BIO 102
BIOLOGY ANIMALS

NATIONAL OPEN UNIVERSITY OF NIGERIA

BIO 102: BIOLOGY OF ANIMALS

COURSE GUIDE

NATIONAL OPEN UNIVERSITY OF NIGERIA

CONTENTS

Introduction

Biology 102 (General Biology) is a three semesters, three credit units course. It is taken at the beginning and is available to all students wanting to do the B.Sc Education, Biology; B.Sc. Education Integrated Science and B.Sc. Agricultural Extension Management.

The course has fifteen units which deal with the general principles of classifying living organisms. As you go through this course, you will learn the basic principles underlying the study of biology and that organisms are grouped together by their similarities in structures and ecological adaptations. You will also get to know that organisms are put into different groups because of differences in structure, function and habit. Through studying the structure and ecological adaptations of the organisms, you will understand why they occupy particular positions in the classification scheme.

The main pre-requisite for this course is that you must have studied some (one or two of) science subjects like Biology, Integrated Science, Health Science, Chemistry or physics at the Secondary School level; and have obtained at least a credit in them.

In this course guide, you are told about the course materials you need and how you can work through the course successfully. You are also advised about the amount of time you can spend on each unit. You are also getting some guidance on the tutor-marked assignments.

What you will learn in this Course

You will be introduced to general principles in the study of biology in this course. You will get to know how and why it is that certain organisms belong to the same group and others do not. You will study the external and internal features of a wide range of organisms so that you can learn to see similarities and differences amongst them. You will also study how the structures you have studied adapt the organisms to their particular habitat.

The knowledge of how and why organisms are put into different groups is very basic to an understanding of Biology. You get to know about structure and function of parts of organisms. You will get to know that while some organisms are simple both in structure and functioning, others are more complex.

Aims of the Course

This course aims at:

1. giving you an understanding of how organisms are studied.
2. introducing you to how organisms are classified.
3. outlining of the structure, and functions of organisms.
4. emphasizing the differences and similarities among organisms.
5. explaining the adaptation of organisms to their environment.

Course Objectives

To achieve these aims, the following overall objectives are set for this course. At he beginning of each unit, unit objectives will be stated. You will do well if you read them as you study the particular unit and refer to them as you go on in your study so that you can monitor your own progress. When you look at the objectives, as you are here advised to do, at the end of the unit, you can ascertain that you have done all you are required to do. However, when you successfully complete this course, you should be able to:

1. Illustrate how organisms are classified.
2. Describe the external features of organisms studied in this course.
3. Describe the internal features of the organisms.
4. Explain features for the adaptation of organisms to their environment.

5. Draw up the similarities between bacteria and algae.
6. Identify organisms by their habitats.
7. Make labeled drawings of named organisms.
8. Make comparisons among organisms by pointing out similarities and differences.
9. Use hand lens and microscopes to study the external features of organisms.

Working through this Course

If you want to complete this course successfully, you will have to go through these study units according to instructions specified. You will also need to do practical exercises for which you will at times need a hand lens. In a few cases you will need a microscope which you can use at the study centre. You are expected to respond to the self assessment exercises. You are also requested to submit your assignment for the purpose of assessment. There is a final examination which you will need to write at the end of the course. The course should last 51 weeks.

Study Units

The units of the course are as follows:

Unit 1: Classification of organisms – characteristics of each kingdom and specimen identification key structure and ecological adaptations of the following organisms stressing their position in the plant and animal kingdoms.
Unit 2: Viruses
Unit 3: Bacteria
Unit 4: Cell
Unit 5: Fungi
Unit 6: Algae
Unit 7: Bryophytes + Pteridophytes
Unit 8: Spermatophytes – Conifers
Unit 9: Spermatophytes – Angiosperms
Unit 10: Protozoa, Chlophora
Unit 11: Protozoa Rhizopoda and Apicomplea
Unit 12: Prifera
Unit 13: Cuidaria
Unit 14: Platyhelminthes
Unit 15: Nematodes
Unit 16: Annelida
Unit 17: Arthropods
Unit 18: Superclass Crestacea
Unit 19: Insecta
Unit 20: Chilopoda and Piplopode
Unit 21: Mallusca and Echinodermata

Unit 22: Protochordata and Fishes
Unit 23: Amphibia and Reptilia
Unit 24: Birds
Unit 25: Mammals.

The first unit gives a general basic information about the study of structures, classification and adaptation. The rest deal with a detailed study of structure, identification, functioning and adaptation of each of the groups. In each of the units, a theoretical treatment as well as practical study of the organism(s) is involved. Each unit contains between 2 – 3 hours study, accompanied by a number of self-assessment tests which help you reinforce your learning and assess yourself. Along with the tutor-marked exercises, these will help you achieve the objectives of the course.

Assignment File

The assignment file will be sent to you in due course. In this file you will find the details of the work you must submit to your tutor for marking. The marks you obtain for these assignments will count towards the final mark you obtain for this course. Further information on assignments will be found in the Assignment like itself and later on this course guide in the section on assessment.

Presentation Schedule

The presentation schedule included in your course materials gives you the important dates for this year for the completion of tutor-marked assignments and attending tutorials. Remember, you are required to submit all your assignments by the due date. You should guard against falling behind in your work.

Assessment

There are two aspects of the assessment in this course. First are the tutor-marked assignments, second there are the written examination.

You are expected to use the information, knowledge and techniques gathered during the course to tackle your assignments. You are also to submit your assignments to your tutor for formal assessment as stipulated in the Presentation Schedule and the Assignment File. The work you submit to your tutor for assessment will count for 50% of your total course mark.

At the end of the course, you will be expected to sit for a three hours final examination. This examination will contribute to 50% of your total course mark.

Tutor-Marked Assignments (TMAs)

There are five tutor-marked assignments in this course. You only need to submit four of the five. However, if you submit the five, the highest four will be counted for you. Each assignment counts 12.5% towards your total course mark.

The assignment questions for the units in this course can be found in the Assignment file. You will be able to complete your assignments from the information and materials contained in your study units, reference books and practical exercises. You will however be at an advantage if you can read more widely as a degree student. The references you are given will give you these additional readings. You can find them in the study centres.

When you have completed each assignment, send it, together with a TMA (tutor-marked assignment) form, to your tutor. Make sure that each assignment reaches your tutor on or before the deadline given in the Presentation Schedule and Assignment File. If, for any reason, you cannot complete your work on time, contact your tutor <u>before</u> the assignment is due to discuss the possibility of an extension. Extensions will not be granted after the due date unless there are exceptional cases.

Final Examination and Grading

The final examination for BIO 102 will be of three hours' duration and have a value of 50% of the total course grade. The examination will consist of questions which reflect the types of self-testing, practice exercises and tutor-marked problems you have previously encountered. All areas of the course will be assessed.

Use the time between finishing the last unit and sitting the examination to revise the entire course. You might find it useful to review your self-tests, tutor-marked assignments and comments on them before the examination.

The final examination covers information from all parts of the course.

Course Marking Scheme

In the table below, you are shown how the actual course marking is broken down.

Assessment	Marks
Assignment 1 – 5	Five assignments, best four marks of five count @ 12.5% each = 50% of course marks.
Final examination	50% of overall course marks
Total	100% of course marks.

Table 1: Course Marking Scheme.

Course Overview

The table shown below is a summary showing the unit titles, the number of weeks you should take to complete each unit, as well as the assignment that follow them.

Unit	Title of Work	Weeks for completing activity	Assessment (end of unit)
1.	Course Guide classification, characteristics and identification. Structure and ecological adaptations of:-	1	3 Assignments
2-3	Viruses and Bacteria	1	
4-5	Cells and Fungi	3	
6	Algae	3	3 Assignments
7	Bryophytes and Pteridophytes	4	
8-9	Conifers and Angiosperms	4	
10-13	Protozoa Porifea and Cridaria	4	8 Assignments
14-17	Platyhelminthes, Nematodes and Annelida	5	2 Assignments
18-20	Anthropods Crustacea, Insecta and Diplopods	5	3 Assignments
21-22	Mollusca, Echinoderms and Protochordata and Fishes	3	1 Assignment
23-25	Vertebrates – Amphibia, Reptilia, Birds and Mammals	12	3 Assignments
	Total	51	

How to get the most from this Course

The advantage of distance learning is that you can read and work through specially designed study materials at your own pace and at a time and place that suits you most so you read the lecture instead of listening to the lecturer. However, the same way the lecturer might give you some assignments, so do the study units tell you what to do.

All of the study units follow a common format. There is first of all an introduction on the subject matter of the unit, and how a particular unit is integrated with other units and the course as a whole. Next, there is the set of learning objectives. These are to let you know what you should be able to do by the time you have completed the unit. You should use these objectives to guide you study. When you have finished the unit, you must go back and ensure that you have achieved the set objectives. If you form this habit, you will increase your chances of passing the course significantly.

In the main content of the unit you will be guided to read from other sources as well as do practical work either in the laboratory at the study centre or on your own at a venue you may choose. The practical sessions are very important. They give you the opportunity to interact directly with the organism you are studying. They also enable you to learn to do things the way scientists all over the world do.

The self assessment tests you will encounter throughout the units help you to achieve the objectives of the unit. They also help prepare you for the assignments and exercises. Answers are usually given at appropriate points, but most times at the end of the unit. You can use the following practical steps for working through your course unit:

1. Read this course guide thoroughly.

2. Using the 'course overview' organize a study schedule for yourself. Pay attention to the time you are advised to spend on each unit and how assignments are set for them. Keep a record of the dates you want to work on each unit.

3. Once you have created a schedule of work for yourself, the next important issue is to keep to it. Many students fail because they get behind their work schedule and are unable to cover their course work. If you get into difficulties with your schedule, please let your tutor know before it is too late for help.

4. Turn to unit 1, and read the introduction and objectives for the unit.

5. Get all the study materials you need. You will get the information about what you need from the 'overview' at the beginning of each unit. You will always read the study unit and may be a reference material (book) at the same time. You will also need your writing materials like pen and pencil.

6. Work through the unit. The content of the unit itself has been arranged to provide a sequence for you to follow. So use the unit to guide your reading and follow all instructions very closely.

7. Collect your Assignment file before the due date and make sure you do the assignments carefully. They have been designed to help you meet the objectives of the course and so will help you pass your exams. Ensure also that you submit your assignments on or before the due date and not later.

8. Review the objectives for each study unit to confirm that you have achieved them. If you are not sure about any objective, review the study unit and consult your tutor.

9. When you are sure you have achieved all objectives, you can start on the next unit. Pace your work repeating the same procedure so far outlined for each unit. Work from unit to unit ensuring that you follow your work schedule.

10. Do not wait for the result of the assignment on the previous unit before you start on the next unit. Pay particular attention to all comments made by the tutor on your assignment. Consult your tutor as soon as possible if you have any problems.

11. After submitting the assignment for the last unit review the course objectives again both at the beginning of each unit and the end. Also review the course objectives in this guide. Then start preparing yourself for the final examinations.

Tutors and Tutorials

The details of the tutorial hours will be made available to you in due course. You will be informed about dates, times and location of these tutorials. You will also be given the name and phone number of your tutor as soon as you are allocated a tutorial group.

Your tutor will mark and comment on your assignments, keep a close watch on your progress and on any difficulty you might encounter and provide assistance to you throughout the course. You must send your tutor-marked assignments to your tutor well before the due date. They will be marked by the tutor and returned to you as soon as possible.

Do not hesitate to phone or e-mail your tutor if you have any difficulties. You could also contact your discussion board if necessary. You will need to contact your tutor if:

1. you do not understand any part of the study units or references.
2. you have difficulty with the self-test or exercises.
3. you have a question or problem with an assignment, with your tutor's comments on an assignment or with the grading on an assignment.

Try to attend the tutorials. It is the only chance to have face to face contact with your tutor and ask questions which are instantly answered. During the tutorials, you can raise any questions on problems you encountered in the course of your study. To gain maximum benefit from the course tutorials, prepare a question list before attending them. You will learn a lot from participating actively in the discussions.

Summary

BIOLOGY 102 introduces you to the general principles of classifying organism. It also teaches you how to study the structural adaptations in living things. At the end of this course you will have been equipped with the basic skills for identifying and classifying organisms.

You will be able to answer questions like these:

1. How do you classify living organisms?
2. Describe the structural adaptation of a named organism to the environment.
3. Draw up differences and similarities between named organisms.
4. Make labeled diagrams of named organisms.
5. Describe in details the external features of named organisms.

These are only a few of the many questions you should have been able to answer. To gain the most from this course, observe in details all the plants and animals you come across every day and look out for those features that enable them to survive where you find them.

We wish you success with the course and hope that you will find it both interesting and useful. Enjoy your study with the NOU. We wish you every success.

BIO 102: BIOLOGY OF ANIMALS

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NATIONAL OPEN UNIVERSITY OF NIGERIA

MODULE 1

UNIT 1

Classification and Characteristics of Organisms

Table of Contents

1.0 Introduction

If we are to be able to learn about the great number of living things, plant and animals that exist, we must have a means of putting them into manageable compartment. Unless we are able to do this, we will find the task overwhelming. Over the years classification schemes in biology have changed either because more organisms are being discovered or more knowledge about already known ones have been found.

The act by which we put plants and animals in groups is called classification and the science of classification is called taxonomy. Taxonomy is made up of nomenclature (naming) and systematics (putting into groups) which is done according to similarities and differences.

Nomenclature in biology is binominal following the work of Carl-Linnaeus (1707-78). By this binominal system each organism has two Latin name (which are internationally agreed to avoid confusion of local names). The specific and generic names. This is the same way you have your first name and your family name. The generic name begins with capital letter while the specific begins with small letter. The generic name may be abbreviated into the first letter of the word e.g. Homo Sapiens can be written as H. Sapiens.

Gradually, several geniuses were grouped into family; several families into order several orders into class; several classes into phylum and several phyla into kingdoms.

Thus the hierarchy can be presented beginning with the highest thus:

- Kingdom
- Phylum
- Class
- Family
- Order
- Genus
- Species.

You can see that by the time organisms are so grouped and named, you will find it easier to have a global view of the living world. Let us therefore learn how to do this by setting the following objectives for this unit.

