running mammals such as the antelopes and deer, and the relatively slow moving species such as pigs and hippopotamus. Artiodactyls are paraxonic (i.e. the plane of symmetry passes between the third and fourth digits). In all species the number of digits is reduced at least by the loss of the first digit, and the second and fifth digits are small in many. The third and fourth digits, however, remain large and bear weight in all artiodactyls. This pattern has earned them their name Artiodactyla, which means "even-toed.

3.3 Characteristics of the Order Cetacea (e.g. whales, dolphins)

Members of the order Cetacea 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).

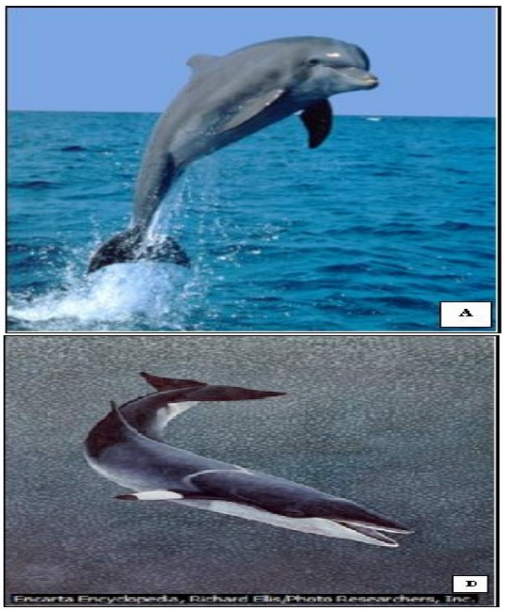

Fig. 43: **A: Dolphin B: Minke Whale** (see the flipper-like forelimbs and the characteristic elongated tail that ends in two horizontal lobes) Source: **A:** www.dolphinsc.com/images/Dolphin.jpg. Microsoft ® Encarta ® 2009. © 1993-2008 Microsoft Corporation. **B:** Richard Ellis/Photo Researchers, Inc. Microsoft ® Encarta ® 2009. © 1993-2008 Microsoft Corporation

Cetaceans are relatively large, generally characterised by streamlined bodies that glide easily through the marine environment. The Cetacea are one of the most distinctive and highly specialised orders of mammals. They include the largest animal that has ever lived, the blue whale; the highly intelligent and communicative dolphins; the tusked narwhals and blind river dolphins and singing humpback whales - nearly 80 living species in all. Although hunting and other human activities have endangered most cetacean species, the outlook for many is improving. Whales are highly specialised for life in the water. Most species are marine but dolphin species are found in the Yangtze, Amazon, Paraná, Indus and Ganges Rivers. Whales have stream-like bodies with highly compressed neck vertebrae, dorsal fins, and a tail with two finlike flukes arranged horizontally. Modern whales have greatly elongated anterior skull bones, and the nostrils are located on the top of the head, forming the blowhole. The forelimbs are specialised to form flippers, and the hind limbs and pelvis are extremely small and do not normally extend out of the body wall of the animal.

4.0 CONCLUSION

The order Edentata is characterised by animals with reduced or no teeth, reduced teeth without enamel, and heavily clawed forelimbs. The artiodactylans are animals with even number of toes. Members of the order Cetacea are aquatic, have blowholes on their heads, flipper-like forelimbs, they have vestigial hindlimbs and elongated tails that end in two horizontal lobes.

5.0 SUMMARY

In this unit, you were introduced to three eutherian orders namely:
Edentata, which we described as eutherians that:

- have reduced or no teeth
- lack enamel (the hard thin calcium-containing covering of the crown of a tooth)
- have heavily clawed forelimbs for burrowing.

Artiodactyla, which have:

- hooves with even number of toes (e.g. 2, 4) and

Cetacea, which we described as:

- aquatic
- having blowholes on their heads
- having flipper-like forelimbs
- having vestigial hindlimbs

- having elongated tails that end in two horizontal lobes (like a caudal fin).

6.0 TUTOR-MARKED ASSIGNMENT

i. Visit a livestock farm or an abattoir. Name any members of the order Artiodactyla you see there. Give the features that aided your identification.

ii. Take a critical look of the hooves of at least two of the members of the order Artiodactyla. How many toes does each have? Make good drawings of the toes.

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UNIT 4 EUTHERIANS: PERISSODACTYLA, CHIROPTERA, INSECTIVORA

CONTENTS

1.0 INTRODUCTION

In this unit, you will learn about another three additional orders of eutherians namely; Perissodactyla, Chiroptera and Insectivora. Attempts will be made to characterise each order and present photographs of some members of each order so as to help you identify and recognise them.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- describe the three eutherian orders of Perissodactyla, Chiroptera and Insectivora
- distinguish and recognise members of each order by their characteristic features.

3.0 MAIN CONTENT

3.1 Order Perissodactyla (e.g. horses, zebras, rhinoceroses, tapirs)

Members of this eutherian order have the following characteristics:

- hooves with odd number of toes (e.g. 1, 3)
- the middle toe on each hoof is usually larger than its neighbour.
- relatively large grazers and, unlike the ruminant even-toed ungulates (artiodactyls), with relatively simple stomachs because they are hindgut fermenters, digesting plant cellulose in their intestines rather than in one or more stomachs.

Fig. 44: **A: Zebra B: Horse**
Source**:** G.I. Bernard/Oxford Scientific Films and Elisabeth Weiland/Photo Researchers, Inc. Microsoft ® Encarta ® 2009. © 1993-2008 Microsoft Corporation

Fig. 45: A Hoof of a Horse (one-toed ungulate)
Source**:** http://en.wikipedia.org/wiki/Odd-toed_ungulate (12th February, 2012)

Members of this order have odd number of toes. Odd-toed ungulates comprise the order Perissodactyla (uneven finger/toe). The middle toe on each hoof is usually larger than its neighbours. In all species, the third digit is the most prominent on all feet; the plane of symmetry (the dividing line) of the foot passes through this digit; on this basis, the perissodactyls are said to have a mesaxonic foot. The first digit (equivalent to the thumb or big toe of humans) is lost in all species. Perissodactyls are truly unguligrade, with the heel, sole, and digits of the foot never touching the ground.

3.2 Characteristics of the Order Chiroptera (e.g. bats)

This order is well represented by bats, which are mammals:

- capable of flight
- wings derived from skin-folds which extend from fingers to body and legs.

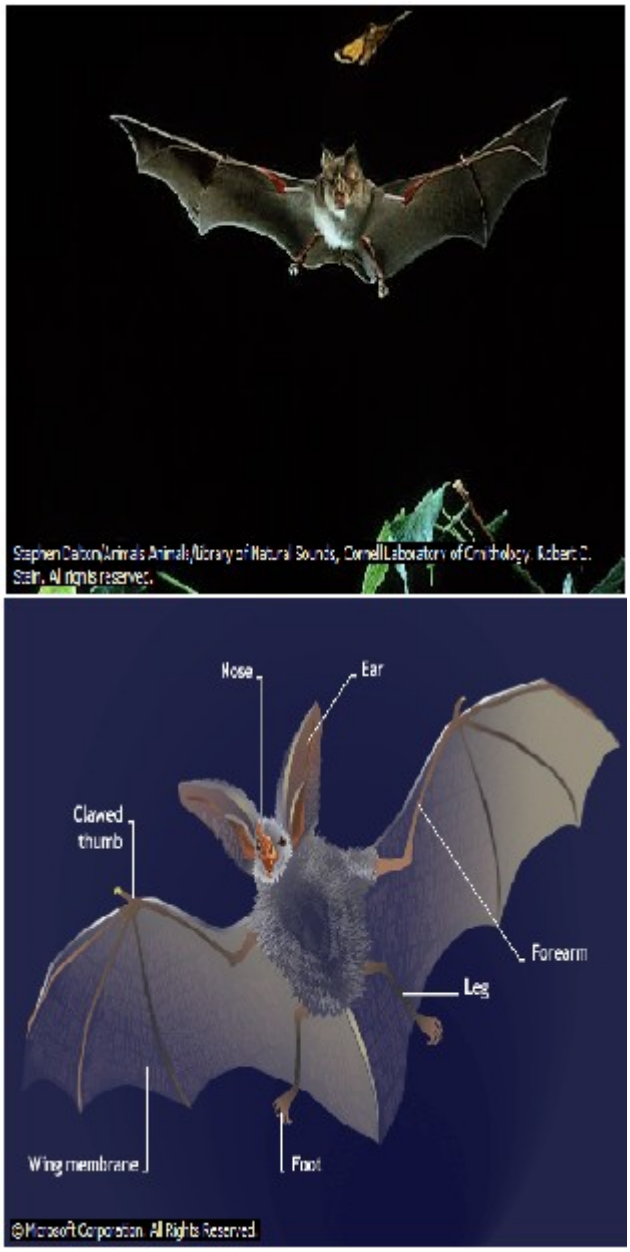

Fig. 46: Bats

Source**:** Stephen Dalton/Animals Animals/Library of Natural Sounds, Cornell Laboratory of Ornithology, Robert C. Stein. All rights reserved.© Microsoft Corporation. Microsoft ® Encarta ® 2009. © 1993-2008 Microsoft Corporation

The bat is the only mammal naturally capable of true and sustained flight. A bat's wings are supported by bones of the forelimbs, like those in human hand. Each wing has a clawed thumb that the bat uses for clinging to trees, cave walls, or buildings. Other mammals said to fly, such as flying squirrels, gliding possums, and colugos, glide rather than fly, and can only glide for short distances. Bats do not flap their entire forelimbs, as birds do, but instead flap their spread-out digits, which are very long and covered with a thin membrane.