2.0 Objectives

It is hoped that by the end of this unit, you will be able to:

1. Say why we need to classify organisms.
2. Name the seven major classification groups.
3. Name the five main kingdoms of living organisms and describe their general characteristics.
4. Name and describe the characteristic features of the major phyla of the five kingdoms.
5. Make specimen identification and keys.

You have already seen why we must classify and the seven major classification groups in biology in the introduction.

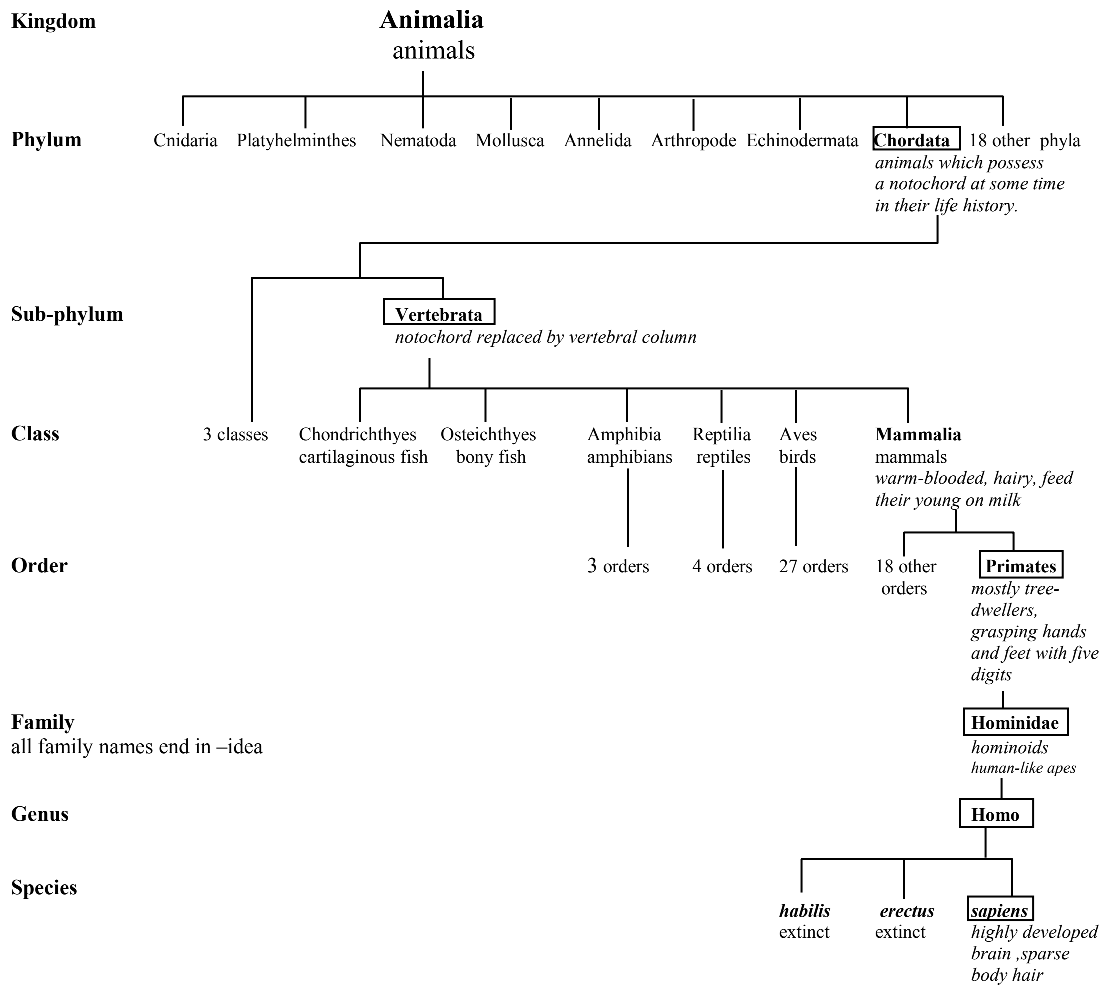

Fig. 1.1 Example of a hierarchy of taxonomic groups.

3.0 Taxonomy

3.1 Taxonomic Hierarchy

You can see that each group contains a number of the lower hierarchy. Example the sub-phylum vertebrata is made up of six classes, while the class mammalia is made up of nineteen orders and so on. In the animal sub-phylum only the class mammalia have hairs and feed their young with milk. However the mammalian, reptiles, birds, amphibian and the fishes have the vertebral column, and so are all called vertebrae.

3.2 Species

The term species describes the group of closely related organisms which are capable of interbreeding produce fertile offspring. But there are a few exception to this definition. Before we look at these exceptions let us first of all understand how the exceptions can come to be. By implication, the exception to the above underlined definition would mean that when some members of the same species interbreed, their offspring are not fertile. For example a crossbreed between tigers and lions do not always produce infertile offspring when a male tiger mates with a female lion, the tighou which results is fertile. But that of a female tiger and male lion (ligers) are not. Sometimes two genetically related organisms can produce infertile offspring as is the case of a cross between donkey and a cow producing a mule.

When members of the same specie, in their struggle to survive have to adapted to very different conditions, they, with time develop to become so different from each other that they can no longer interbreed successfully to produce fertile offspring. This process of development is also responsible for the phenomena whereby seemingly different species still interbreed successfully. It is therefore different to precisely really define species. However I am sure you can easily see why a fish cannot interbreed with a bird. Higher up the hierarchy, differences between groups are more obvious.

3.3 Types of Classification

There are two main types - artificial and natural. A classification is artificial when its organism are grouped together through considering only a few easily observed characteristics. For example all worm-like organisms put together by Linnaeus. By this he put snails, earthworms, millipedes and others together. He did not consider other important natural characteristics like the possession of a backbone which would have easily separated the snakes and the earthworms.

A natural classification considers more evidences than the artificial. It includes both internal and external features. It also includes similarities in growth and development, reproduction physiology anatomy biochemistry and behaviour, The most use classification to is the natural and phylogenetic (based on evolutionary relationships).

You may need to note too that recently even the computer is involved in the classification. All data are fed into the computer about organisms and using such data, the computer ‘places’ the organism. This is called numerical taxonomy.

Now let us see how organisms are classified. If however you feel like taking a break you can do so now. When you are refreshed, we can go to section 3.4

3.4 The Super Kingdoms – Virus and Eukaryote

For a long time living things were grouped in just two kingdoms (plants and animals) till recently. It was believed that plants were antotrophic (synthesized their own organic requirements from inorganic sources); and that animals depended on organic sources (heterotrophism). Animals must therefore move about to seek their food for which they need a developed nervous system to do. On the other hand plants do not need to move since they can tap from their location the raw materials with which they manufacture.

The fact that all cellular forms have one or the other of these two opposing features:-

1. DNA is not enclosed by nuclear membrane and is free in the cytoplasm (prokaryotes).
2. DNA enclosed in the nuclear membrane (eukaryotes).

It means that prokaryotes do not have the nuclear and that eukaryotes evolved from prokaryotes.

Another difficulty in putting all organisms as either plants or animals is the fact that the fungi, even though they do not move about to seek their food, do not photosynthesize (i.e. they are heterotrophes).

So in 1982, Margulis and Schwartz proposed the system presently being used and presented here in Fig. 1.2

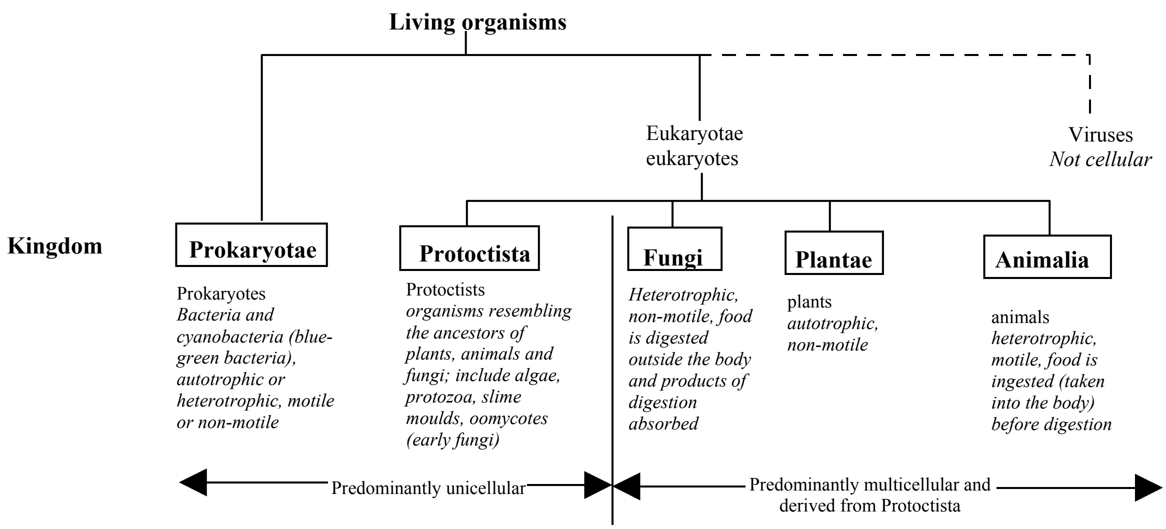

Fig. 1.2: The five kingdom classification of living organisms, according to Margulis and Schwartz. Some of the chief characteristics of the kingdoms are shown. Viruses do not fit neatly into any classification of living organisms because they have a very simple, non-cellular structure and cannot exist independently of other organisms.

Figure 1.2: The five kingdom classification you will see that this figure by implication makes the eukaryotes a super kingdom, the eukaryotae. So before we study the characteristics of the five kingdoms: Prokaryotae, Protoctista, Fungi, Plantae and Animalia, let us study the characteristics of the viruses and the eukaryotae.

Exercise 1.1: Study practice

You will wonder how you can learn to know the information in this figure which is very important for your understanding of classification. It is however not so difficult. The only way to know it is by doing it. Read it, try to recall it by writing it without looking at your study unit. Checking what you have missed out as you again look at your study unit and trying it again. It takes time so do not get anxious. You will soon be able to write all. Remember to always spell currently.

3.4.1 The Viruses (Super Kingdom)

You will notice that in the Fig. 1.2, the line of the viruses is doted. This is not only to indicate that they are not cellular. It is also to show that they are considered as the boundary between living and non living things. Their major features are:

1. They are the smallest living organisms
2. They are a cellular in structure
3. They only reproduce by invading living cells
4. They are obligate endoparasites, causing disease to their host.
5. They are simple in structure. Have only a small piece of nucleic acid, either DNA or RNA surrounded by a protein or lipo-protein coat.
6. They are on the boundary between what we regard as living and non-living.
7. Each virus is very host specific. This means that they only infect certain types of cells.

You will see that these characteristics are very different from the eukaryotae whose characteristics are summarized here:

3.4.2 Eukaryotae (Super Kingdom)

- Except for the protoctista, are multicellular, larger
- Have DNA is linear and contain in a defined nucleus.
- Have both DNA and RNA
- Have many organs in their individual cells.
- Have complex structures of cell walls and membranes.

You will not be surprised therefore that they form two different large divisions of the living world. One group is certainly living with high degree of organization while the other is hardly living.

Self-Assessment Exercise

Can you name the two different groups?

Answer

Eukaryotae and Viruses respectively of course, I am glad you are following.

3.5.1 The Five Kingdoms

The Prokaryotae Kingdom

We can now come back to the study of the five kingdoms. Here again let us gradually move from the virus which we cannot definitely describe as living, through to the Prokaryotae which may be defined as 'just living'. So we will begin by comparing the 'just living' Prokaryoatee with the 'really living'Eukaryotae as in Table 1.1.

Table 1.1: Major differences between prokaryotes and eukaryotes.

Feature	**Prokaryote**	**Eukaryote**
Organisms	Bacteria	Protoctists, fungi, plants and animals
Cell size	Average diameter 0.5-10μm	10-100 μm diameter common; commonly 1000-10 000 times volume of prokaryotic cells
Form	Mainly unicellular	Mainly multicellular (except Protoctista, many of which are unicellular
Evolutionary origin	3.5 thousand million years ago	1.2 thousand million years ago, evolved from prokaryotes
Cell division	Mostly binary fission, no spindle	Mitosis, meiosis, or both; spindle formed
Genetic material	DNA is circular and lies free in the cytoplasm (no true nucleus) DNA is naked (not associated with proteins or RNA to form chromosomes	DNA is linear and contained in a nucleus. DNA is associated with proteins and RNA to form chromosomes
Protein synthesis	70S ribosomes (smaller) No endoplasmic reticulum present (Many other details of protein synthesis differ, including susceptibility to antibiotics, e.g. prokaryotes inhibited by streptomycin)	80S ribosomes (larger) Ribosomes may be attached to endoplasmic reticulum

Organelles	Few organelles None are surrounded by an envelope (two membranes) Internal membranes scarce; if present usually associated with respiration or photosynthesis	Many organelles Envelope-bound organelles present, e.g. nucleus, mitochondria, chloroplasts Great diversity of organelles bounded by single membranes, e.g. Golgi apparatus, lysosomes, vacuoles, mcrobodies, endoplasmic reticulum
Cell Walls	Rigid and contain polysaccharides with amino acids; murein is main strengthening compound	Cells walls of green plants and fungi rigid and contain polysaccharides; cellulose is main strengthening compound of plant walls, chitin of fungal walls (none animal cells)
Flagella	Simple, lacking microtubules; extracellular (not enclosed by cell surface membrane) 20mm diameter	Complex, with '9+2' arrangement of microtubules; intracellular (surrounded by cell surface membrane) 200 μm diameter
Respiration	Mesosomes in bacteria, except cytoplasmic membranes in blue-green bacteria	Mitochondria for aerobic respiration
Photosynthesis	No chloroplasts; takes place on membranes which show no stacking	Chloroplasts containing membranes which are usually stacked into lamellae or grana
Nitrogen fixation	Some have the ability	None have the ability.

Please remember at this point that the purpose of this unit is to give you an overview of the nature of all living things. Because of the immense number of living things and the knowledge available about them, we must group them so that we can manage to conceptualize them. The means by which this is done in biology is by classification. We are now in the process of stating why certain organisms belong to the same group.

The next group for us to consider as we move from most simple virus is the protoctista kingdom.

3.5.2 Protoctista Kingdom

This group is the least natural of the five kingdoms. Can you remember what we said about classification being natural and unnatural? If we now say that this group is the least natural what would you expect? Yes, you will expect that the organisms group here are more diverse in nature and that only a few criteria have been used to bring them together. Yes, the protoctista are a group of eukaryotic organisms that could not fit into the other three (fungi, plantae and animalia) kingdoms. Many of them are unicellular. Protoctista includes all those eukaryotes that are considered as ancestors of plants, animals and fungi. These are the early plants (algae), early animals (protozoa) and early fungi (oomycota). It also includes the slime moulds which produce spores like fungi but creep slowly over surfaces and so are motile like animals. These are seen as links between the prokaryotes and the eukaryotes. The main groups of the protoctista are shown in Fig. 1.2.

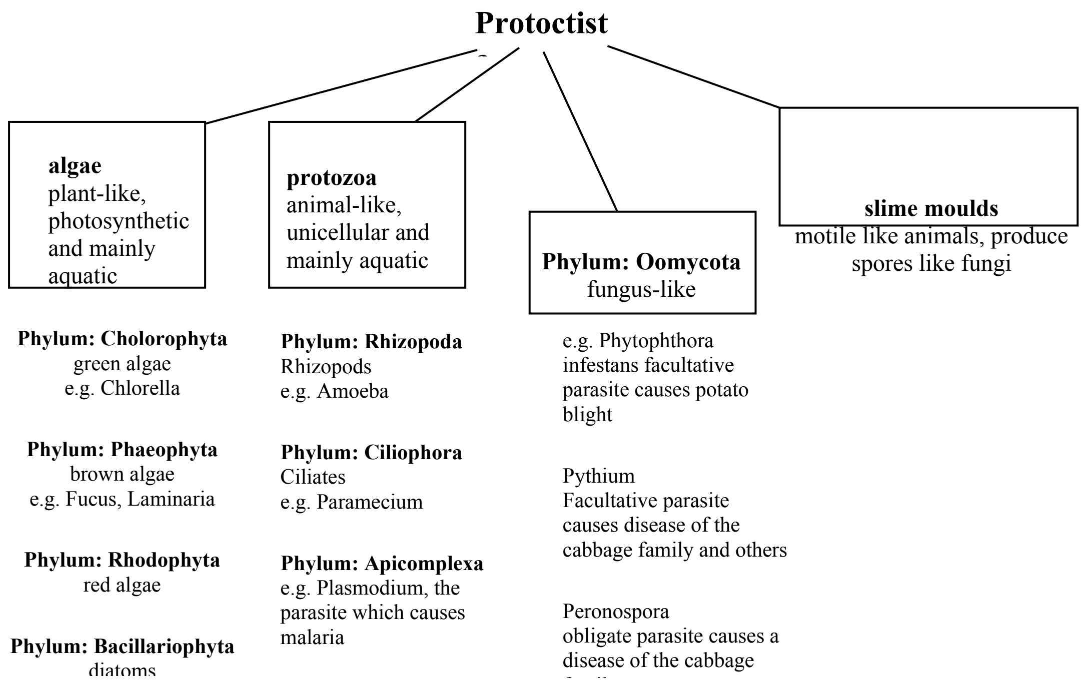

Fig. 1.2: The main groups of Protoctista and some examples of the phyla and genera they contain. Not all groups or phyla are shown.

3.5.3 Fungi Kingdom

These are a large group of up to eighty thousand species. They are not motile yet they do not synthesize their own food. They digest they food from without them and only absorb the products of their digestion.

Table 1.2 Classification and Characteristics of Fungi

Kingdom Fungi

General Characteristics

Heterotrophic nutrition because they lack chlorophyll and are therefore non-photosynthetic. They can be parasites, saprotrophs or mutualists. Nutrition is absorptive; digestion takes place outside the body and nutrients are absorbed directly. Digestion does not take place inside the body, unlike animals.

Rigid cell walls containing chitin as the fibrillar material. Chitin is a nitrogen-containing polysaccharide, very similar in structure to cellulose. Like cellulose it has high tensile strength. It therefore gives shape to the hyphae and prevents osmotic bursting of cells. Body is usually a mycelium, a network of fine tubular filaments called hyphae. These may be septate (have cross-walls), e.g. Penicillium, or aseptate (no cross-walls), e.g Mucor.

If carbohydrate is stored, it is usually as glycogen, not starch

Reproduce by means of spores

Non-motile.

Phylum Zygomycota	*Phylum Ascomycota*	*Phylum Basidiomycota*
A sexual reproduction By Conidia or sporangia Containing spores	A sexual reproduction by conidia No sporangia	A sexual reproduction by formation of spores. Not common
Non-septate hyphae and Large well-developed Branching mycelium	Septate hyphae	Septate hyphae
e.g. Rhizopus stolonifer, common bread mould, a saprotroph Mucor, common moulds, saprotroph	e.g. Penillium and Aspergillus, saprotrophic moulds saccharomyces (yeast), unicellular saprotrophs Erysiphe, obligate parasites causing powdery mildews, e.g. of barley.	e.g. Agaricus campestris, field mushroom, saprotroph

Exercise 1.2 Study Practice

You will need to read and re-read this tables until you get used to remembering the essential features of each group. The best way to do these is to first read them like you read a story. Then you read them again with the aim of remembering the specific characteristics. Then you will put away your study unit and try to write from memory, the characteristics for the kingdom and phyla under it. You will then go back to your study unit to cross check the facts you have missed. Take good note of these missing ones. Place them in their right position both in your mind and in your draft. Then go back to the study unit and re-read the third time again like a story. This time a picture of the nature of these organism must have formed in your mind's eye. When you finally write down the characteristics in your jotter the next time, you will be almost 100% correct. It takes time. You do not have to hurry. You only need to be conscientious.

The next group to consider is the kingdom plantae.

3.5.4 The Kingdom Plantae

Evolutionally, plants (autotrophic eukaryotes) arrived on earth only 420 million years ago, where as other life have existed here since 3.5 thousand million years ago.

You will remember that autotrophic means that the organism has an inorganic source of carbon which is carbon dioxide. Plant are also photoautotrophic which means that they get their energy from light. The rest of their variation is a result to adaptation to life on land. This is summarily shown in Fig. 1.3.

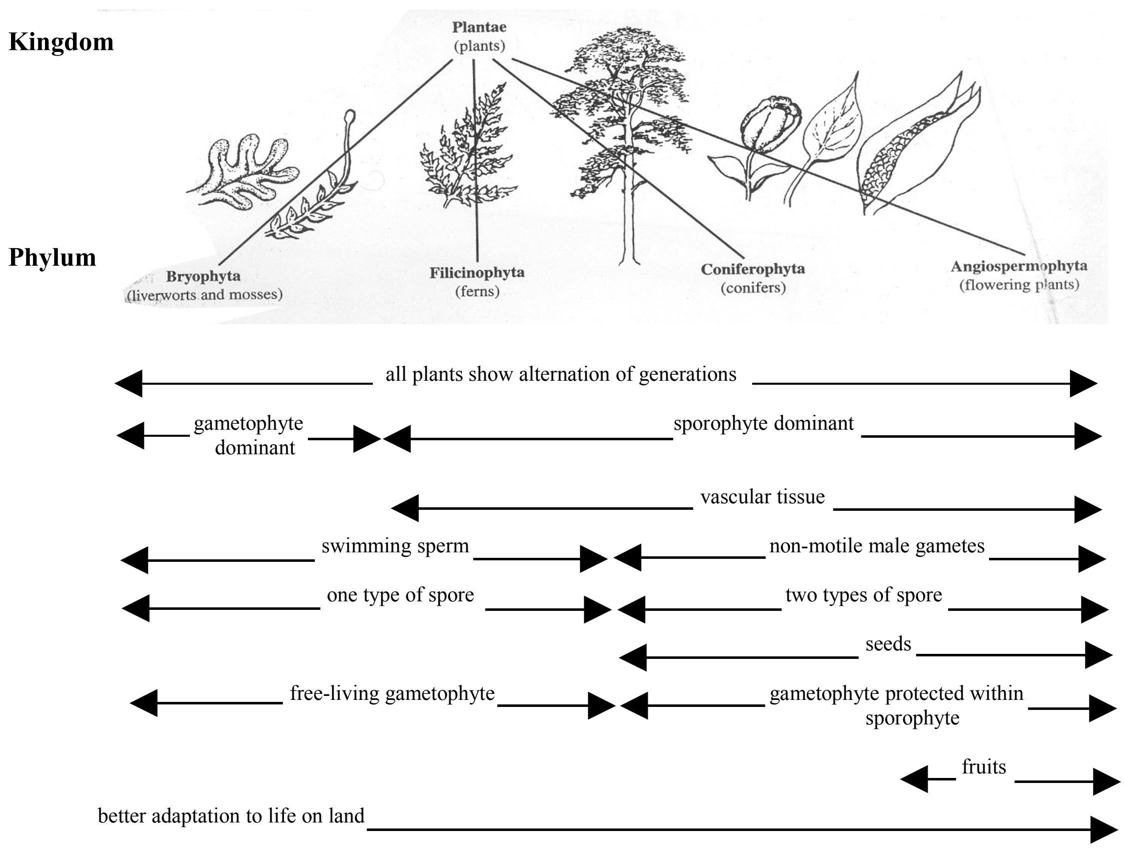

Fig. 1.3 Classification of plants and some of the main trends in plant evolution

There are four major phyla in the kingdom plantae. You will also need to know their major characteristics of each. The knowledge of this will help you in identifying them. Here are the major characteristics of the four phyla: Phylum – Bryophyta.

Table 1.3: Classification and characteristics of the phylum Bryophyta (bryophytes).

Phylum Bryophyta

General characteristics
Alternation of generations in which the gametophyte generation is dominant
No vascular tissue, that is no xylem or phloem
Body is a thallus, or differentiated into simple 'leaves' and 'stems'
No true roots, stems or leaves: the gametophyte is anchored by filamentous rhizoids
Sporophyte is attached to, and is dependent upon, the gametophyte for its nutrition
Spores are produced by the sporophyte in a spore capsule on the end of a slender stalk above the gametophyte
Live mainly in damp, shady places.

*Class Hepaticae (*liverworts)	*Class Musci (*mosses)
Gametophyte is a flattened structure that varies from being a thallus (rare) to 'reafy' with a stem (majority), with intermediate lobed types	Gametophyte 'leafy' with a stem
'Leaves' (of leafy types) in three ranks along the stem	'Leaves' spirally arranged
Rhizoids unicellular	Rhizoids multicellular
Capsule of sporophyte splits into four valves for spore dispersal: elaters aid dispersal	Capsule of sporophyte has an elaborate mechanism of spore dispersal, dependent on dry conditions and involving teeth or pores
e.g. pellia, a thallose liverwort Marchantia, a thallose liverwort, with antheridia and archegonia on stalked structures above the thallus Lophocolea, a leafy liverwort, common on rotting wood	e.g. Funaria Mnium, a common woodland moss similar in appearance to Funaria Sphagnum, bog moss: forms peat in wet acid habitats (bogs).

Phylum Filicinophyta (ferns)

Table 1.4: Characteristics of the phylum Filicinophyta (ferns)

Phylum Filicinophyta (ferns)

General characteristics
Alternation of generations in which the sporophyte is dominant
Gametophyte is reduced to a small, simple prothallus
Vascular tissue present (xylem and phloem) in sporophyte:
sporophyte therefore has true roots, stems and leaves
Leaves relatively large and called fronds
Spores produced in sporangia which are usually in clusters called sori

e.g. *Dryopteris filix-mas* (male fern)
Pteridium (bracken)

Phyla coniferophyta (conifers) and Angiospermophyta (flowering plants). These are the seed bearing plants which have been described as the most of two groups conifers and angiosperms. The seeds of conifers are located on the surface of specialized scale leaves. In angiosperms seeds are enclosed and so get more protection.

Table 1.5: Classification and characteristics of the seed-bearing plants.

Seed-bearing plants

General characteristics

Sporophyte is the dominant generation; gametophyte generation is severely reduced

Sporophyte produces two types of spores (in other words, it is **heterosporous).** The two types are micropores and megaspores;

microspore = pollen grain, megaspore = embryo sac

The embryo sac (megaspore) remains completely enclosed in the ovule (megasporangium); a fertilized ovule is a seed*

Water is not needed for sexual reproduction because male gametes do not swim (except in a few primitive members); they are conveyed to the ovum by a pollen tube to effect fertilization*

Complex vascular tissues in roots, stems and leaves

Phylum Coniferophyta (conifers)	*Phylum Angiospermophyta* (flowering plants)
Usually produce cones on which sporangia, spores and seeds develop	Produce flowers in which sporangia, spores and seeds develop*
Seeds are not enclosed in an ovary. They lie on the surface of specialized leaves called ovuliferous scales in structures called cones*	Seeds are enclosed in an ovary*
No fruit because no ovary	After fertilization, the ovary develops into a fruit* *Classes* Dicotyledoneae and Monocotyledoneae (see table 2.11)

*diagnostic feature.

Among the flowering plants the two main groups (monocots and dycots) and their major differences are also important. The knowledge of these differences will help you in identifying them. Here you can see these differences on Table 1.6.

Table 1.6: Major differences between dicotyledons and monocotyledons.