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

A notable feature of these eutherian mammals is that:

- they feeds on insects
- they are mostly nocturnal
- Majority are terrestrial, many burrowing in the ground, although a few are arboreal and others aquatic.
- have plantigrade or partially plantigrade feet i.e. they apply the whole or the greater portion of the soles to the ground when walking; and generally have five toes, each terminating in a claw.

Fig. 47: A:**Hedgehog (note body spines) B:Mole (note the extra thumb and apparent lack of eyes)**
Source: **A:** I. H. Nock Sci. images, 2011 **B**:
http://en.wikipedia.org/wiki/mole

The name Insectivora (insect eater) refers to the food habit of the group as a whole. Although shrews and moles are not all strictly insectivorous, insects and other small animal life constitute the chief dietary items of most members of the group. Hedgehogs are mammals with long, pointed

spines and soft, furry bellies. When threatened, they roll into a ball such that their spines point in all directions. Moles are small mammals with large claws that spend most of their time underground. Moles have polydactyl hands; each hand has an extra thumb (also known as a prepollex) next to the regular thumb. Moles are nearly blind; they use their sense of touch to navigate their dark burrows. Moles are found in Australia and South Africa.

Fig. 48: A Shrew
Source: http://www.bbc.co.uk/nature/life/Common_Shrew

Shrews are active day and night, but mostly after dark. They are active most of the time, resting for only a few minutes between bursts of activity. Shrews are common in our environment and give out a sharp sound when confronted by humans, dogs, cats etc. They are not liked by cats because they have a pungent smell.

4.0 CONCLUSION

Eutherians of the order Perissodactyla have hooves with an odd number of toes, Chiroptera are mammals capable of flight and Insectivora feed largely on insects.

5.0 SUMMARY

In this unit, we have, like in previous units, examined and described three orders namely:

Perissodactyla (e.g. horses, zebras, and rhinoceroses), which have hooves with odd number of toes (e.g. 1, 3)

Chiroptera (e.g. bats) described as eutherians capable of flight; have wings derived from skin-folds which extend from fingers to body and legs

Insectivora (e.g. hedgehogs and moles), was described as eutherians that feed on insects as their main dietary item.

6.0 TUTOR-MARKED ASSIGNMENT

i. Attempt to locate a horse anywhere you can find one. Take close look at its hoof. How many toes does it have?
ii. Looking at the external features of a bat in the order Chiroptera above, one may describe it as a bird. On what basis is the bat considered a mammal and a eutherian but not a bird?

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UNIT 5 EUTHERIANS: RODENTIA, LAGOMORPHA, PRIMATA

CONTENTS

1.0 INTRODUCTION

In this unit, we shall be looking at the last three orders of the eutherians, which contain members that we all know and often in contact with. The order Rodentia contains members such as rats, mice, Guinea pigs etc. The Lagomorpha include members such as rabbits and hares while the order Primata contains humans and their close relatives – the apes and monkeys.

2.0 OBJECTIVE

At the end of this unit, you should be able to:

- describe the characteristic features of the three eutherian orders namely Rodentia, Lagormorpha and Primata.

3.0 MAIN CONTENT

3.1 Characteristics of the Order Rodentia (e.g. mice, rats, squirrels, marmots, capybara, beavers, porcupines, hamsters, Guinea pigs)

Rodentia is an order of mammals characterised by:

- two continuously-growing chisel-like incisors in the upper and lower jaws which must be kept short by gnawing
- no canine teeth
- diastema (space/gap between teeth).

Forty per cent of mammal species are rodents, and they are found in vast numbers on all continents other than Antarctica. Common rodents include mice, rats, squirrels, porcupines, beavers, guinea pigs, and hamsters. Rodents have sharp incisors that they use to gnaw wood, break into food, and bite predators. Most rodents eat seeds or plants, though some have more varied diets. Some species have historically been pests, eating seeds stored by people and spreading disease.

Fig. 49: **A: Capybara B: Beaver (*Castor*)**
Note the characteristic flat and broad tail of the beaver. Source:
A: http://en.wikipedia.org/wiki/Capybara (accessed 12th January, 2012)
B: http://en.wikipedia.org/wiki/ Beaver (accessed 12th January, 2012)

The capybara (*Hydrochoerus hydrochaeris*) is the largest extant rodent in the world (weighing up to 91 kg). Its closest relative is the guinea pig. The rodent is native to South America where it inhabits savannas and dense forests and lives near bodies of water. It is a highly social species and can be found in groups as large as 100 individuals but usually live in groups of 10-20 individuals. The capybara is not a threatened species though it is hunted for meat and skin. The beaver (genus *Castor*) is primarily nocturnal, large and semi-aquatic. Beavers have flat and broad tails (Figure 49 above) and sharp front teeth. They use their teeth to cut down trees for wood to build lodges and dams. They build dams to provide still, deep water to protect against predators, and to float food and building material. The North American beaver population was once over 60 million, but as of 1988 was 6-12 million. This population decline is due to extensive hunting for fur, for glands used as medicine and perfume, and because their harvesting of trees and flooding of waterways may interfere with other land uses. They are the second-largest rodent in the world (after the capybara).

Fig. 50: A: **Porcupine B: Sharp Quills/Spines of Porcupines**
(porcupine spines are used locally by women in Nigeria for braiding/parting hair)
Source**: A:** Raymond A. Mendez/Animals, Microsoft ® Encarta ® 2009**.** © 1993-2008 Microsoft Corporation. **B**: http://upload Wikimedia.org/commons/f/f1/Stekelvarken_Aiquilles_Porc%C3%A9pi c.jpg

Porcupines (spined pigs) are rodents with a coat of sharp spines, or quills, which the animal uses for defense or camouflage from predators. They are indigenous to the Americas, southern Asia and Africa. Porcupines are the third largest of the rodents (63-91 cm long; 5.4-16 kg), behind the capybara and the beaver. They are rounded, large and slow moving and are usually brown, grey, but rarely white. The common porcupine is an herbivore; it eats leaves, herbs, twigs and plants like cabbage, clover or the bark of trees. In Nigeria, the meat of porcupines is eaten as a delicacy (bush meat).

Fig. 51: **A: House Mice B: Chipmunk - Squirrel**
Source: Tom McHugh/Photo Researchers, Inc.and S. J. Krasemann/Peter Arnold, Inc. Microsoft ® Encarta ® 2009. © 1993-2008 Microsoft Corporation

Mice are small rodents found all over the world. The common house mouse (Figure 51A) can be destructive, causing damage and eating up crops, and spreading disease through their faeces. Squirrels are generally small animals with slender bodies, bushy tails and large eyes. Their fur

is generally soft and silky, although much thicker in some species than others. Squirrels live in almost every habitat from tropical rainforest to semi-arid desert, avoiding only the high polar regions and the driest of deserts. They are predominantly herbivorous, subsisting on seeds and nuts, but many will eat insects and even small vertebrates.

3.2 Characteristics of the Order Lagomorpha (e.g. rabbits, hares, pikas)

Members of this order include rabbits and hares that we, to some extent, are familiar with. They have in common:

- four continuously-growing chisel-like incisors for gnawing
- diastema (space/gap between the teeth)
- wholly herbivorous
- strong hind legs for running and jumping.

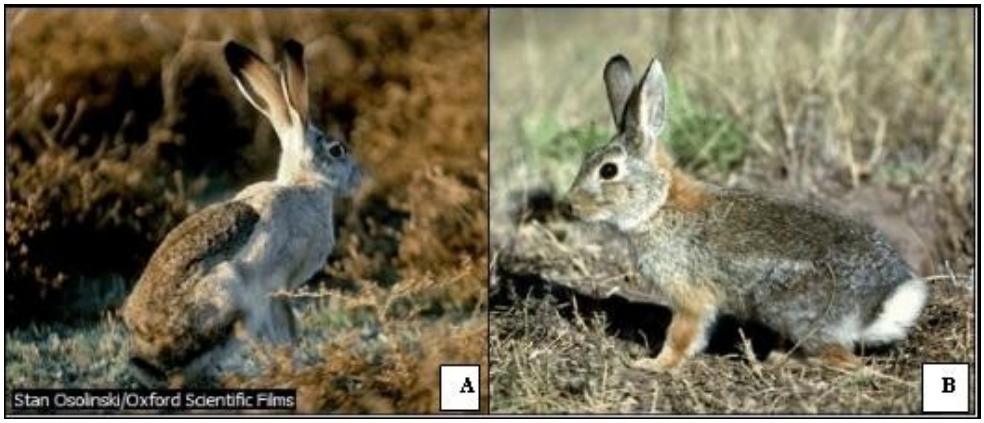

Fig. 52: A: Hare B: Rabbits
Source: Stan Osolinski/Oxford Scientific Films. Microsoft ® Encarta ® 2009. © 1993-2008 Microsoft Corporation

Hares are normally wild and have relatively longer ears than rabbits and usually larger than rabbits. Hares are born with fur on the body and with open eyes, and the adults merely construct a simple nest and rarely live in colonies. Rabbits have been domesticated and give birth to hairless offspring with closed eyes, and tend to live in colonies in underground burrows. Both of these animals are found in Nigeria and are very much loved for their meat.