	Class Dicotyledoneae	Class Monocotyledoneae
Examples	Pea, rose, buttercup, dandelion	Grasses, iris, orchids, lilies
Leaf morphology	Net-like pattern of veins (reticulate venation) Lamina (blade) and petiole (leaf stalk) Dorsal and ventral surfaces differ	Veins are parallel (parallel venation) Typically long and thin (grass-like) (fig 2.40) Identical dorsal and ventral surfaces.
Stem anatomy	Ring of vascular bundles Vascular cambium usually present, giving to rise to secondary growth	Vascular bundles scattered Vascular cambium usually absent, so no secondary growth (exceptions occur, e.g. palms)
Root morphology	Primary root (first root from seed) persists as a tap root that develops lateral roots (secondary roots)	Adventitious roots from the base of the stem take over from the primary root, giving rise to a fibrous root system
Root anatomy	Few groups of xylem (2-8) (see chapter 13) Vascular cambium often present, giving rise to secondary growth	Many groups of xylem (commonly up to 30) Vascular cambium usually absent, so no secondary growth
Seed morphology	Embryo has two cotyledons (seed leaves	Embryo has one cotyledon
Flowers	Parts mainly in fours and fives Usually distinct petals and sepals Often insect pollinated	Parts usually in three No distinct petals and sepals. These structures are combined to form 'perianth segments' Often wind pollinated.

Exercise 1.3 Study Practice

Don't forget your study exercises. You have a lot to learn now. We have finally come to the animal kingdom. If however you feel you need a break, this is a convenient point to take it. You will come back refreshed to learn about the animal world. You are making good progress.

3.5.5 Kingdom Animalia

You will remember we said animals are one of the four eukaryote kingdoms. They are multicellular, heterotrophic, ingest food, digest food within and egest the undigested wastes. Like the plantae, the rest of the variations among animal beyond the description just given depend on their evolutional trend and their adaptation to their various hapitats.

Table 1.7: Characteristics of the phylum Porifera (sponges).

Phylum Porifera
Characteristic features
Some cell differentiation, but no tissue organization
Body has two layers of cells
Adults do not show locomotion
All marine
Body frequently lacks symmetry
Single body cavity
Numerous pores in body wall
Usually a skeleton of calcareous or silica-rich spicules, or horny fibres
No differentiated nervous system
Asexual reproduction by budding
All are hermaphrodite
Great regenerative power
'Dead-end' phylum – it has not given rise to any other group of organisms.

Table 1.8: Classification and characteristics of the phylum Cnidaria (cnidarians).

Phylum Cnidaria

Characteristic features
Diploblastic animals: body wall composed of two layers of cells, an outer **ectoderm** and an inner **endoderm**; these layers are separated by a structureless, gelatinous layer of **mesogloea** which may contain cells that have migrated from other layers*
Tissue level of organization achieved
Radial symmetry
Body is basically sac-shaped with a single opening, the 'mouth', for ingestion and egestion. The single cavity within the sac is called the **enteron** and is where digestion takes place
Two structural types, **polyps** and **medusae**. Polyps are sessile (stay in one place) and may be solitary, e.g. *Hydra*, or colonial, e.g. *Obelia.* Medusae are free-swimming and solitary*
Polymorphism exhibited, that is individuals have specialized shapes with different functions – a form of division of labour

Class Hydrozoa (hydroids)	*Class Scyphozoa* (jellyfish)	*Class Anthozoa* (corals and sea anemones)
Polyp dominant in life cycle	Small polyp sometimes present as a larval stage	Polyp only-more complex than those of the Hydrozoa
Medusa simple	Large highly organized medusa dominant in life cycle	No medusa
Polyps solitary or colonial		Polyps solitary (anemones, some corals) or Colonial (most corals)
Nematoblasts (stinging cells)	Nematoblasts	Nematoblasts
e.g. Hydra (no medusa phase) *Obelia*	e.g. *Aurelia* (jellyfish)	e.g. Actinia (beadlet anemone) *Madrepora* (coral)

Table 1.9: Classification and characteristics of the phylum Platyhelminthes (flatworms).

Phylum Platyhelminthes

Characteristic features
Tripoblastic
Bilateral symmetry
Unsegmented (like nematode worms, unlike annelid worms)
Accelomate
Flatened shape
Mouth but no anus

Class Turbellaria (turbellarians)	*Class Trematoda* (flukes)	*Class Cestoda* (tapeworms)
Free living; aquatic	Endoparasitic (live inside host) or ectoparasitic (live on outer surface of host)	Endoparasitic (live inside host)
Delicate, soft body	Leaf-like shape	Elongated body divided into proglottides which are able to break off
Suckers rarely present	Usually ventral sucker in addition to sucker on 'head' for attachment to host	Suckers and hooks on 'head' (scolex) for attachment to host
Outer surface covered with cilia for jocomotion; cuticle absent	Thick cuticle with spines (protection); no cilia in adult (locomotion not needed because not parasitic)	Thick cuticle (protection); no cilia in adult
Enteron present	Enteron present	No enteron (no digestion required - absorbs predigested food from host)
Sense organs in adult	Sense organs only in free-living larval stages	Sense organs only in free-living larval stages
e.g. *Planaria*	e.g. *Fasciola* (liver fluke) *Schistosoma* (blood fluke) - cause of schistosomiasis (bilharzias) in many tropical countries	e.g. *Taenia* (tapeworm)

Table 1.10: Characteristics of the phylum Nematoda (nematodes or roundworms).

Phylum Nematoda

Characteristic features
Triploblastic
Bilateral symmetry
Elongated, round 'worms' with pointed ends*
Unsegmented (like flatworms, but unlike annelid worms)
Alimentary canal with mouth and anus
Sexes separate
Some free living, many important plant and animal parasites
Anterior and shows a degree of cephalisation (development of a head)

Table 1.11: Classification of the phylum Annelida (annelids or segmented worms).

Phylum Annelida

Characteristic features
Triploblastic, coelomate
Bilateral symmetry
Metameric segmentation
Prostomium, a lip-like extension of the first segment situated above the mouth
Definite cuticle (outer covering)
Chaetae, hair-like structures made of chitin and arranged segmentally (except leeches)*

Class Polychaeta (polychaetes or bristleworms)	*Class Oligochaeta* (oligochaetes or earthworms)	*Class Hirudinea* (leeches)
Marine	Inhabit fresh water or damp earth	Ectoparasites with anterior and Posterior suckers
Distinct head	No distinct head	No distinct head
Chaetae numerous on lateral extensions of the body called parapodia*	Few chaetae – in pairs or single, no parapodia	Small fixed number of segments, no chaetae or parapodia*
No clitellum	Clitellum or 'saddle' which secretes a Cocoon in which the eggs are deposited	No clitellum
e.g. *Arenicola* (lugworm) *Nereis* (ragworm)	e.g. *Lumbricus* (earthworm)	e.g. *Hirudo* (leech)

Table 1.12: Classification of the phylum Arthropoda (arthropods).

Phylum Arthropoda

Characteristic features
Triploblastic, coelomate
Metameric segmentation, bilateral symmetry
Exoskeleton* of chitin and sometimes calcareous matter; may be rigid, stiff or flexible
Each segment typically bears a pair of jointed appendages used for locomotion or feeding or sensory purposes*
Coelom much reduced, main body cavity a haemocoel

Superclass Crustacea (crustaceans)**	*Class Insecta* (insects)	*Class Chilopoda* (centipedes)	*Class Diplopoda* (millipedes)	*Class Arachnida* (arachnids)
Mainly aquatic	Mainly terrestrial	Mainly terrestrial	Terrestrial	Terrestrial
Cephalothorax (head and thorax not distinctly separate)	Well-defined head, thorax, abdomen	Clearly defined head Other body segments all similar	Clearly defined head Other body segments all similar	Cephalothorax (head and thorax not distinctly separate); thorax separated from abdomen by a narrow waist-like constriction
Two pairs of antennae	One pair of antennae	One pair of antennae	One pair of antennae	No antennae
At lest three pairs of mouthparts appendages	Usually three pairs of mouthparts	One pair of mouth-parts (jaws)	One pair of mouth-parts (jaws)	No true mouthparts but one pair of used in capturing prey and one pair of sensory palps
Pair of compound eye raised on stalks	Pair of compound eyes and simple eyes	Eyes simple, compound or absent	Eyes simple, compound or absent	Simple eyes only (no compound eyes)
Appendages often modified for swimming , as mainly aquatic, number of legs variable, sometimes 10	Three pairs of legs on thorax, one pair per segment. Usually one or two pairs of wings on thorax (on second and/or third segments)	Numerous legs, all identical, one pair per segment	Numerous legs, all identical, two pairs per segment	Four pairs of walking legs (segments 4-7)
Larval form occurs	Life cycle commonly involves metamorphosis either 'complete' or 'incomplete', with a larval stage	No larval form	No larval form	No larval form
Typical gaseous exchange by gills-outgrowths of the body wall or limbs	No gills in adult Gaseous exchange by tracheae (tubes inside body	Gaseous exchange by tracheae	Gaseous exchange by tracheae	Gaseous exchange by 'lung' books or 'gill' books or tracheae
e.g. Daphnia (water-flea) Astacus (crayfish Also barnacles, prawns, crabs, lobsters, woodlice	e.g. Periplaneta (cockroach) Apis (bee) Pieris (white butterfly) Also bugs, beetles, fleas, wasps, flies, dragonflies, termites, grasshoppers, earwigs.	Mainly carnivorous e.g. Lithobius (centipede)	Mainly herbivorous e.g. Iulus (millipede)	e.g. Scorpio (scorpion) Epeira (web-spinning spider) Also mites, ticks

Table 1.13: Classification and characteristics of the phylum Mollusca (mollusks).

Phylum Mollusca

Characteristic features
Unsegmented, triploblastic coelomates
Usually bilaterally symmetrical
Body soft and fleshy and divided into a head, ventral muscular foot and dorsal visceral hump*
Over the hump the skin (mantle) secretes a calcareous shell
Main body cavity is a haemocoel
No limbs

Class Gastropoda (gastropods)	*Class Pelycopoda* (bivalves)	*Class Cephalopoda* (cephalopods)
Terrestrial, marine and fresh water	Aquatic	Aquatic. Largest and most complex mollusks
Asymmetrical	Bilateral symmetry	Bilateral symmetry
Shell of one piece, usually coiled Due to rotation of hump during growth	Shell consists of two hinged halves called valves (hence the term 'bivalve'. Body enclosed by the valves and laterally compressed	Shell often reduced and internal or wholly absent
Large flat foot used in locomotion	Foot reduced in size and often used for burrowing in sand or mud	Adapted for fast swimming. Foot modified to form part of head and tentacles
Head, eyes and sensory tentacles	Head greatly reduced in size, tentacles absent	Head highly developed with tentacles with suckers, and well-developed eyes
Radula, a rasping tongue-like structure used in feeding	Filter feeder	Radula and horny beak
Anus is anterior	Anus is posterior	Anus is posterior
e.g. Helix aspersa (land snail) patella (limpet) Buccinum (whelk) Limax (slug)	e.g. Mytilus edulis Ostrea (oyster)	e.g. Sepia officinalis (cuttlefish) Loligo (squid) Octopus vulgaris (octopus)

Table 1.14: Classification and characteristics of the phylum Echinodermata (echinoderms).

Phylum Echinodermata

Characteristic features
Triploblastic, coelomate
All marine
Adult shows five-way (pentamerous) radial symmetry*
Tube feet for locomotion*
Calcareous exoskeleton
No head. Mouth generally on lower (oral) surface of body and on upper (aboral)surface

*Class Stelleroidea (*starfish)	*Class Echinoidea* (sea urchir)
Star-shaped, flattened	Globular
Arms not sharply separate from disc	Does not possess arms
Few calcareous plates in body wall; movable spines	Numerous calcareous plates in body wall, attached to each other to form a rigid structure; relatively long movable
spines	
e.g. Asterias	e.g. Echinocardium

Table 1.15: Classification and characteristics of the phylum Chordata (chordates).

Phylum Chordata

Characteristic features
Notochord present at some stage in the life history. This is a flexible rod of tightly packed, vacuolated cells held together with a firm sheath*
Triploblastic coelomate
Bilateral symmetry
Pharyngeal (visceral(clefts present (slits in the pharynx)*
Dorsal, hollow nerve cord*
Segmental muscle blocks (myotomes) on either side of the body
Post anal tail (tail starts posterior to anus)*
Limbs formed from more than one body segment*

Subphylum Vertebrata (vertebrates)

Characteristic features
Notochord replaced in adult by a vertebral column (backbone), a series of vertebrae made either of bone or cartilage*
Well-developed central nervous system including brain.* Skull protects the brain
Internal skeleton
Pharyngeal clefts (gill slits), few in number
Two pairs of fins or limbs.* These are attached to the rest of the skeleton by girdles, pectoral and pelvic*

Class Chondrichthyes (cartilaginous fish)	Class Osteichthyes (bony fish)	Class Amphibia (amphibians)	Class Reptilia (reptiles)	Class Aves (birds)	Class Mammalia (mammals)
Skin with placoid (tooth-like) scales	Skin with cycloid scales (thin, round and made of bone)	Soft moist skin can used for gaseous exchange to supplement lungs. No scales	Dry scaly skin with horny scales	Skin bears feathers, legs have scales	Skin bears hair with two types of glands sebaceous and sweat
Cartilaginous skeleton	Bony skeleton	Bony	Bony	Bony	Bony
Paired, fleshy pectoral and pelvic fins Asymmetric tail fin helps prevent sinking (no air bladder or swim bladder for buoyancy)	Paired pectoral and pelvic fins supported by bony rays, giving greater maneuverability. Symmetrical tail fin	Two pairs pentadactyl limbs	Two pairs pentadactyl limbs usually present	Two pairs pentadactyl limbs, front pair form wings	Two pairs pentadactyl limbs
Visceral clefts present as separate gill openings; five pairs	Visceral clefts present as separate gill openings, but covered by a bony flap (operculum), four pairs	Visceral clefts present in aquatic larva (tadpole) only, lungs in adult, which is usually terrestrial	Visceral clefts never develop gills	Visceral clefts develop gills	Visceral clefts never develop gills
		Metamorphosis for larva to adult in life cycle			
No external ear	No external ear	No external ear	No external ear	No external ear	External ear (in addition to middle and inner ear)

Table 1.15 (cont.)

Eggs produced, internal fertilization	Eggs produced, external fertilization	Eggs produced, external fertilization. Adults must return to water for reproduction	Fertilised yolky eggs laid on land or eggs retained until hatching. Eggs have a leathery skin. Internal fertilization	As reptiles but eggs in calcareous shells, internal fertiliza-tion	Only two general lay eggs, the spiny anteater and the duck-billed platypus. Embryo develops in mother. Mother has mammary glands which produce milk for the newborn. Internal fertilization
			Teeth lost and developed		Different types of teeth for different functions
					Muscular diaphragm between thorax and abdomen
Poikilothermic ('cold-blooded')	Poikilothermic	Poikilothermic	Poikilothermic	Homeothermic	Homeothermic ('warm-blooded')
e.g. Scyliorhinus (dogfish)	e.g. Clupea (herring)	e.g. Rana (frog) Bufo (toad) Also newts and salamanders	e.g. Natrix (grass snake) Crocodylus (crocodile) Also lizards, alligators, turtles, tortoises. Dinosaurs were reptiles	e.g. Columba (pigeon) Aquila (eagle)	e.g. Homo (human) Canis (dog)

These organisms will be studied in greater details. Remember that what we have here is an overview to enable us put in manageable groups the whole living world.

Again let me remind of your study exercises after each characteristics you are presented with. Don't get anxious you need to know the principles. If you have to identify any organism presented to you, the would need to bother about how to make identification keys. So lets see how we do it.

3.6 Specification Identification Keys

A key is a method by which biologists conveniently identify an organism. To do a key these are the steps you must take:

1. List the observable characteristics e.g. shape, colour, number of appendages, segments.
2. Match them with the diagnostic features of a particular group keys such as these could be described as artificial because they deal only with appearances. However many keys allow organism to be classified into a natural phylogenetic hierarchical classification system .

There are various types of keys but a dichotomous are the simplest. It is made up of dichotomous pairs of lead statements which are mutually exclusive. By using these statements, features can be eliminated from one statement to another unit the ‘leads’ point to some particular organism – thus identifying the unknown. See table 1.16.

Table 1.16: Extract of key to cultivated Leguminosae.

1.	Woody trees and shrubs	2
	Herbaceous and annual plants	15
2.	Climbing	3
	Non-climbing	4
3.	Flowers bright red	Lobster claw
	Flowers mauve, sometimes white, forming sprays	Wisteria
4.	Flowers all or partly yellow	5
	Flowers not yellow	8
5.	Branches with thorns and spines	6
	Branches without thorns and spines	7
6.	Leaves absent, plant spiny all over	Gorse
	Leaves present on young shoots, spines on older branches	Needlewhin
7.	Young stem square, leaves small with three leaflets	Broom
	Stems not square, leaves longer than 2.5cm	9
8.	etc.	

4.0 Conclusion

In this you have taken a quick study of all living things and even of viruses which are sometimes considered as not living. You have seen how organisms are classified and how it is easier to study them in their groups. In such a group, you can already tell what characteristics they have. You have also learnt how to make an identification key. You now know that to identify means to say where an organism belongs with reasons.

5.0 Summary

Having placed the organisms in their respective ‘pigeon roles’, it is time to now study each of them closely and in greater details. In subsequent units we will take a group at a time. You will in all cases like to refer to t his unit to remind yourself of their overall characteristics.

6.0 Tutor-Marked Question

Name the five kingdoms into which living things are classified. Give the main characteristic of each of the kingdom and name specific examples.

Illustrate their evolutionary relationship to each other in a diagrammatic form.

7.0 References and Other Resources

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UNIT 2

Viruses

Table of Contents

1.0 Introduction

Viruses are the smallest living organisms. They have no cellular structure. They can only reproduce by invading living cells. They can only live parasitically inside other living organism. By this we can call them obligate parasites. Because they are so small and acellular, possess some but not all the properties of life. Some people do not consider them as living organism. They are mostly disease carrying although here we will only concern ourselves with their method of growth multiplication and the qualities of life they possess. They however are not always disease causing.

The followings are the objectives of this unit.

2.0 Objectives

By going through this unit you should be able to:

1. Give the basic characteristics of viruses
2. Draw and labeled the generalized structure of the virus.
3. Describe the structure of a virus
4. Explain why viruses are seen as occupying the boundary line between living and non living things

3.0 Characteristics

The characteristics of viruses can be listed as follows:

1. They are the smallest living organisms.
2. They do not have a cellular structure.
3. They can only reproduce when they invade other living cells.
4. Their simple structure consist of the genetic material (DNA or RNA) surrounded by proteins or lipoproteins.
5. They occupy a boundary line between living and non-living
6. They are host specific.

3.1 Structure of a Generalized Virus

Viruses are the smallest of living organisms they range in size from 20-200mm. They are on the average fifty times smaller than bacteria. Like bacteria they cannot be seen with the light microscope. They pass through filters which retain bacteria.

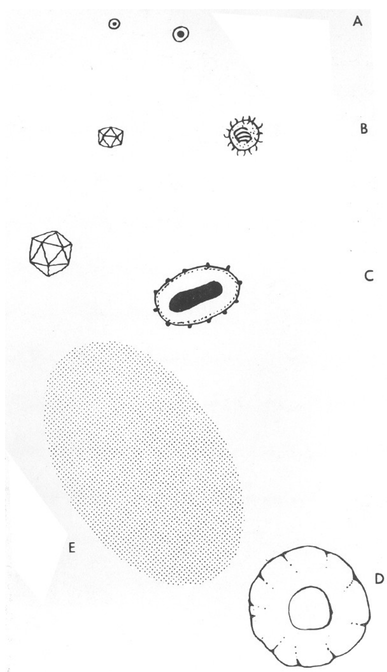


Fig. 2.1 Comparative sizes of viruses and a bacterium. A. Viruses that cause polio and the common cold, and the yellow fever virus. B. Conjunctivitis and influenza viruses. C. Measles and smallpox viruses. D. Mantle virus (causes trachoma), which responds to antibiotics. E. A bacterium. If drawn to the same scale, a human red blood cell, actually less than 0.01mm in diameter, would be more than one foot across.

They do not have cellular structure. They are very simple in structure. They have a core of generic material, either DNA or RNA both either in single or double strands.

There is a protective coat or capsid around the core. The two combine to from a nucleocapsid. Some may have an additional envelop round the capsid. This envelop is made up of an additional lipoprotein layer. This is especially true of the ones that cause H10 and influenza. The capsids are made up of identical repeating subunits called capsomeres.

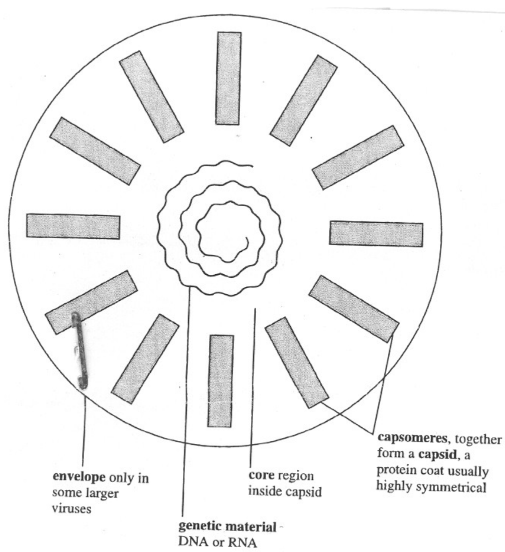


Fig. 2.2 A generalized virus.

3.2 Self Assessment Exercise 1

Here you will learn how to practice drawing. This is an important aspect of learning in biology. To learn a drawing you copy it from your learning unit looking at all details exactly as it is given including the labels correctly spelt. Then you close your copy and the study unit and try to reproduce the drawing on your own. Then go back and check for correctness. Try, try until you get all right. Now you have to practice drawing and labeling the generalized structure of a virus.

1. In six simple sentences give the general characteristics of viruses.
   - Viruses can only reproduce by invading living cells and generally causing them disease. They are therefore called obligate parasites. They are not all disease causing but most of them are.

- Each type of virus recognizes and infect only particular kinds of cells. Viruses are therefore highly specific to their hosts.

- They can therefore be said to occupy the boundary between living and non-living things.

- They are generally rod-shaped or many sided crystals usually with short tail-like projection.

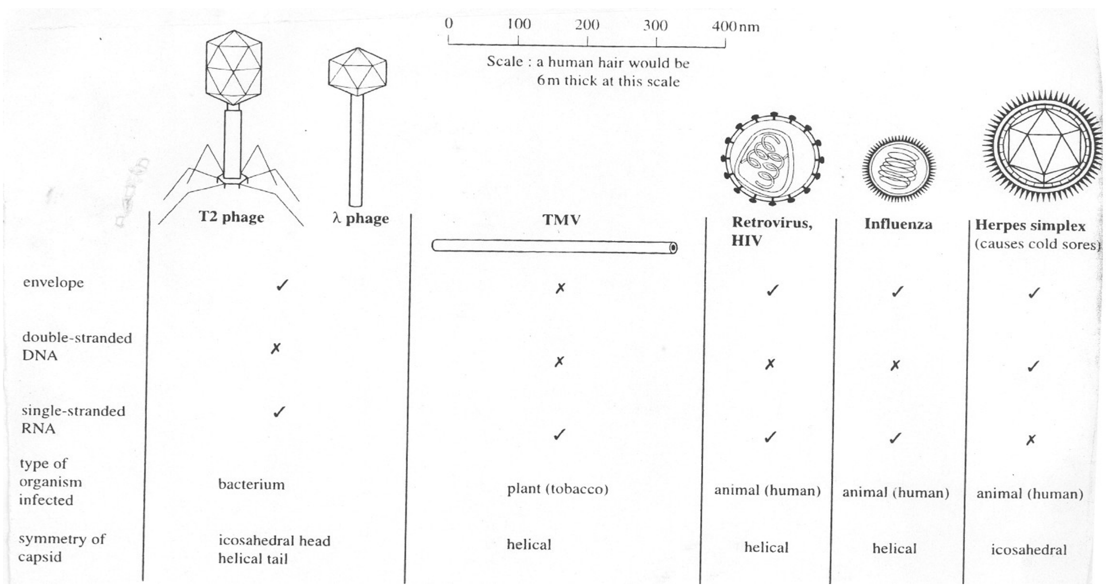


Fig. 2.3 Some simplified diagrams of viruses showing different sizes and symmetry. The T2 phage is shown with its tail fibres released prior to infection; the λ (lambda) phage does not have tail fibres.

3.3 Importance of Viruses

Viruses are important to man because of their activities. They causes diseases not only to man but also to his crops. They have been analyzed to contain nucleoprotein which have extraordinary molecular weight of up to two million.

The viruses which cause tomato and tobacco mosaic have molecular weight of 60 to 100 million. Those that cause fowl plague have a molecular weight of 200 to 400 million. Inspite of this they cannot be called living. They have no life of their own. They only exhibit living characteristics when they enter their hosts. No virus for example have any respiration of its own. It depends upon the enzymes of the host to do its work

They attack almost all sorts of living things including bacteria. Those that attack bacteria are called bacteriophases. See Fig. 2.4

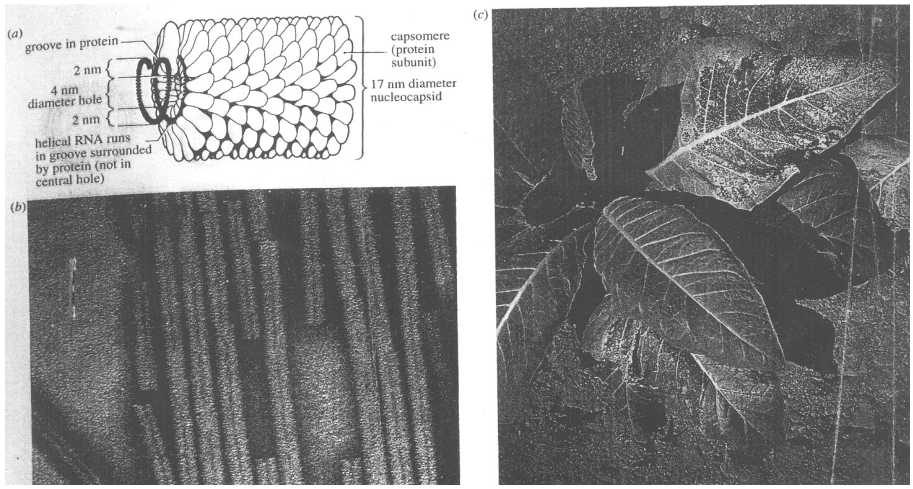


Fig. 2.4 (a) Structure of tobacco mosaic virus (TMV) showing helical symmetry of the capsid. Only part of the rod-shaped virus is shown. The drawing is based on X-ray diffraction, biochemical and electron microscope data. (b) Electron micrograph of a negatively stained tobacco mosaic virus (x 800 000). The capsid (coat) is made of 2130 identical protein capsomeres. (c) Tobacco plant infected with TMV. Note the characteristic mosaic pattern on the leaves where tissue is dying.

The viruses that affect bacteria contain only DNA as their basic form of nucleic acid. This DNA is comparable to genetic DNA and make people think that there is a relationship between the behaviour of virus DNA and material DNA in the nucleus of other living things. Numerous studies are being carried out by the use of radioactive isotopes of several of the elements that are constituents of proteins and nuclei acids.
Viruses that affect plant like that which causes the tobacco mosaic contain RNA .

Before we end this study of viruses let us learn about the structure and life cycle of a retrovirus, HIV. You need to know about this virus because it causes a disease which is relatively new and is spreading rather fast. As a biology student you want to have an idea of what it is all about.

The virus which causes the disease is called the <u>human immunodeficiency virus</u>. It belong to the group of RNA viruses known as <u>retroviruses</u>; so called because these viruses can change their RNAs back into DNA copy using an enzyme. The enzyme they use is called the reverse transcriptase. They do this by copying a section of the DNA (gene) to make the RNA in a process called transcription. The enzyme in control in this process is called reverse transcriptase. In your biology programme you may later also learn how this particular enzyme is useful in genetic engineering.