Fig. 53: A: **New Zealand Rabbit. B: American Pika (*Ochotona*)**
Source**: A:** I.H.Nock Science images, 2012;**B:**
http://en.wikipedia.org/wiki/Pika

New Zealand rabbits have well-rounded bodies; slender and muscular faces with round cheeks; large, long back feet; and small, short front pectoral muscles, long perforated ears that stand straight up, bright eyes, and thick, snowy fur on their bodies. They are generally used for scientific research however the meat is eaten as a delicacy in Nigeria. Pikas are small mammals of America and parts of Europe. They have short limbs and rounded ears. Like rabbits, they are herbivores.

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

We come to an interesting order of the eutherians, in which includes monkeys, apes and humans are accomodated. This is where we belong together with our close relatives - the monkeys and apes. So what do we have in common with monkeys and apes that warrant our being put together in the same order? As primates, we share the following characteristics:

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

Fig. 54: A: The Mangabey Monkey B: Apes (right)
Source: **A:** McHugh/Photo Researchers, Inc. **B:** Daniel J. Cox/Liaison Agency/© Microsoft Corporation. Microsoft ® Encarta ® 2009. © 1993-2008 Microsoft Corporation

Apes (chimpanzees, gorillas, and gibbons) are larger than monkeys and do not have tails. Their arms are also usually longer than their legs.

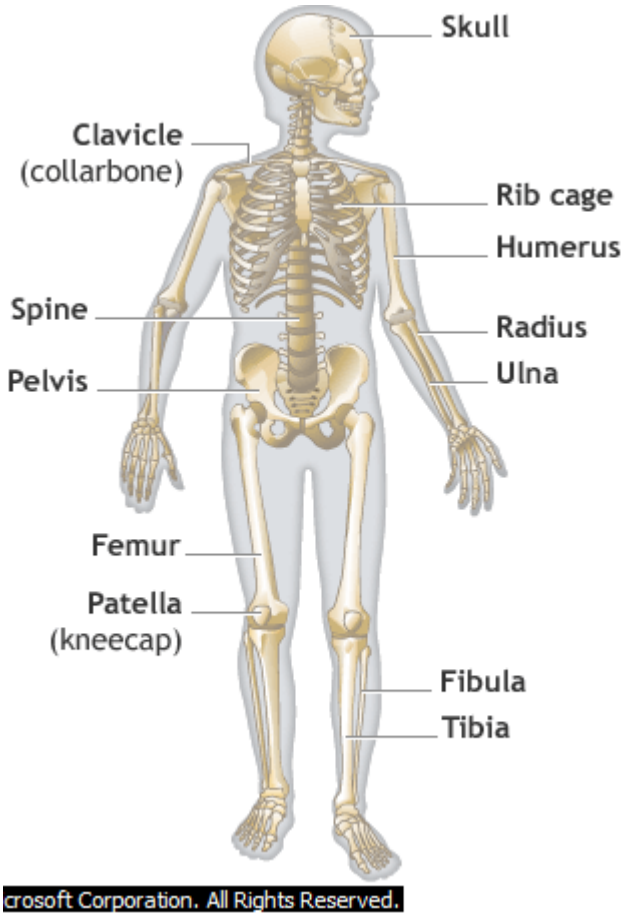

Fig. 55: The Human Skeletal System

Source: © Microsoft Corporation. Microsoft ® Encarta ® 2009. © 1993-2008 Microsoft Corporation

The human body contains 206 bones of various shapes and sizes. Bones protect our internal organs and support our body as we stand, sit, walk, and run.

4.0 CONCLUSION

We have described members of the order Rodentia as having two continuously chisel-like incisors, the Largomorpha as having four continuously growing chisel-like incisors and with strong hind legs for running and jumping, while members of Primata have highly developed cerebral cortex.

5.0 SUMMARY

In this unit, we have examined three mammalian orders namely:

Rodentia (e.g. mice, rats, beaver. squirrel), which we described as eutherians with two continuously growing - chisel-like incisors in the upper and lower jaws.

Lagomorpha (e.g. hares, rabbits), which have:

- four continuously chisel-like incisors for gnawing
- strong hind legs for running and jumping.

Primates (e.g. monkeys, apes, humans), which share the following characteristics:

- highly developed cerebral cortex.
- opposable thumbs.
- forward facing eyes
- omnivorous

6.0 TUTOR-MARKED ASSIGNMENT

i. How will you distinguish the rat from the rabbit by looking at their teeth?
ii. How will you distinguish the hare from the rabbit?
iii. How will you distinguish the monkey and the ape?

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MODULE 4 EVOLUTION, ADAPTIVE RADIATION AND ZOOGEOGRAPHY

UNIT 1 EVOLUTION OF CHORDATES

CONTENTS

1.0 INTRODUCTION

This unit is devoted to the evolution of chordates. In other words, we shall be discussing the origin of chordates and attempt to paint a picture of how changes occurred from the simplest invertebrate form of chordates leading to the emergence of more complex vertebrate form terminating with the mammals. It must be emphasised that the Theory of Evolution, like classification, is also in a state of flux - ever changing as new facts emerge to explain away the position previously held.

2.0 OBJECTIVE

At the end of this unit, you should be able to:

- discuss the evolution of chordates.

3.0 MAIN CONTENT

3.1 General Principle of Evolution

When we talk of evolution, we are simply referring 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). The changes in a given generation may be small and not sufficient to cause any noticeable change but can accumulate with each generation and can, over time cause substantial changes in the population resulting in the emergence of new species. For example, if we say that mammals evolved from reptiles, that would mean that changes occurred in reptiles and accumulated over many generations and over time (usually millions of years), the changes became substantial leading to the emergence of new organisms in the form of mammals.

According to the theory of evolution, all known species of organisms descended from a common ancestor (or ancestral gene pool) and came into being through a process of gradual change and divergence as we have highlighted above. Accordingly, inheritable material i.e. genes are passed on from generation to generation giving an organism its inherited traits or what you might call its make-up. These traits (inherited characteristics) vary within populations, with organisms showing heritable differences (variations) in their traits in the course of time.

So we may ask, what causes the change that eventually leads to the emergence of new organisms? New variants arise in a population by two main ways, either from mutations (random changes) in genes or from the transfer of genes between populations and between species. New combinations of genes are also produced by genetic recombination, which can increase variation between organisms. Through these methods, variants either become more common or rare. Two major mechanisms determine which variants will become more common or rare in a population. One is natural selection, 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. This occurs because organisms with advantageous traits are more likely to reproduce such that more individuals in the next generation will inherit these traits and thus promote the survival of the traits. Over many generations, adaptations occur through a combination of successive, small, random changes in traits, and natural selection of the variants best-suited for their environment. This is what we generally referred to as the survival of the fittest. The second major mechanism is genetic drift, which is an independent process that produces random changes in the frequency of

traits in a population. Genetic drift results from the role that chance plays in whether a given trait will be passed on as individuals survive and reproduce.

The relative importance of natural selection and genetic drift in a population varies depending on the strength of the selection and the effective population size, which is the number of individuals capable of breeding. Natural selection usually predominates in large populations, while genetic drift dominates in small populations. The dominance of genetic drift in small populations can even lead to the fixation of slightly deleterious mutations. As a result, changing population size can dramatically influence the course of evolution. Population bottlenecks (where the population shrinks temporarily and therefore loses genetic variation) result in a more uniform population.

With this background knowledge on evolution, we shall now attempt to explain the evolution of chordates.

3.2 Evolution of Chordates

It is believed that chordates originated from invertebrates. It has however been difficult to determine which invertebrate group the chordates developed from, chordate ancestors were soft bodied animals and thus were not preserved as fossils. Unlike the previously held position that chordates evolved from hemichordates, it is now thought that chordates evolved from urochordates. This explains why hemichordates are no longer considered as chordates.

In attempts to work out the evolutionary relationships of the chordates, several hypotheses have been produced, but the current consensus is that chordates are monophyletic, that is they have a single common ancestor, which itself is a chordate. In other words, chordates evolved from primitive chordate ancestors. It must be emphasized that there is still no universal agreement as to the origin of chordates. However, the most celebrated hypothesis on the evolution of chordates is that by Garstang. Garstang's Hypothesis noted the similarity between the tadpole larva and a fish. He proposed that a sea squirt (Urochordata: see Module 1, Unit 4 above) tadpole larva might have been the ancestor of the vertebrates, if it never matured or metamorphosed. This process is called **pedomorphosis** - i. e. the evolutionary retention of juvenile or larval traits in adults. In other words, an ancestral tunicate gave rise to the higher chordate groups through an evolutionary process (pedomorphosis) whereby structural and swimming characteristics of the tunicate tadpole larva were retained into adulthood. Through this

process, the tunicate ancestral line is thought to have evolved into the larger swimming chordates.

Evolution is accompanied by morphological, anatomical and physiological changes. As much as we can, we shall attempt to show the trend of changes that occurred in the course of the evolution of chordates. We shall however focus our attention on few selected changes, which are mainly morphological in nature.