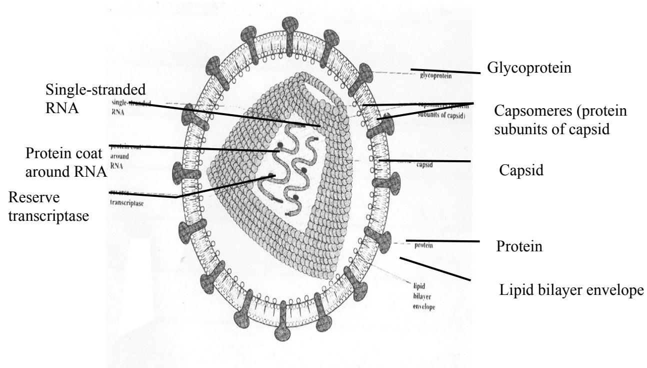


Fig. 2.5 Structure of the HIV virus, an example of a retrovirus. The cone-shaped capsid is made of a helical spiral of capsomeres. It is cut open to reveal the two copies of the RNA genetic code. Reserve transcriptase is an enzyme which converts single-stranded RNA into double-stranded DNA copies. The capsid is enclosed in a protein shell which is anchored in a lipid bilayer, or envelope, obtained from the cell surface membrane of the previous host cell. This envelope contains viral glycoproteins which bind specifically to helper T-cell receptors, enabling the virus to enter its host.

3.4 Why Viruses are Boundary-line Organisms

Viruses are sometimes described as boundary line organisms. They are seen as occupying between living and non-living because by their characteristics they could be described as living and non-living.

They are living because they have the genetic material and are able to reproduce themselves. However if we assume that all living things are made up of cells, then viruses are not living because they do not have a cellular structure. They also exist in an inert state until they find their exact host. When this happens the genetic instructions they carry in the DNA or RNA can how instruct the host material to replicate its type and so they continue to grow. Until this happens viruses are not evident because they show no life activity.

Once inside the body of the human, the HIV virus infects certain white blood cells called the T-helper lymphocytes. This result in the degeneration of the immune system in the human. Fig. 11.7 gives a summary of the life cycle of the HIV virus.

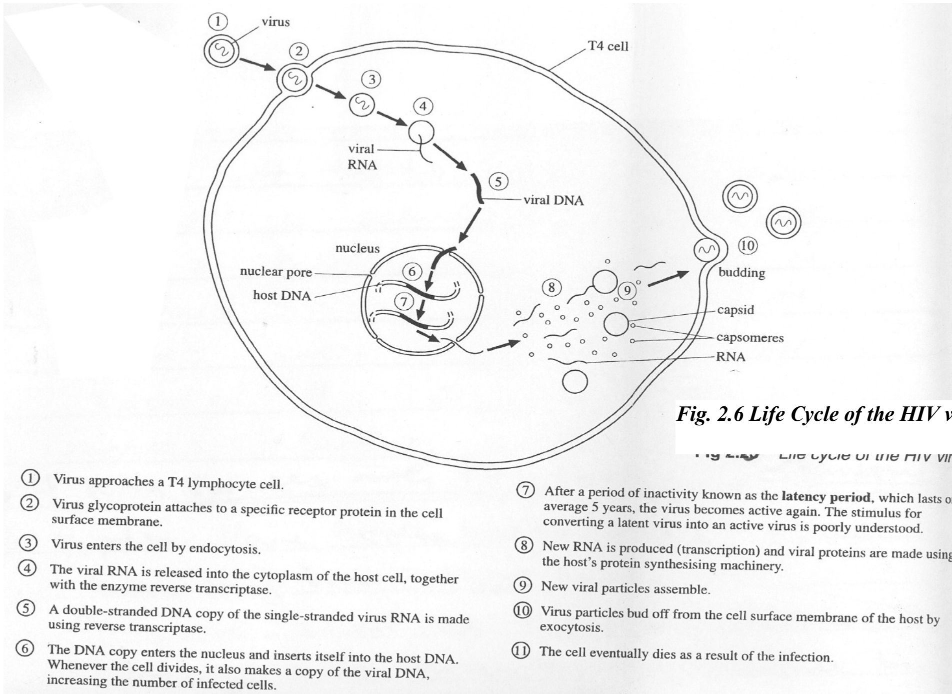
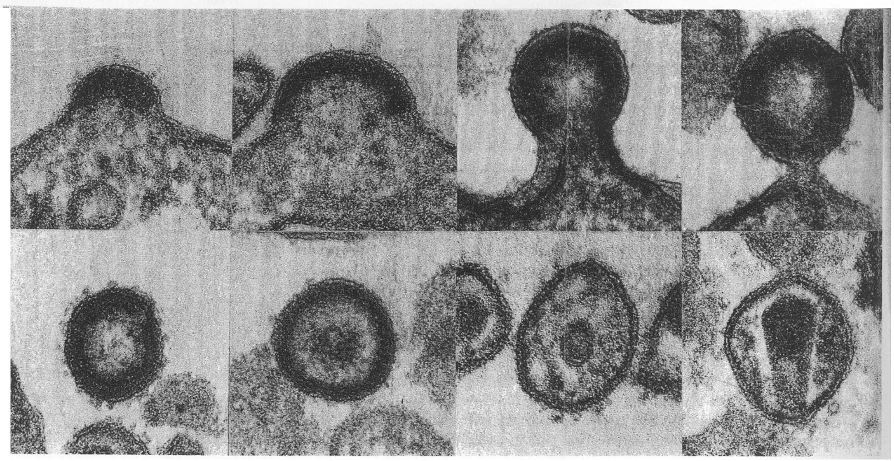


Fig. 2.6 Life Cycle of the HIV virus



4.0 Conclusion

In this unit you have learnt the structure and functioning of viruses. You have learnt that viruses do not have a life of their own. They begin to show signs that they are alive when they gain entry into their host. It is not surprising therefore that biologists have put them in a completely separate group of their own. They are acellular. They are very simple in structure, consisting of a small piece of nuclei acid – DNA or RNA surrounded by protein or a lipoprotein coat. In the description of their life cycles in their various hosts you have seen how they use this simple structure to perpetrate themselves

4.1 Self Assessment Question 2

Why are viruses boundary-line between living and non living?

5.0 Summary

Even in their simple state, the viruses give us an insight into life. It would look like they contain the most essential elements that make life possible in their simple structure. Once in a host, these structures can be put to use to exhibit life. They also indicate that other organisms have added a lot more to themselves in their development processes.

Viruses may therefore be the earliest forms of life. Hence they should occupy the lowest level in the evolutionary tree. In subsequent units you will see how organisms grow progressively more complex.

5.1 Answers to Self Assessment Question

1. You are right if you state the characteristics of viruses as follows:
    - Smallest living organisms
    - Have no cellular structure
    - Can only reproduce by invading living cells
    - Simple structure consisting of DNA or RNA, surrounded by a protein or lipoprotein coat
    - Are on the boundary line between living and non living things
    - Are host specific.

2. Viruses are in the borderline between living and non living things because they
    - They have genetic materials like living things
    - Are capable of reproduction like living things
    - Do not carry out their life processes on their own like living things
    - They must enter the cells of other living things to carry out life processes
    - They have no cells like living things.

6.0 Tutor-Marked Assignment

What are the characteristic features of viruses

b) Describe the structure of a virus
c) Illustrate y our answer with a well labeled diagram of a generalized virus.

7.0 References and Other Resources

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UNIT 3

Bacteria

Table of Contents

1.0 Introduction

You have just learnt that unicellular organisms are considered the lowest of all organisms because, all the functions performed by various systems in more complex organism are carried out in these single cells. Now you will learn more about unicellular organisms except for viruses. They are called prokaryotic because they do not have nuclear membrane. The nuclear material is spread on over the cell, which contain very few organelles. They are however very important to the living world because of their wide range of activities as you will see later in this unit.

2.0 Objectives

By the end of this unit you should be able to:

- Describe the general characteristics of bacteria
- Classify bacteria
- Describe how the high surface volume ratio affect bacterial activity
- Explain some life processes 9Respiration, Nutrition and Digestion, growth and reproduction in bacteria.
- Differentiate between the photosynthetic activities of the bacteria and that of plants.
- With the aid of formulae explain the process of nitrogen fixation by bacteria.

3.1 The Characteristics of Bacteria

Bacteria characteristics can be described under the following sub-heading – size, classification, structure and movement because all of these show the peculiarities of these organisms which is among the smallest of all organisms of living things. Let us start by talking about the size.

3.1.1 Size

Using the light microscope, and its highest possible magnification (100x) we can only the general shape of some bacteria. The smallest bacteria is about 0005 micrometers μ across. The largest may be up to .02 μ long. We can measure bacteria in micrometers one micrometer is equal to $\frac{1}{1000}$ (one thousandth of a millimeter).

3.1.2 Classification

There are more than 2000 bacterial species. In the three-kingdom classification system they are classified in the kingdom protita. We can further classified bacteria by their shapes. The spherical are called cocci; rod-shape are bacilli and spiral shaped are called spirilla. We can also describe bacteria with pre-fixes e.g. – diplo – meaning two; staphylo – which means cluster; strepto which means chain, other factors are today used to identify bacteria. These include size, staining properties, conditions needed for growth, as well as the appearance of the colony. A colony is the large group of bacteria that arose from a single bacterium: Figure 3.1 classification of Bacteria by shape.

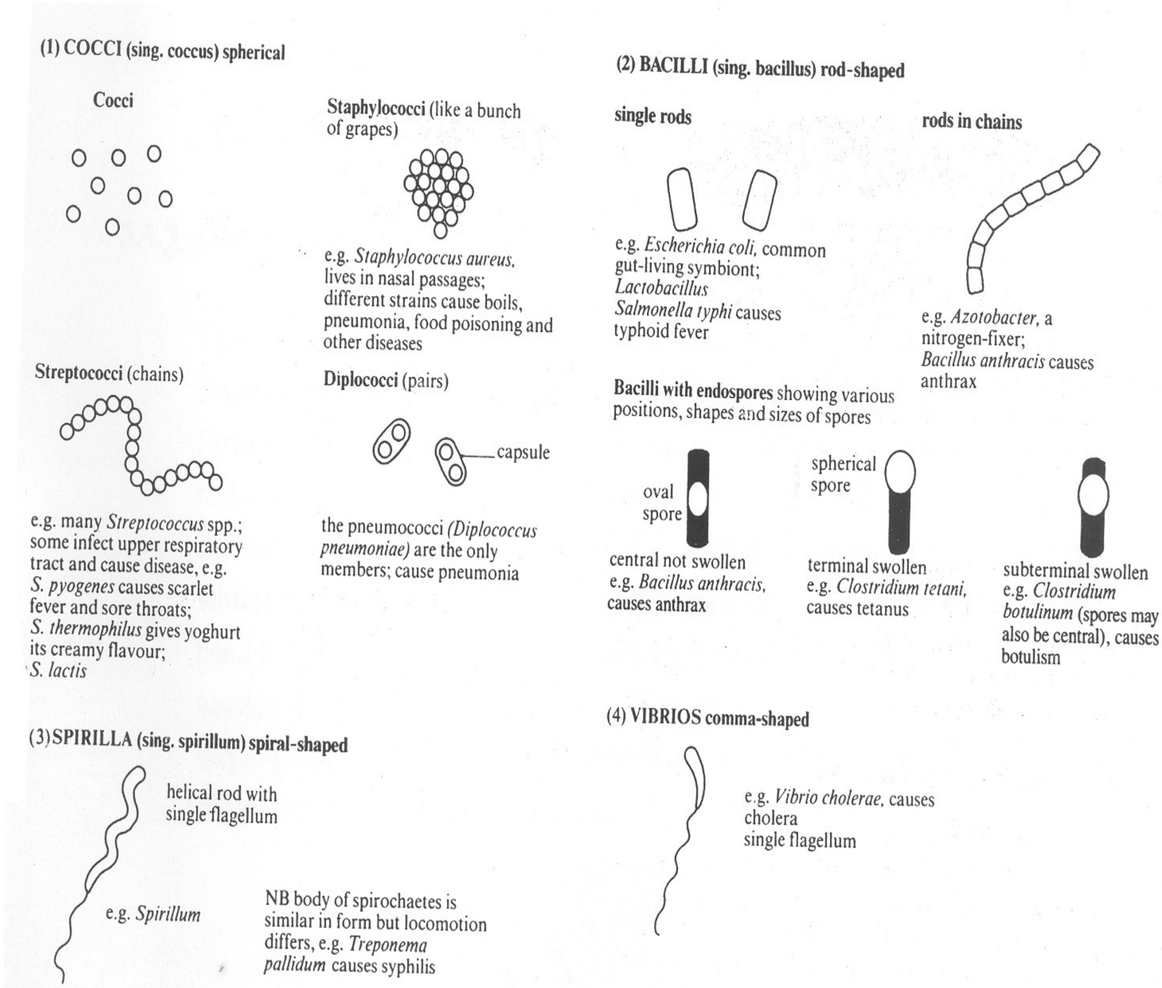

Fig. 3.1 Forms of bacteria, illustrated by some common useful and harmful types

3.1.3 Structure

The bacteria has an outermost chitinous cell wall, which keeps it in shape. Some bacteria (mycoplasmas) which can change their shape however do not have cell wall at all. Others have cell walls that are less rigid than others. Some bacteria have a substance or coating on the outside of the cell wall with a definite boundary. Such coating is called a slime layer. We can say that these coats protect the bacteria from viral infections, changes in the environment and the natural body defences of those organisms, which bacteria invade. The cell wall in some bacteria is strong and rigid because of the presence of murein, which prevent the cell from bursting when it absolves water with its tiny pores. These pores allow the passage of molecules. Some times bacteria are grouped by the structures of their walls into Gram negative and Gram positive.

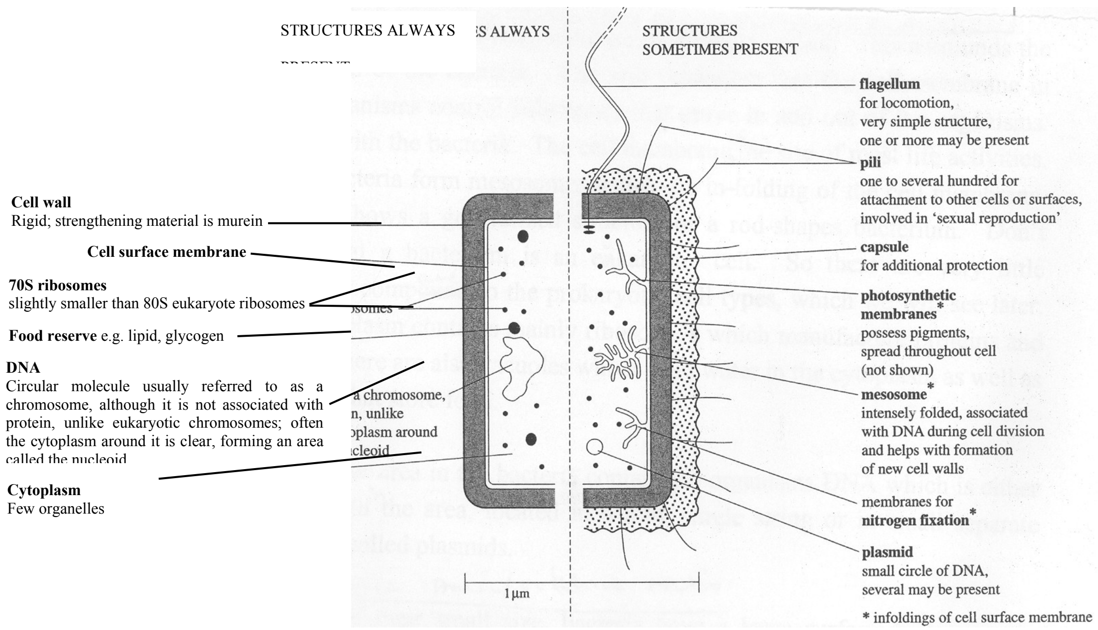

Fig. 3.2 Structure of a generalized rod-shaped bacterium (a typical prokaryote cell). The cell contains little structure compared with a eukaryotic cell.

All bacteria have cell membrane on their inner surface. This surrounds the cytoplasm of the bacteria. You will remember that the cell membrane in most organisms control substances that move in and out of the organisms. So it is with the bacteria. The cell membrane is the site of most life activities. Some bacteria form mesosomes which are in-folding of the cell membrane. Fig. 3.2 shows a generalized structure of a rod-shapes bacterium. Don't forget that a bacterium is an eukaryotic cell. So there are very little structures compared to the prokaryotic cell types, which we will see later. The cytoplasm contains mainly ribosome's which manufacture proteins and water. There are also vacuoles which store water in the cytoplasm as well as granules that store food.

The nuclear area in the bacteria contain the organisms DNA which is either spread within the area, located in a long single string or in small separate segments called plasmids.

3.1.4 Surface Area/Volume Ratio

Because of their small size, bacteria have a large surface/volume ratio which in a typical spherical bacterium can be expressed as about 120,000, where as in a single cell animal like amoeba it can be as low as 400. In our own bodies example and surface/volume ratio is even smaller – a mere 0.3. This is an advantage for the bacteria. All life process can therefore happen rather very fast with minimum hindrance by mass.

3.2.5 Growth and Reproduction

The advantages of the small size of the bacteria is easily demonstrated by its growth rate. When the condition is favourable, a bacterium can grow to full size and divide once in every fifteen minutes.

SAQ: What do you think is a favourable condition? Yes, it is that in which the Bacterium can best flourish e.g. adequate supply of the right source of energy and carbon (fundamental material for growth). Therefore, dividing every 15 minutes, there can be 48 generations of bacteria in a day. By calculation how many bacteria in one day?

Yes we will have up to 280 quadrillion offspring by a single bacterium. It has also been discovered that bacteria are involved in some kind of sexual reproduction by cell contact which may be similar to conjugation in which there is an exchange of genetic material. Some cells with fertility (F) factor in their genes are able to donate (serving as mates) genetic material. While others serve as female recipients, which not only receive the (F) factor but also the rest of the DNA. This process if relatively slower 9up to 90 minutes) than the division of cells responsible for the fast growth rate we have earlier described in the asexual reproduction.

3.1.6 Feeding and Nutrition

This is the process by which organism acquire energy and the fundamental material required for growth. Organism can only use two forms of energy, either chemical or light. Those who use light are phototrophs and those who use chemical sources are chemotrophs.

Described by the sources of their growth material, bacterial can also be grouped into autotrophs when the source of carbon is in organic. So you see, four categories of bacteria can occur like – this;

Table 3.1: The four nutritional categories of living organisms, according to sources of energy and carbon. Example are given of bacteria in each category. Plants are photoantotrophic. Fungi and animals are chemoautotrophic

	CARBON SOURCE	
	autotrophic source of carbon is inorganic (carbon dioxide)	**heterotrophic** source of carbon is organic

ENERGY SOURCE	**phototrophic** (photosynthetic light energy used	**photoautotrophic** e.g. blue-green bacteria	**photoheterotrophic** e.g. purple non-sulphur bacteria
	chemotrophic (chemosynthetis) chemical energy used	**chemoautotrophic** e.g. Nitrosomonas and Nitrobacter, nitrifying bacteria involved in the nitrogen cycle	**chemoheterotrophic** most bacteria – all the saprotrophs, parasites and mutualists (symbionts)

Photoautotrophic bacteria are like algae and plants because they carry out photosynthesis and use carbon dioxide as their carbon source. Blue-green bacteria live on top of fresh waters, and seas and fresh. They are also found as gelatinous mat-like growths on shaded soils, rocks mud wood and some living organisms. The blue-green bacteria have chlorophylla like plants as well as a characteristic pigment called phycocyanin. They produce oxygen in photosynthesis.

SAQ: So, what can we say about the blue-green bacteria in their evolutionary position? You can say that they seem to be a link between the rest of the bacteria and t he eukaryotes. This is because other bacterial do not produce oxygen, contain chlorophyll nor have photosynthetic membranes.

Some blue-green bacteria like Anabaena fix nitrogen of the air of form ammonia from which amino acids and protein compounds can be synthesized. This is done by heterocysts which are cells that develop when there is nitrogen shortage. They export these nitrogenous compounds for other nutrient like carbohydrates.

Chemoautotrophic bacteria use carbon dioxide as their source of carbon but obtain their energy from chemical reactions. They oxidize ammonia and nitrates. Some of them are important members of the nitrogen cycle. They carryout the process of nitrification in two stages. (See Formulae below).

Colonies of the genus Azobactria are nitrogen fixers. They live in root nodules. They fix nitrogen in two stages. The nitrosomonas oxidize ammonia to nitrite and so release energy. This is shown in the formular:

1) $$NH_4^+ \xrightarrow{\text{oxygen}} NO_2^- + \text{energy}$$

2) $$NO_2^- \xrightarrow{\text{oxygen}} NO_3^- + \text{energy}$$

Fig. 3.3: The Formula for the Nitrification Process

Chemoheterotrophic bacteria obtain energy from the chemical in their food, which puts them in three basic groups:

Saprophytes: Those who feed on decaying and deed matter. They secrete enzymes onto the dead organic matter which get digested out side the bacteria. The bacteria then absorb and assimilate the soluble products of digestion. They are, along with fungi decomposers. They bring about decay and recycling of nutrients.
Symbiosis (mutualism) describes the relationship between two organisms that live together and derive benefits mutually. Rhizobium is a bacteria (a nitrogen fixer) living in the roots of leguminous plants. Escherichia coli lives in the colon of man; probably contributing vitamins B and K. While man gives it shelter. These are examples of symbiotics.

Parasites, cause harm to their host on or in which they live. They are of different species from their host. When they cause diseases they are called pathogens. Many bacterial are disease causing e.g. the pnenmococci, the staphylococci etc.

4.0 Conclusion

We have seen that bacteria are very small simple organisms which live almost every where, air, fresh water, as spores in salt water, soil and as helpful and harmful organisms in plants and animals. They are diverse in performance. While some build up through photosynthesis, others decompose by the saprophytic activities and style. While some need light others will only thrive in the dark. You must by now be aware that though they are small, they are very important. But for them, the whole system of living things would collapse.

5.0 Summary

In this unit you have learnt about a group of organisms that appear to be among the earliest to inhabit the earth. You have also seen the possible link between the bacteria and other higher organisms like the algae. In the next unit we will continue to learn more about algae.

6.0 Tutor-Marked Assignment

Describe, naming specific examples, how the nature and processes in the bacteria affect the system of living things. Your description should be as comprehensive as possible. The minimum length of your assignment should be at least 7 typed pages. They typing should be double spacing using the fine Times New Roman font size 12. Illustrate your points with diagrams as much as possible.

7.0 References and Other Resources

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UNIT 4

The Cell – The Unit of Living Organisms

Table of Contents

1.0 Introduction

The cell is the unit of the living organism, be it plant or animal. They have a basic general structure although they could differ in structure and function by specialization. In this unit you will learn of the general structure of cells as well as the ways cells could be specialized to perform special functions. You will understand the increase in size of animals that we will be learning later better if at this stage you are able to conceive of the structure, size and functioning of a cell. Always remember that the cell is the unit of the living organism. To help us go through this unit successfully, let us set the following objectives to be achieved by you.

2.0 Objectives

As you go through this unit, you will be able to:

1. Draw and label fully the generalized animal cell.
2. Name and say the functions of at least ten major parts of the cell.
3. Distinguish between plant and animal cells.
4. Define cell specialization.

5. Name and say the special functions of at least five types of cells.

3.1 The Cell Concept

It was the German physiologist Theordor Schwann who first published the generalization that all organisms are composed of essentially like parts, called cells. All organisms are either made of one cell or several cells. Since his publication, the cell concept has come to mean the concept of life, its origin, its nature and continuity.

3.2 Cell Size, Shape and Organization

3.2.1 Cell Size

An organism is made up of many cells. A cell is usually too small to be seen by the naked eye. However you can imagine the size of a cell if you follow these instructions.

Exercise

1. Take your ruler, measure 1cm.
2. Divide the cm into 10 parts – you get 1mm.
3. Imagine what organisms or parts of organism that can have a diameter of 1mm; the seed of pepper?
4. Now take your ruler and measure 1mm.
5. Try to see how you can break this measurement of 1mm into a thousand parts. A cell can be 25 parts of this $^{1}/_{1000}$ units wide.
6. You will see that cannot continue to divide any more as you did the centimeter measure. It has become too small for you to manage with your naked eye.
7. You can however continue with the aid of a microscope. (You remember what you learnt from your practical biology course about microscopes and their uses in biology).

In the body of an adult man, it is estimated that there are about 30,000,000,000,000 cells. This can be more compactly represented as $30x10^{12}$. This is roughly equal to the number of seconds in 950,000years.

3.2.2 Shape

We may simply describe the shape of cells by recalling what bubbles of soap look like. When a cell has nothing stiff inside it interfering with its plastic nature, it assumes a spherical shape. It also assumes this shape in water. Where the cells touch each other, the walls of a group of cells become flat, while their face surfaces are convex. Alone, as single cells, each cell flattens out on a hard surface. In water in which it is freely suspended, it is spherical. Where there are a group of cells, they are flat at the sides they touch each other, whereas, on their free surfaces they are convex.

The picture of soap bubbles best describes cells when in group. Now let us see how each cell is organized.

3.2.3 Organization

There are three main parts in a cell, the central nucleus, the outermost membrane and the region in between these two, the endoplasm.

The Nucleus

Every cell has a nucleus although in some (red blood cell) it disappears, while in others (bacteria) the nuclear material is not enclosed within a nuclear membrane. The nucleus is the central organelle of the cell. It directs the manufacture of proteins and other cell constituents. It is also responsible for carrying genetic materials. We say that the nucleus is active when it is carrying out self replication in which genetic materials are transferred from one generation to the other. However when it is not actively dividing, we can say that the nucleus is resting or at interphase. When it is dividing, it does not have a membrane and its contents are more distinct and more deeply staining. There is also a nucleolus, a dense, solid body inside the nucleus. It is responsible for spelling out the RNA to be produced in cell reproduction. At interphase, the cell is more active. While during cell division, cell metabolic activities virtually come to a standstill. Most of what is known about the nuclear structures was learnt from evidences of the dividing state. Under the electron microscope, the nuclear membrane is seen as a double layer with pores.

The Cell Membrane

This is the layer of protoplasm living the outermost surface of the cell. It serves to control the movement in and out of the cell. This process can be called controlled diffusion. It is through this process that all the things required by cell for all life metabolism are received and all that must be passed out are expelled. You must understand that the whole cell is active physically, chemically and mechanically. For example, when a great number of substances attempt to pass through the cell membrane at the same time, there is a “jam”. Small molecules or ions with electric charge may experience difficulty charged. Many cells also take in substances from outside by extending the cell membrane by pinocystosis. Look at Figs, 4.1 and 4.2.

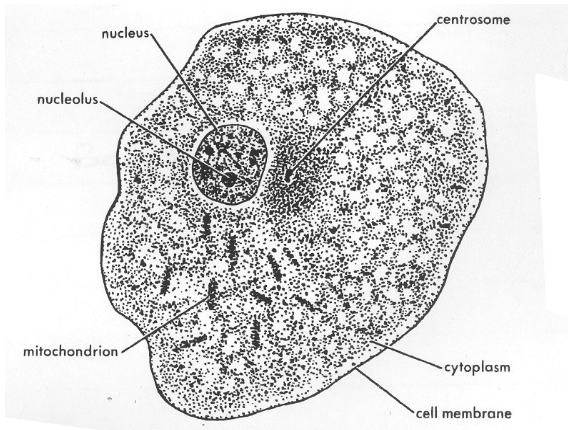


Fig. 4.1 Animal cell, as seen with light microscope, showing nucleus with nucleolus; the centrosome in dense cytoplasm outside nucleus; the alveolar appearance of the cytoplasm with included granules and mitochondria; and the cell membrane, or plasmalemma.

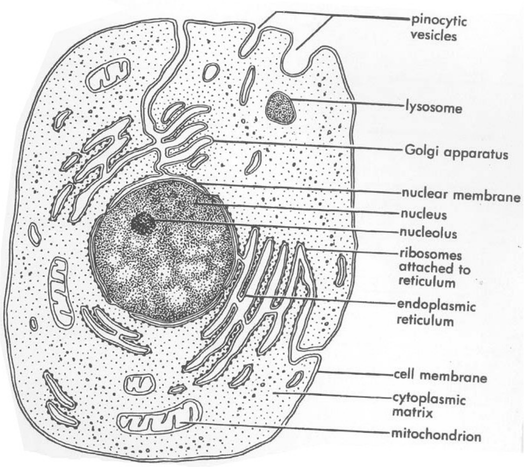


Fig. 4.2 Diagram of cell showing membrane systems, nucleus, and inclusions..