You would recall that we included the hemichordates amongst the Chordates (which is the old tradition) in order to broaden our understanding of the evolution of chordates. In describing the hemichordates, we referred to them as half chordates because, amongst other things, their support structure i.e. the notochord -called the stomochord is rudimentary in nature and therefore not a true notochord. Furthermore, the so-called notochord is restricted to the proboscis region of the animal. We can argue that the primitive form of the hemichordates must have had a much rudimentary notochord than that of the modern hemichordates.

With the exclusion of the hemichordates from the phylum Chordata, the most primitive chordates are the urochordates (tunicates). In tunicates, the chordate characteristics can be observed only by examining the entire life cycle. The adult feeds using a 'pharyngeal basket', a type of pharyngeal gill formed into a mesh-like basket. Cilia on the gill draw water into the mouth, through the basket mesh and out through the exhalent siphon. Tunicates have an unusual heart which pumps by 'wringing out'. It also reverses direction periodically.

You would recall that the tunicates are usually hermaphroditic, often casting eggs and sperm directly into the sea. After fertilisation, the zygote develops into a 'tadpole larva'. It is only in this swimming larva that the remaining three chordate characters i.e. notochord, dorsal nerve cord and post-anal tail manifest.

Arising from the tadpole were the lancelets (Cephalochordes) that live in shallow tropical sandy-bottom environments. The advancement to the cephalochordates was accompanied by the development of a strong supportive notochord that runs the full length of the animal and angled muscles along the body used for brief periods of swimming, such as when the animal is dislodged from the sand. In this animal, we also saw the emergence of a distinct head and the concentration of the feeding apparatus in the head region. They stick their heads out of the sand and feed somewhat like a tunicate. Cilia-driven currents 'suck' water into the mouth and across the pharyngeal gills.

At this stage, further changes gave rise to the first aquatic vertebrates - the pisces (fishes).

Here, the next group of chordates to evolve was the jawless fish (Agnatha). Modern representatives of this group are the hagfishes and lampreys (see Unit 2 Module 2). Hagfishes are generally deep-water marine scavengers. They burrow into the mud, sticking their heads out until they detect waterborne odors of food such as decaying flesh. Hagfish are clearly an evolutionary intermediate between lancelets and fish. Although better swimmers than lancelets, they lack the jaws, paired fins and gill covers of true fishes. Instead, they have a fin-like flap of skin along the body, and only simple pore openings for the gill chamber. The affinities between Cephalochordates and the hagfish/lamprey group are most striking when the larva of the lamprey (ammocoetes larva) is examined. These larvae strongly resemble lancelets, with the addition of a pumping gill chamber. Although hagfish and lampreys do not have a segmented vertebral column, their notochord is somewhat calcified and stronger than that of cephalochordates. Here too, we noted an improvement in cephalisation with a brain encased in a cranium.

Over time, the pace of chordate evolution picked up with the evolution of a variety of groups of fishes. The major ancestral fish line first acquired paired fins. One descendant line acquired a cartilaginous skeleton (chondrichthyes) leading to one of the most successful and ancient group of fishes, the sharks and rays. Another ancestral line developed calcified bones (osteichthyes) and ray-fins stiffened with spines. It is thought that lungs evolved from the bony fishes to supplement ‘gill breathing’.

It is speculated that one line of ancient lobe-finned fishes evolved the ability to walk on land over time. This evolution is said to have happened when a combination of conditions allowed previously uninhabitable land to be colonised by plants, insects and other invertebrates. Indeed, land invasion by chordates was linked, at least in part, to the availability of prolific, essentially untapped, food resources (mostly insects). This thought is centred on the mudskipper (crawling fish), which provides an excellent model for the movement of chordates from water to land over 400 million years ago. Mudskippers live in mangrove swamps where they feed both in water and on the land. They move about by ‘walking’ with their pectoral and pelvic fins. One line of lobe-finned fishes eventually developed good abilities to walk over land, and although these ancient land chordates are said to have began with 8 digits on their feet, their line eventually led to the 5-toed, 4-legged tetrapod ancestor to all modern land vertebrates. This ancestral line split into several groups. One group, the Amphibia, retained more ancestral

features including the dependence on water to complete their reproductive cycles.

To be on land, the amphibians had to develop efficient lungs to replace the gills used for gaseous exchange in fishes. In addition, they developed moist skin; which supplemented gaseous exchange by their not too efficient lungs. Similarly, two pairs of pentadactyl limbs also evolved to replace fins as organs of locomotion which were needed to walk on land. This resulted in the emergence of the four legged chordates we earlier referred to as the tetrapods including amphibians, reptiles, birds and mammals. All this development however did not position the amphibians well for life on land as they have to return to water for fertilisation of eggs and development of the immature stage in the form of tadpole which, like fish, breath via gills. That explains why you see frogs and or toads returning to water to lay eggs from which the immature tadpole stage hatches and develops. The eggs are not protected by any shell and cannot withstand desiccation and therefore the need for water. The ability to live in both water and on land gave rise to the name amphibians, meaning "double life." Amphibians were the first vertebrates to live on land. However, they returned to the water to breed.

Next is the emergence of other groups from water through the development of a fluid-filled package to hold the developing embryo - the egg. Of these ancestral groups, one developed scales leading to modern reptiles and to the dinosaurs. The dinosaurs finally died out millions of years ago but evidence now clearly indicates that a group of dinosaurs developed feathers to give rise to birds.

Reptiles emerged better equipped for life on land than the amphibians. A better and more efficient lung system evolved and the moist skin of amphibians gave way to a dry scaly skin that is impervious to gases and also used to prevent water loss. Furthermore, they developed strong limbs and eggs with a leathery shell for protecting the eggs. In addition, the developing embryo was held in a liquid-filled space encased by an amniotic membrane giving the semblance of the ancestral pond associated with aquatic life. The amniotic membrane therefore first appeared in reptiles before advancing to other members of amniota (birds and mammals). The eggs also have a large yolk as food source for the developing reptile, which hatches as a miniature adult, unlike amphibians that hatch into tadpoles before developing to adults. In reptiles, we observed copulation and internal fertilisation of eggs in contrast to external fertilisation in fishes and amphibians.

From reptiles came birds and mammals. The birds evolved a more efficient lung system than reptiles. The scaly skin in reptiles however gave way to feathers. However, the scaly skin was retained on the lower part of the hind limbs of birds. We are sure you must have noticed scales on the legs of birds that you come across in your environment. The most outstanding feature that accompanied the evolution of birds from reptiles was the modification of the pair of forelimbs to wings, while the leathery shell that covered the eggs of reptiles gave way to a more protective hard calcareous shell in birds. With such calcareous shelled eggs, birds were able to nest and dwell on land.

The evolution of mammals from reptiles was accompanied by the development of dermal hairs in follicles with sebaceous and sweat glands, mammary glands for milk production, and a diaphragm that separated the thorax from the abdomen. However, mammals evolved along two lines giving rise to the prototherians (monotremes) and the therians. In the course of evolution, the protherians maintained some reptilian features such as laying shell eggs, having a single opening (cloaca) for the passage of urine, stool and genital products, low body temperature between 30°C and 33°C (though homoeothermic), and a lower basal metabolic rate than other mammals. The monotremes, represented by the duck-billed platypus and echidna, are both restricted to the Australasian region. You would recall that in our study of monotremes, we said that the leathery egg of echidna hatched into a 'larva', which remained in the mother's pouch and fed off a patch that secreted milk - a primitive mammary gland.

The therians on the other hand showed remarkable advancement by having shell-less eggs that are retained in the female thus allowing embryonic development to takes place in the mother. By this, the stage was set for giving birth to live young. Based on the nature of the placenta, the therians were divided into metatherians and eutherians. The metatherians are considered primitive because their placenta-like structure is poorly developed and its function is complemented by a yolk sac as in reptiles. This limited the time needed for the embryo to fully develop in its mother as seen in the pouched mammals - the marsupials e.g. kangaroo. Here, embryonic development lasts for a just a month after which the underdeveloped is delivered 'prematurely' and then nursed in a pouch for seven months to develop fully. In the eutherians, the placenta supports the developing embryo by providing nutrition and removal of waste until the embryo is fully developed to an advanced mature stage before delivery. In other words, the placenta provides a complete and not a partial nutritive connection between the mother and the embryo; on account of this, they are considered to be most diverse and successful group of mammals. It needs be mentioned that over

evolutionary time, some members of the group have also returned to the sea.

In presenting the evolution of chordates as above, we have taken just some few structural

changes to illustrate the point. Indeed, there are many other features that we did not consider. For this level of study, we took a simplistic approach by leaving out the estimated timing (period) at which each group of chordates is said to have evolved from one stage to the other. We also left out the controversies surrounding some groups concerning their evolutionary links with their ancestors. You must realise that as classification is continuously changing so is the concept of evolution especially now that modern tools in genetics are being employed to generate new information.

4.0 CONCLUSION

Chordates have evolved from an ancestral stock with a flexible notochord to more rigid cartilaginous or bony vertebral column, showing remarkable adaptations from life in water to life on land.

5.0 SUMMARY

As diverse as they may first seem, the chordates represent a unified monophyletic line of evolution in the animal portion of the tree of life. Living chordates, such as sea squirts, larvaceans, lancelets, hagfish, sharks, bony fish, salamanders, turtles, snakes, birds, and mammals all reflect descent from a common ancestor with the four chordate characteristics i.e. notochord, dorsal nerve cord, post anal tail and pharyngeal gill. We humans belong to one tiny branch on this section of the tree of life.

6.0 TUTOR-MARKED ASSIGNMENT

i. Show how the eggs of chordates have adapted to the process of evolution from amphibians to mammals.
ii. Reptiles are better adapted to life on land than amphibians. Discuss.

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UNIT 2 ADAPTIVE RADIATION OF CHORDATES

CONTENTS

1.0 INTRODUCTION

In this unit, we shall be looking at the fallout of evolution, especially, how this has caused speciation in animals, leading to adaption to new environments.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- explain what adaptive radiation means
- discuss how chordates adapted to new environments.

3.0 MAIN CONTENT

3.1 Adaptive Radiation of Chordates

By adaptive radiation, we mean the emergence of diverse group of organisms from an ancestral form into several different forms that adapt to different environments. Adaptive radiation describes the rapid speciation of a single or a few species to fill many ecological niches. It often occurs when a species is introduced into a new ecosystem, or when a species can survive in an environment that was previously unreachable or that has suddenly changed. This is an evolutionary process driven by mutation and natural selection.

The dynamics of adaptive radiation is viewed within the context that within a relatively short time, many species evolve from a single or a few ancestor species. From this large number of genetic combinations, only a few can survive long term. After the rapid development of many new species, many or most of them die out as quickly as they appeared. This is what is often described as the survival of the fittest as stated

earlier on. The surviving species are almost perfectly adapted to the new environment. The rise and fall of new species is now progressing very slowly, compared to the initial outburst of species.

Adaptive radiation is facilitated by geographic isolation whereby a population of animals reaching a new area gradually becomes isolated from the parent stock and eventually becomes distinct over time. Even in a given area, it is possible to have diversity of habitats which may create diverse populations of the same animals. For example, in an area with deciduous forest, grassland and marsh etc., you may find different species of an organism inhabiting each niche. It is also possible to have two or more species inhabiting one place/area but specialised to take different foods or to forage in different ways. In other words, a group/species may enter a new adaptive zone and by natural selection begin gradual changes which may lead to them doing things completely different from the usual pattern of the parent stock. Such specialisation ultimately results in a number of genetically distinct but similar-looking species over time. This commonly occurs when a species colonises a new habitat in which it has little or no competition. For example, a flock of one species of bird may arrive on some sparsely populated islands. Finding little or no competition, the birds may evolve rapidly into a number of species, each adapted to one of the available niches. The most celebrated example of adaptive radiation is that reported by Charles Darwin on his visit to the Galápagos Islands off the coast of South America. Based on his observations, he reasoned that one species of finch (a bird) colonised the islands thousands of years ago and through the gradual process of adaptation gave rise to the 14 species of finch-like birds that exist there now. Darwin observed that the birds look very similar but differ greatly in the appearance of the shape of their bills, which arose from adaptation to their mode of eating. Some species possessed large beaks for cracking seeds. Others had smaller beaks for eating vegetation, and still others featured long, thin beaks for eating insects.

It is believed that the birds (Darwin's finches – as they come to be known) developed from a single species, of which over time, radiated into many species that adapted to the various niches available on the islands. Darwin observed that the mainland finches were all of one type, possessing short straight beaks for crushing seeds. On the Galápagos Islands, however, he recorded **13** species that fell into six main types, each having a beak specially adapted for dealing with a particular kind of food. The Galápagos finches exploit a wide range of ecological niches, which on the mainland are already occupied by other groups of birds. It was observed that the large ground finches, which were closest

to the mainland finches in food and habit, had a typical finch-like beak for crushing seeds.

In contrast to the large ground finches, the cactus ground finches have a long straight beak and split tongue for getting nectar out of the flowers of the prickly pear cactus available there. The vegetarian tree finch, on the other hand, has a curved parrot-like beak with which it feeds on buds and fruits. Those that feed on insects (insectivorous tree finches) have a similar beak which they use for feeding on beetles and other small insects. Then there is the warbler finch, which is so like a true warbler that at first it was thought to be one. It uses its slender beak for feeding on small insects which it catches as it flies like a true warbler. But the most remarkable of all the Galápagos birds is the woodpecker finch. This resembles true woodpeckers in its ability to climb up vertical tree trunks and bore holes in wood in search of insects. The true woodpecker uses its long tongue to seek out the insect, whereas the woodpecker finch, not having a long tongue, picks up a small stick or cactus spine in its beak and pokes this into the hole. When the insect emerges the bird drops the stick and devours the insect. Quite apart from its evolutionary implications, this remains an interesting case of tool-using by an animal other than humans.

There are three basic types of adaptive radiation:

1. **General adaptation**: In this situation, a species develops a radically new ability which enables it reach new parts of its environment. For example birds able to fly.

2. **Environmental change**: Here a species, in contrast to the other species in the ecosystem, successfully survives a radical changed environment and then branches into new species that cover the new ecological niches created by the environmental change. An example of the result of an environmental change is the rapid spread and development of mammalian species after the extinction of the dinosaurs. Radical environment change can also be caused by hurricanes and tsunamis that can wipe out life in an area to near extinction.

3. **Archipelagoes**: This refers to isolated ecosystems, such as islands and mountain areas such as the Galapagos Islands visited by Charles Darwin. Here, new species which upon establishing itself undergoes rapid divergent evolution as was the case with the Darwin's finches.

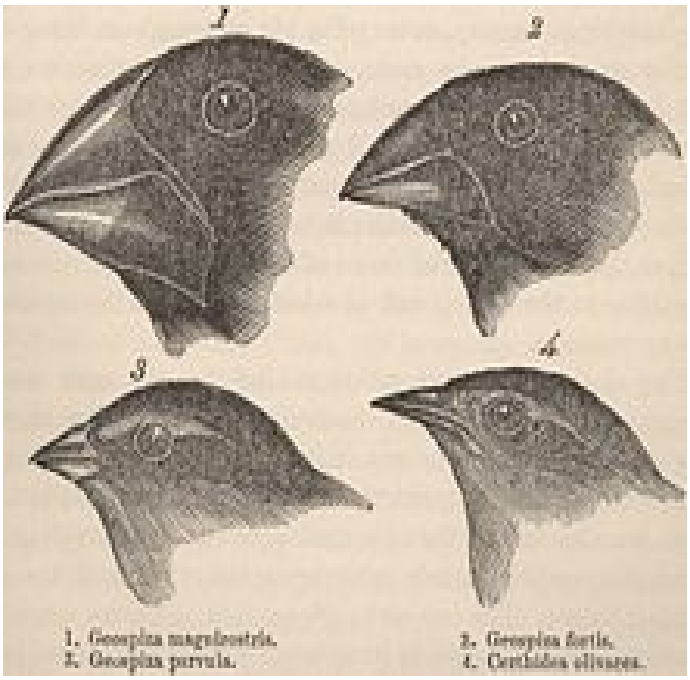

Fig. 1: Some Galapagos Finches showing different Beak Shapes

1). Large ground finch (*Geospiza magnirostris*) 2). Medium ground finch (*Geospiza fortis*) 3). Small tree finch (*Camarhynchus parvulus*) 4). Warbler finch (*Certhidea olivacea*)

The birds vary in size from 10 to 20 cm and weigh between 8 and 38 grams. The smallest is the Warbler Finch and the largest is the Vegetarian Finch. The most important differences between species are in the size and shape of their beaks; the beaks are highly adapted to different food sources.

4.0 CONCLUSION

Adaptive radiation occurs when a single species evolves into several species, each adapting and filling a unique ecological niche.

5.0 SUMMARY

In this unit, we have learnt what adaptive radiation is all about and the driving force behind it. We defined adaptive radiation as the emergence of diverse groups of organisms from an ancestral form, which adapt to different environments. We illustrated adaptive radiation with the most celebrated example, observed and reported by Charles Darwin on his visit to the Galápagos Islands, off the coast of South America. We learnt that the 14 species of finch-like birds that exist today on the Islands came from one species of finch (parent stock) that colonised the islands thousands of years ago, and through the gradual process of adaptation

gave rise to what we see there today. Finally, we also learnt that adaptive radiation is of three basic types namely General Adaptation (where a species develops a radically new ability, such as ability to fly, to reach new parts of its environment; environmental changes (whereby a species survives a radical change in the environment and gradually evolves into a new organism adapts to the new environment) and Archipelagoes (where a species evolves into a new species on account of being isolated by a landform e.g. an island).

6.0 TUTOR-MARKED ASSIGNMENT

i. What do you understand by adaptive radiation?
ii. Imagine a strong tsunami hitting an island, causing its shores to be submerged under water such that only a grain-eating bird species survived. Paint a scenario of possible adaptive radiation whereby the surviving bird species had only insects to feed on.

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UNIT 3 ZOOGEOGRAPHY OF THE NEARTIC AND NEOTROPICAL REGIONS

CONTENTS

1.0 INTRODUCTION

We are bringing our study to a close by looking at the global distribution of vertebrates.

You would recall that during the course of previous unit, we mentioned the animals that are found in our environment and those that are restricted to certain parts of the globe. For example, in describing the monotremes (Unit 1, Module 3), we said they were not found anywhere but in Australia and New Guinea. We were indirectly talking about zoogeography, which is the study of the distribution of animals across the globe. In this unit, we shall look at zoogeography in more detail and then highlight the major animals found in two of the six zoogeographic regions of the world - Neartic and Neotropical regions.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- explain what zoogeography is all about
- describe the major vertebrate fauna in the Neartic and Neotropical regions.

3.0 MAIN CONTENT

3.1 Zoogeography

Zoogeography may be defined as the scientific study of the areas where different animals live and the causes and effects of such distribution,

especially distributions on a large or global scale. In other words, zoogeography is the study of the patterns of the past, present, and future distribution of animals (and their attributes) in nature and the processes that regulate these distributions. It is the scientific analysis of the spatial and temporal patterns of biodiversity. Zoogeography is often divided into two main branches: "ecological zoogeography" and "historical zoogeography". In the former, the role of present day/current biotic and abiotic interactions in influencing animal distributions is investigated; the latter is concerned with historical reconstruction of the origin, dispersal, and extinction of taxa.

With this definition in mind, we shall attempt to show the distribution of vertebrates worldwide. Generally, these animals have characteristic patterns of distribution on the land masses. As animals increase in number by reproduction, they redistribute themselves in all directions. Dispersal continues until a barrier is reached. The reason for such discontinuous distribution of related groups may be due to the development of the barriers or due to the extinction of forms in the intermediate area. The question we may ask is how did this distribution come about? To a large extent, the answer remains hypothetical although some have been supported by fossil evidence. We can attempt to answer this question by using adaptive radiation as a tool. Looking at the map of the world below, you will find that South America, Africa and Australia are separated from one another by great bodies of water. Evidence suggests that in the geological past, the continents constituted one large land mass. A theory holds that the main group of modern mammals arose somewhere in the northern hemisphere (for instance, Europe) and then migrated to in three major directions: to South America through the Isthmus of Panama; to Africa via the Strait of Gibraltar, and to Australia via the South East Asia. As earlier mentioned, the migration took place before the land masses were separated. Once the animals got to the various continents, they presumably became isolated from one other by various barriers, including the submergence of the strip of land between North and South America, giving rise to the Isthmus of Panama, which caused the separation of South America. Africa too was cut by the Strait of Gibraltar; the desert in the north of Africa brought further isolation within the African continent. The connection between Southeast Asia and Australia was also severe, leading to the separation of Australia. The isolated animals then evolved along their own lines such that many different forms arose filling every available habitat (a situation we earlier described as adaptive radiation). Let us illustrate by an example supported by fossil evidence. Let us look at the camel family (Camelidae), which is represented by the present-day camel in Africa and Asia, and by the llama in South America. Fossil records suggest that

the evolution of camels started in South America from where they migrated across the Bering Straits into Asia and then to Africa, and through the Isthmus of Panama into South America. Once they were isolated, they began to evolve along their own lines giving rise to the modern camels we see in Africa and Asia and the llama in South America. This type of distribution, in which a group of organisms has representatives in widely separated localities, as we have seen in camels, is said to be discontinuous.

We shall now attempt to look at the distribution of vertebrates across the globe. According to Darlington (1957), the continents of the whole world can be divided into six zoogeographic regions, namely:

1. Nearctic region
2. Neotropical region
3. Palaearctic region
4. Afrotropical (Ethiopian) region
5. Oriental region
6. Australian region.

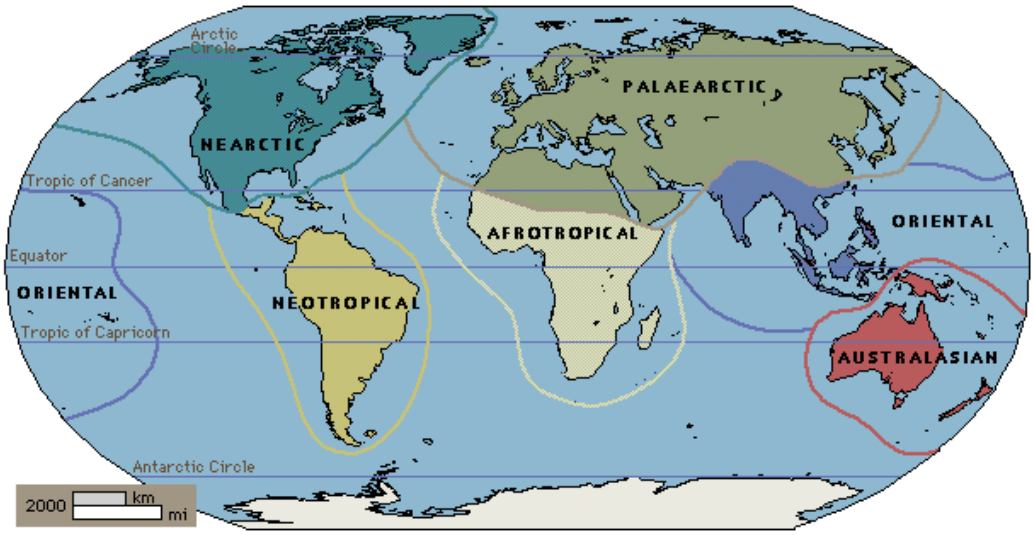

Fig. 2: Zoogeographical Regions of the World
Source:http://encarta.msn.com/media_461536032_761577282_-1_1/Zoogeographic_Regions.html. (accessed 15th September, 2009)

The world's land area is divided into six zoogeographic regions, each with different fauna. Within these regions, animals are grouped by the particular habitat they occupy. Land animals will tend toward habitats based on factors such as indigenous food and availability of natural protection from predators.

3.2 Fauna of the Nearctic Region

The Nearctic region covers most of North America, including Greenland and the highlands of Mexico. This region is known as the headquarters of urodels (i.e. the tailed amphibians). The Nearctic region shows great variation in climatic conditions and temperatures. In North Greenland, ice is seen. There is a range of mountains extending from North to South. In the South west of North America there are deserts.

The region has the following four sub regions:

1. **California Sub-region**: This includes part of North America, Nevada and Cascade ranges, and part of British Columbia. Vertebrates like vampire bats and free-tailed bats are found in this sub-region.
2. **Rocky mountain sub-region**: It includes mountains of East California which provides habitation for terrestrial vertebrates such as goats, Prairie dogs and lizards.
3. **Alleghasy Sub-region**: This area includes the rocky mountain area and lakes of the Eastern parts of U.S.A. vampire bats, star-nosed moles, opossums, wild turkeys and Carolina parrots are found here.
4. **Canadian Sub-region**: It includes the remaining parts of North America and Greenland. Bison, polar bears, arctic foxes and reindeers are its common fauna.

The fauna of the Nearctic region include:

- **Fishes**: Catfishes, garpike, paddle fishes, and cyprinodonts.
- **Amphibians**: Amphiumas, salamanders, toads (*Bufo*) and frogs (*Hyla* and *Rana*).
- **Reptiles**: Numerous reptiles such as musk turtle, trionyx, emydines, alligators, ophiosaurs, and vipers.
- **Birds**: Pelicans, herons, humming birds, woodpeckers, mocking birds, larks and sand-pipers.
- **Mammals**: Mammals such as squirrels, moles, rabbits, beavers, cats, bats, deer, bears, weasels, opossum, porcupine and armadillo.

3.3 Fauna of the Neotropical Region (bird continent)

This region includes South America, Central America, Mexico and the West Indies, which have tropical conditions. The southern part of South America has temperate zones with luxuriant forests and deserts, plains and rivers. In the Amazon area, thick evergreen forests occur. In

addition, grassy plains are present in Argentina; The Andes Mountains are also included. These conditions give rise to good vegetation that is rich in fauna, particularly birds.

Like the Neartic region, the Neotropical region is also divided into 4 sub- regions:

1. **Chilean Sub-region**: It includes the West Coast of South America. It contains the Andes mountain range, Bolivia, Peru and Argentina. It houses the three-toed Ostrich called *Rhea americana* and the oil birds.
2. **Brazilian Sub-region**: It includes tropical forests of South America. It shows evergreen forests and plains. Rivers are also present and hence richer vegetation. The sub-region supports rich fauna such as monkeys, vampire bats and armadillos.
3. **Mexican Sub-region**: This is the area north of the Isthmus of Panama. This region contains the Rocky Mountains, with sub-tropical conditions. Tapirs and mud-terrapins etc. are common.
4. **West Indies or Anthelia Sub-region**: The region contains the West Indies islands (without Trinidad and Tobago). The islands are mountainous, with poor vertebrate fauna.

The fauna in the Neotropical region include:

- **Fishes**: Catfishes, Dipnoi and lepidosiren (also called freshwater lung fish).
- **Amphibians**: Frogs (*Pipa pipa*, *Hyla*, *Bufo*, *Rana* etc.) are common. Urodeles are very few.
- **Reptiles:** The reptiles of this sub-region resemble those of the Ethiopian and Oriental zones; these include crocodiles, alligator, turtles, tortoises, lizards, and many snakes.
- **Birds:** The avian fauna of this region is striking and peculiar, for this reason South America is called bird continent. Birds include *Rhea americana* (3 toed ostrich) - American Ostrich, Tinamus (flightless bird endemic to this region), ducks, pigeons, parrots, swifts, wood peckers, king fishers, starks, ant thrushers, tree creepers, and oil birds, which are endemic to this region only.
- **Mammals:** New World monkeys, armadillos, sloths, ant eaters, didelphis, tapiers, deers, squirrels and rabbits.

4.0 CONCLUSION

Zoogeography describes the distribution of animals across the globe including the Nearctic and Neotropic regions, which we have examined in this unit.

5.0 SUMMARY

In this unit, we have learnt about the distribution of animals over the globe (zoogeography) and attempted to explain how they all came about. We learnt that the world can be divided into six zoogeographic regions namely:

1. Nearctic region
2. Neotropical region
3. Palaearctic region
4. Ethiopian region
5. Oriental region
6. Australasian region.

We then took a close look at the Nearctic and Neotropical regions and their rich fauna.

6.0 TUTOR-MARKED ASSIGNMENT

i. Define zoogeography and attempt to explain how animals are distributed over the globe.
ii. Name the zoogeographic regions of the world. Which region is known as the 'bird continent' and why?

7.0 REFERENCES/FURTHER READING

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UNIT 4 ZOOGEOGRAPHY OF THE PALAEARCTIC AND AFROTROPICAL REGIONS

CONTENTS

1.0 INTRODUCTION

In continuation of our study on zoogeography, we shall, in this unit, be looking at two zoogeographic regions namely, Palaearctic and Afrotropical along with their respective fauna.

2.0 OBJECTIVE

At the end of this unit, you should be able to:

- describe the Palaearctic and Afrotropical zoogeographic regions and their respective fauna.

3.0 MAIN CONTENT

3.1 Fauna of the Palaearctic Region

This region is described as the largest of the six zoogeographic regions covering an area of 36, 259,834 km^2 (14,000,000 $miles^2$). The region is comprised of Europe, Asia, North of Himalayas and Northern parts of Africa. This region shows wide range of temperature fluctuations and rainfall. It includes the polar arctic region. On its Northern side it shows temperate conditions. Eastern Asia shows deciduous forests. In the Northern region 'Steppe' grasslands are present.

The region therefore shows wide fluctuations in physical and climatic features, which support good fauna.

The Palaearctic region, like the other regions described earlier, is divided into four sub-regions. These are:

1. **European Sub-region**: Northern and central Europe, Black sea and caucasus rare included in it. It is represented by 85 families of vertebrates. Amphibians and reptiles are represented with six families each. Myogale, only one genus of mammal is present. Bird like Tits, wagtails, mammals like wolf and moles are common in this sub-region.
2. **Mediterranean Sub-region**: Remaining parts of Europe; Africa and Arabian portions are included in it. 124 families of terrestrial vertebrates occur here. Birds, like upupa and Pastor, mammals such as elephants, hyenas and porcupines are seen in this sub-region.
3. **Siberian sub-region**: Northern Asia, Himalayas are included in it. 94 families of vertebrates are included in it. Families of musk deer and moles are confined to this sub-region.
4. **Manchurian Sub-region**: This area includes Mangolia, Japan, Korea, and Manchuria where Mammals like Tibetan langur, Great Panda, Tufted deer, and Chinese water deer are common.

Put together, the fauna of the Palaearctic region is represented by:

Fishes: Paddle fishes, *Cyprinus*, Anabas and sucker fish (Echenis) are present.

Amphibians: Frogs (*Discoglossus*, *Bufo*, *Hyla*, *Rhacophorus*, Salamanders such as Proteus, *Megalobatrachus*), and a number of tailed amphibians (Urodels) are common.

Reptiles: Snakes (Vipers, *Natrix*, *Dasypettis*), lizards (Monitor), tortoises are common reptiles of the sub-region.

Birds: Hawks, cuckoos, rails, finches and crows are present but without parrots.

Mammals: We have mammals such as camels, deer, wolves, horses, pigs, hedgehogs, bats, beavers, dogs, cats, squirrels, rabbits, mice, bats and moles.

It is said that the vertebrate fauna of the Palaearctic Region is not very rich and shows overlap with the fauna of the Nearctic Region.

3.2 Afrotropical (Ethiopian) Region

This region, also refers to as the Ethiopian region, includes Africa, Southern part of Arabia and the Island of Madagascar. Afrotropical

region shows extensive desert on the North side i.e. the Sahara desert. On its Western side is thick forests while the rest of Africa is green land. This region is also divided in four sub regions. These are:

- **East African Sub-region**: This region includes tropical Africa and tropical Arabia where high temperature desert conditions prevail; the Sahara desert is included in this sub-region. Animals such as giraffe, zebra, camel, ostrich etc., are common.
- **West African Sub-region**: This sub-region is characterised by thick forest and heavy rainfall. River Congo is included in this region. Because of its rich flora, the sub-region supports a whole range of good fauna including gorillas, gibbons, apes, birds, elephants, panthers, lions , rats, snakes, are present.
- **South African Sub-region**: This comprised of the Southern part of the African continent. It shows peculiar fauna such as Secretory birds, African moles, rats, bandicoots and the South African lung fish (*Protopterus).*
- **Malagasy Sub-region**: This sub-region includes Madagascar and nearby islands and it is well known chameleons which are more popular. It is said that the island got separated from the main land after the development of lemurs, and it is represented by old animals as no fresh evolution takes place there.

When taken together, the fauna of the Afrotropical region is comprised of:

Fishes: Fish fauna is diverse in this region. These include the African freshwater lungfish (*Protopterus*), sharks, tuna fishes, catfishes, cyprinids, electric fishes etc.

Amphibians: This fauna is distinctive. It is represented by Cicaelians (amphibians without limbs, frogs, toads (including *Xenopus* - the African clawed toad, is exclusively in this region). This region is devoid of tailed amphibians such as salamanders.

Reptiles: The reptiles are represented by Chameleons (which characterise the region), crocodiles, tortoises (*Testudo*), turtles (*Trionyx*), lizards (including the flying lizard), and snakes (rattle snakes, cobras, vipers, pythons etc.).

Birds: The most important birds of this region are the two toed-ostrich (*Struthio camelus*). Others include, horn bills, herons, pigeons, parrots, cuckoos, storks, finches, hammer-headed birds, the mouse birds etc. The last two birds are exclusive to this region.

Mammals: These include hyenas, gorillas, chimpanzees, gibbons, horses, elephants, tigers, lions, leopards, camels, deer, pigs and donkeys). Mammals in this region show resemblances with the mammalian fauna of the Oriental region**.** This is likely so because the Afrotropical and Oriental regions are believed to have been connected before the continents drifted apart (continental drift).

Fig. 3: Pictorial Impression of the Fauna of the Afrotropical Region
Source: http://www.zoology.ubc.ca/~etaylor/413www/intro.htm -

4.0 CONCLUSION

The Palaearctic and Afrotropical zoogeographic regions have a rich and diverse fauna in the form fishes, amphibians, reptiles, birds and mammals.

5.0 SUMMARY

Under this unit, we examined the fauna of the Palaearctic and the Afrotropical zoogeographic regions. The Palaeartic region, comprising Europe, Asia, North of Himalayas and Northern parts of Africa is rich in:

Fishes: (Paddle fishes, *Cyprinus*, Anabas and sucker fish).

Amphibians: (Frogs and tailed amphibians).

Reptiles: (Snakes (vipers, lizards and tortoise).

Birds: (hawks, cukoos, rails, finches, crows but without parrots).

Mammals: (Camels, deer, wolves, horses, pigs, hedgehogs, bats, beavers, dogs, cats, squirrels, rabbits, mice, bats and moles).

Similarly, we described the Afrotropical Region as comprising Africa, Southern part of Arabia and the Island of Madagascar. We said that this area is also rich in:

Fishes: (African freshwater lung fish (*Protopterus*), sharks, tuna fishes, cat fishes, cyprinids, electric fishes etc).

Amphibians: (Caecilians (amphibians without limbs), frogs, toads including *Xenopus* - the clawed toad, but devoid of tailed amphibians such as salamanders).

Reptiles: (Chameleons which are prominent in the region, crocodiles, tortoises (*Testudo*), turtles (*Trionyx*), lizards including the flying lizard, and snakes such as rattle snakes, cobras, vipers, pythons, etc).

Birds: (Two toed Ostrich i.e. *Struthio camelus*, horn bills, herons, pigeons, parrots, cuckoos, storks, finches, hammer- headed birds and the mouse birds etc).

Mammals: (Hyenas, gorillas, chimpanzees, gibbons, horses, elephants, tigers, lions, leopards, camels, deers, pigs and donkeys).

6.0 TUTOR-MARKED ASSIGNMENT

i. Describe the Palaerctic and Afrotropical zoogeographic regions and name any unique fauna associated with each region.

7.0 REFERENCES/FURTHER READING

http://www.zoology.ubc.ca/~etaylor/413www/intro.htm (accessed 15th September, 2009).

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UNIT 5 ZOOGEOGRAPHY OF THE ORIENTAL AND AUSTRALASIAN REGIONS

CONTENTS

1.0 INTRODUCTION

In this unit, we shall take a look at the Oriental and Australasian zoogeographic regions. As we describe them, we shall also ascribe to them their respective fauna.

2.0 OBJECTIVE

At the end of this unit, you should be able to:

- describe the Oriental and Australasian zoogeographic regions and their respective fauna.

3.0 MAIN CONTENT

3.1 Fauna of the Oriental Region

The Oriental Region includes the Indian sub-continent, Sri Lanka (Ceylon), Myanmar (Burma), Philippines, Taiwan (Formosa) and China. Like the other regions, the oriental region is divided into four sub-regions. These are:

1. **Indian Sub-Region**: this area includes North and Central India. It starts from the root of Himalayas and extends to Malabar Coast, characterized by plains and deserts with temperate and tropical conditions. Its vertebrate fauna include antelopes, peacock, Indian *Bison*, black elephant and snakes.
2. **Ceylonian Sub-Region**: It includes Sri Lanka, Small Indian Peninsula. It has lions, elephants, horses, rat, bandicoots and snakes,

3. **Indo-China Sub-Region**: This area includes China south of the Palaearctic region. The vertebrate fauna includes gibbons, lemurs, rhinoceros, salamanders and disc tongued frogs.
4. **Indo-Malayan Sub-Region**: It includes the Malayan peninsula and surrounding islands. Its fauna includes gibbons, rhinoceroses, badgers and broad bills (birds).

The fauna population of the Oriental region resembles that of the Afrotropical region. Animals found include:

Fishes: The fish fauna here is dominated by carps and catfishes.

Amphibians: Many species of frogs and toads but tailed amphibians are rare and represented by only one genus, *Tylptotriton*.

Reptiles: There are many reptiles in this region dominated by lizards (flying lizard, chameleon, and monitor lizard), snakes (python, cobra etc.), turtles and crocodiles.

Birds: Birds here include honey guides, wood pecker, horn bill, and peacock etc.

Mammals: Members of the mammalian fauna include the shrews, rabbits, dogs, cats, hyenas, pigs, rhinoceroses, great apes, gorillas, chimpanzees, Himalayan panders, camels etc.

3.2 Fauna of the Australasian Region

We come to the last of the six zoogeographic regions i.e. Australasian Region. This region contains Australia, New Zealand, New Guinea and nearby islands in the Pacific Ocean.

The region is divided into four sub-regions, which are:

1. **Australian Sub-region:** Includes Australia and Tasmania. It is located in the Southwest of the Pacific Ocean and shows very peculiar fauna. It has both tropical and temperate climatic conditions. This is the 'Home of the Marsupials' as there are 34 genera of marsupials in the said region. You will recall that this was emphasized in our study of marsupials under Metatherians in Module 3, Unit 1. In addition, we have the tailed amphibians and the flightless birds like Emus.
2. **Austromalayan Sub-region**: This region includes the Malayan Archepelago islands, Papua New Guinea, Solomon Islands etc. Crowned pigeons, turtles and marsupials occur here.

3. **Polynesian Sub-region**: Includes the Polynesian Islands. The fauna here is poor. Pigeons are however common.
4. **New Zealand Sub-region**: Covers New Zealand and is well known for kiwis. The kiwi is the national symbol of New Zealand. There are also rats and bats; snakes are absent.

We shall now look at the fauna of the whole Australasian Region. This is represented by:

Fishes: The most important fish is a lung fish (*Neoceratodus*). There are many other freshwater and marine fishes such as sharks (*Scoliodon*), mackerel, *Cynoglosus*, carps (*Catla catla)*, Anabas etc.

Reptiles: In New Zealand snakes are absent. The lizard-like reptile, tuatara (*Sphenodon*) is seen only in this region. Other reptiles include monitor lizard (*Varanus*), turtle (*Trionyx, Caretta caretta*), tortoise (*Testudo elegans*), chamaeleon etc.

Amphibians: Tailed amphibians, frogs (including flying species) and toads are common.

Birds: In this region flightless birds such as kiwi (*Apteryx* - present only in New Zealand), Emu (*Dromaeus* - in New Guinea) and Cassowary - present in Australia) are common. Other flight other found in this region include pigeon (*Columba livia*), duck, crane, crow, sparrow (*Passer domesticus*).

Mammals: These include the duck-billed platypus (*Ornithorhynchus*), kangaroo (*Macropus)*, tiger cat (*Dasous*), flying fox (*Pteropus*), marsupial bandicoot (Paramoles), spiny ant eater, (Echidna), rat (*Ratus ratus*), horse (*Equs equs*), donkey (*Equsacinus)* and pig (*Sus*).

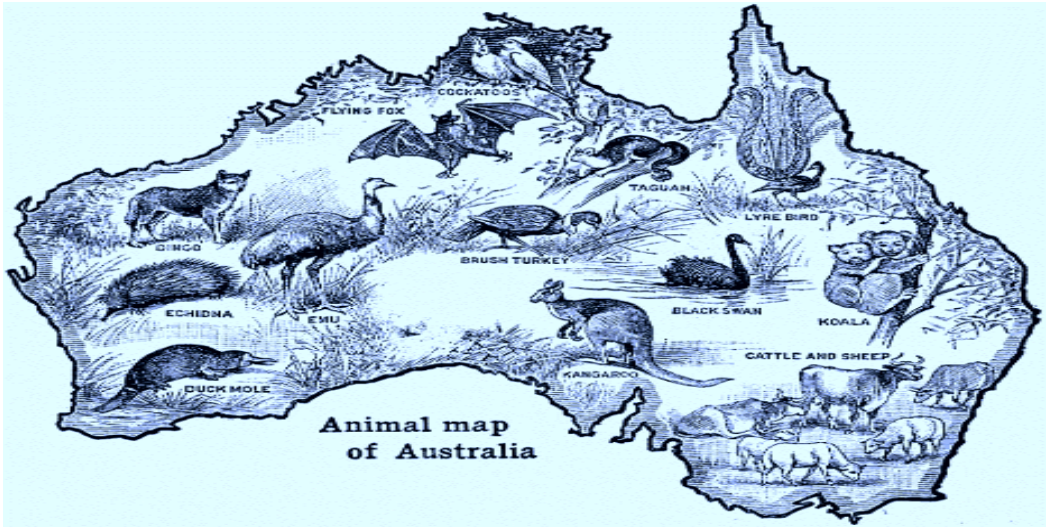

Fig. 4: Pictorial Impression of the Fauna of the Australasian Region
Source:http://biozoom.blogspot.com/2011/01/zoogeography-introduction.html (Accessed 22/8/11)

4.0 CONCLUSION

In this unit, you have learnt about the Oriental and Australasian zoogeographic regions and described their fauna as rich in fishes, amphibians, reptiles, birds and mammals.

5.0 SUMMARY

In this unit, we have taken a look at the Oriental and Australasian Regions. We described the Oriental Region as that area comprising the Indian sub-continent, Sri Lanka (Ceylon), Myanmar (Burma), Philippines, Taiwan (Formosa) and China. Its rich fauna is made up of:

- **Fishes (**dominated by carps and catfishes).
- **Amphibians** (showing many species of frogs and toads but tailed amphibians are very rare).
- **Reptiles (**dominated by lizards such as the flying lizard, chameleon, monitor lizard; snakes, turtles and crocodiles).
- **Birds** (honey guides, wood pecker, horn bill, and peacock etc.).
- **Mammals (**shrews, rabbits, dogs, cats, hyena, pigs, rhinoceros, great apes, gorillas, chimpanzees, Himalayan pandas, camel etc.

The Australasian Region is that area comprising Australia, New Zealand, Papua New Guinea and nearby islands in the Pacific Ocean. The vertebrate fauna of his region include:

- **Fishes (**lung fish, shark (*Scoliodon*), mackerel, *Cynoglosus*, carps (*Catla catla),* Anabas etc.).
- **Reptiles (**lizard-like reptile tuatara (*Sphenodon*) seen only in this region, monitor lizard (*Varanus*). turtle (*Trionyx*, *Caretta caretta*), tortoise (*Testudo elegans*), and chameleon).
- **Amphibians (t**ailed amphibians, frogs (including flying species) and toads).
- **Birds** (flightless birds such as kiwi (*Apteryx* - present only in New Zealand), Emu (*Dromaeus* – in New Guinea) and Casso wails - present in Australia) and other flight birds such as pigeon (*Columba livia*), duck, crane, crow, sparrow (*Passer domesticus*).
- **Mammals (**duck billed platypus (*Ornithorhynchus*), kankaroo (*Macropus),* tiger cat (*Dasous*), flying fox (*Pteropus*), marsupial bandicoot (Paramoles), spiny ant eater, (*Echidna*), rat (*Ratus ratus*), horse (*Equs equs*), donkey (*Equsacinus)* and pig (*Sus*).

6.0 TUTOR-MARKED ASSIGNMENT

i. Describe the Oriental and Australasian zoogeographic regions.
ii. Make a list of the mammals found in the Australasian Region. Assign to each its mammalian order.

7.0 REFERENCES/FURTHER READING

http://encarta.msn.com/media_461536032_761577282_-1_1/Zoogeographic_Regions.html 15th September, 2009.

http://biozoom.blogspot.com/2011/01/zoogeography-introduction.html (accessed 28/11/11)