In Fig. 1, you can see the simple structure of an animal cell as visible under the light microscope. Here the membranes are simply seen as simple lines, be it the nuclear or the cell membrane. Within the nuclear membrane you can see labeled, structures of the nucleus. These are mainly hereditary material which structures are clearer with the electron microscope. A study of their chemical structures also show their chemical components. Between the nuclear and the cell membrane are a protoplasmic mass with granular structures of different sizes and functions.

3.2.4 Differences Between Plant and Animal Cells

All cells have same basic structures in common. But basically plant cells differ from animal cells. The followings are the basic similarities between animal and plant cells. You will need to take proper note of these differences.

1. Animal cells have denser protoplasm and contain many small vacuoles. While in plant cells the vacuoles are larger and fewer.

2. The animal cells have a thin limiting membrane while plant cells have thick cellulose cell-wall.

3. Animal cell never have chloroplasts but plant cells have.

Fig. 4.3a and 4.3b shows plant and animal cells. You will learn to recognize these differences more in your practical course.

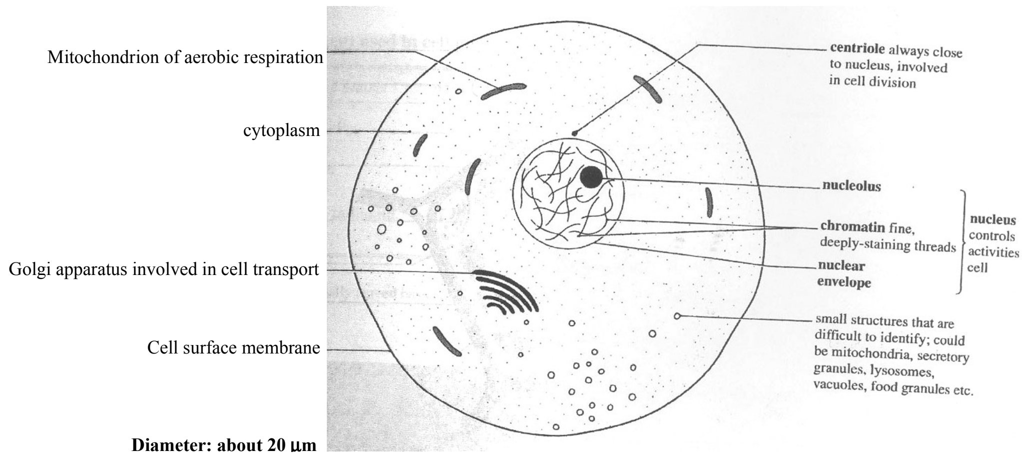


Fig. 4.3a Generalised animal cell as seen with a light microscope

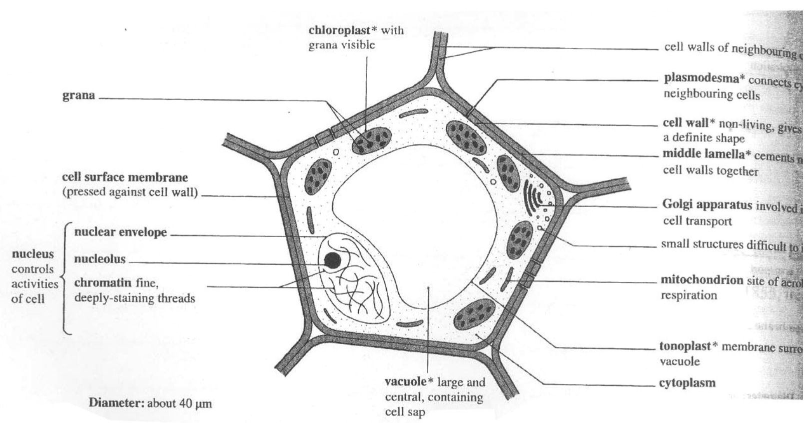


Fig. 4.3b Generalised plant cell as seen with a light microscope

Now let us continue with the organization of cells.

The Endoplasmic Reticulum

The cell membrane often have invaginations and evaginations that sometimes go very deep into the cell. These connect to an interlocking network of double membranes and vesicles extending through the cytoplasm. This is the endoplasmic reticulum. It also is in continuity with the nuclear membrane. The enormous structural surface of the endoplasmic reticulum could be covered with numerous granules called ribosomes responsible for the manufacture of proteins. The reticulum breaks down and reforms each time the cell divides.

The Golgi Bodies are complex membranous components of the cytoplasm. It consists of a double folding and branching system of membranes and vesicles almost similar to the endoplasmic reticulum except that it does not have the ribosomes.

It is believed that the Golgi bodies serve as a gate between living matter and the exterior of the cell regulating the passage the concentration and the condition of water and other substances leaving the cell.

Cytoplasmic Matrix

You remember we have just finished describing the endoplasmic reticulum and the Golgi bodies as folded membranes in the cytoplasm; the difference between them being that the later has no ribosomes and is not as extensive.

The rest of the cytoplasm and the irregular compartments of separated by the reticular membrane is the cytoplamic matrix. It is made of a mixture of water, salts, small organic compounds and macromolecules of many kinds. It can flow like a liquid as well as solidify as it happens with elastic deformation. It tends to be solid (gel) on the surface and liquid (sol) within. It contains a variety of structures called organelles:

The Mitochondria: a complex elongated double membrane structures associated with respiration and energy release.

Lysosome: nearly spherical bodies which contain digestive enzymes. These ingest and digest all food substances.

Chloroplasts: in green plant cells. These are highly organized structures responsible for photosynthesis.

Apart from these there are granules of food like proteins carbohydrates and fats.

Cilia and Flagella: are other types of organelles that could be found in cells. They are associated with locomotion

3.2.5 Exercise 1

Practice drawing the generalized plant and animal cell. Remember how you practice drawing. Look at your study unit. As you look, copy the drawing onto your jotter or your study exercise book. Look carefully at details and copy the drawing exactly. Then put in the labels also represented in the study unit. Ensure that you spell words correctly. Check and re-check your spellings. Then close your study unit and try to draw and label on your own. When you've done so, open your study unit, compare what you have done. By the time you do this twice, you will find that it is easy and you are succeed.

3.2.6 Self Assessment Questions 3

1. How will you describe the shape of the cell?
2. Can you notice any structural differences we have not mentioned?
3. What are t he three basic areas of a cell?
4. What is the importance of the followings to the cell?
    - Nucleus
    - Mitochondria
    - Cell Membrane
    - Ribosome

3.2.7 Kinds of Cells

Now let us look at a few specialized cells. A study of a variety will show you how cells become specialized to perform particular functions. Generally cells are not particularly specialized. However, some are specialized in some distinct ways. The protoplasm for example is generally sensitive in various ways. This sensitivity is transmitted to other parts of the cell as a result (or in response) they contract or expand. These basic qualities of sensitivity, transmission and reactiveness are basic qualities of living substances, be they of plants or animals.

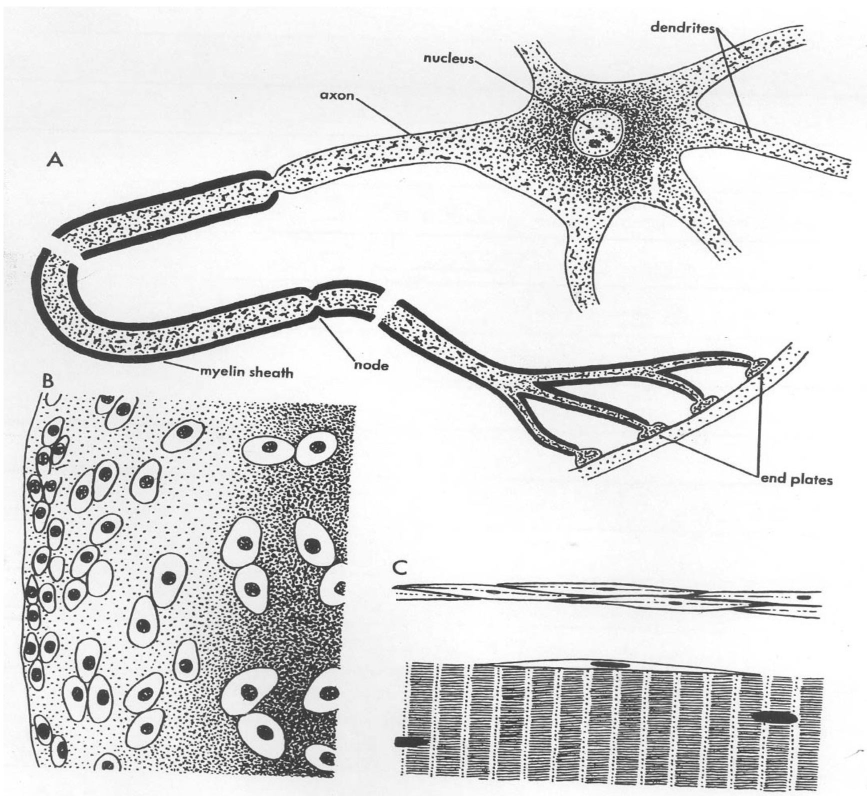
However, the presence of the green pigments and large vacuoles in plant cells are a kind of specialization of plant cells for specific functions. The green pigment chlorophyll is for photosynthesis while the large vacuoles contain aqueous solution of mineral salts which regulate the turgidity of adjoining cytoplasm.

Most plant cells also have a rigid outer cell wall of polysaccharides and lignin. These render rigid mechanical support to the plant as well as prevent any activity within the cytoplasm of such liquefied cells. Example of such cells are found in strengthening tissues like the schlerenchyma of stems. Some animal cells have their outer membranes almost naked. The cell surfaces are very active and invariably possess structures, and with which they receive stimuli. They also often have very contractile protein with which they respond to perceived stimuli. Such form tissues whose contraction could cause a change in the shape of the cell or even the movement of parts or whole animals.

Nerve Cells

Nerve cells are elongated cells which transmit a stimulus from one place to another. It is therefore an example of a specialized cell.

Fig. 4.4 A. Vertebrate motor nerve with myelin sheath and dendritic and axonic processes. B. Cartilage, a supporting tissue consisting of cartilage celss (chondroblasts) and matrix. C. Upper drawing: smooth, or involuntary muscle tissue. Lower drawing: striated, or voluntary muscle tissue.



Electrochemical disturbances pass from point to point within the cell cortex and travel readily from one nerve cell to another.

Muscle Cells

These are another group of specialized cells. They are also elongated, but in their own case they possess such protein materials that contract are relax. See Fig. 4.4c

Secretory Cell

Some cells like those in the pancreas have well developed endoplasmic reticulum equipped with zymogene granules. Even among the secretory cells, there are various kinds. While some are concerned with secreting digestive enzymes, (like those of the pancrease just mentioned) others secrete supporting substances (like the matrix of cartilage or bones) and some even nectar or toxic substances.

You can see that cell specialization is an extreme development of a particular cell to perform a function. This is usually accompanied by the suppression of other functions. You will remember that cells as the living units of organisms, generally perform all living functions to an extent to sustain the cell as living. When cell is specialized to do one of such life functions to a far greater extent, other functions are relatively suppressed. For example the cytoplasm of cells have secretory properties. However the cytoplasm of secretory cells have highly elaborate secretory abilities. Similarly, all cells generally have the respiratory pigment cytochrome. From this a specialized respiratory pigment, haemoglobin may have evolved in red blood cells. The conduction of impulses is a general property of cell surfaces. The conduction of nerve impulses along nerve fibres is an expansion of this characteristic. The light sensitivity is a characteristic of protoplasm in general, but the light-sensitivity of the cells of the eye is an extreme development of this feature. We can continue to multiply examples of cell specialization.

3.2.8 Self-Assessment Exercise 4

Would you like to name some examples of cell specialization in plants and animal which we have not mentioned in this unit? Name at least three examples of cell specialization in plants and animal which we have not mentioned in this unit? Name at least three examples.

Self-Assessment Exercise 5

What is specialization?

3.2.9 Answers to your Self Assessment Questions

1. If you say that because of the elastic nature of cell, when alone on a hard surface, the single cell flattens out because of surface tension forces. However, in water alone, a single cell is spherical in shape. Where they are in a group, their tops are convex but the flatten out at the sides where they touch each other.

2. There are three main differences between plants and animal cells:

	Plants	Animal
1.	Presence of chloroplasts	Chloroplasts absent
2.	Large vacuole	Small vacuoles
3.	Thick cell wall	Thin cell membrane.

3. Basically, the cell has three parts: the **central nucleus**, the **middle cytoplasm** and the **outermost cell membrane**.

   The cell membrane forms the outermost covering of the cell. It control the exit and the entry of substances into the cell. In the cytoplasm are various organelles which help the cell to perform various life functions.

   The third part of the cell is the dense nucleus. It not only controls the activities of the cell but is also responsible for cell reproduction.

   The mitochondria is responsible for aerobic respiration. The cell membrane selectively allow the entrance of various elements into the cell. The ribosome is responsible for the manufacture of proteins.

4. Some specialize cells like guard cells, taste buds, pollen grains, xylem cells, intestinal cells and a few correct answers you could give to this question. Specialization is the development of the ability of one cellular function over all others.

4.0 Conclusion

We have studied the structure of the cell in this unit of life. The basic structure of the cell is that it possesses a central controlling unit which is responsible for both the day to day existence of the cell as well as reproduction and continuity of the cell. There is also can outer membrane which serves and a means of exit and entry of substances. The substance between the nucleus and the outermost membrane is the cytoplasm which are various structures called organelles responsible for various life functions including respiration, protein synthesis excretion, osmoregulation and others. You also learnt that generally cells are not specialized. Rather every cell has the basic ability to perform all life functions. However, in specialized cells some aspect of these life functions are exaggerated all the expense of others. This is the meaning of specialization.

You learnt specialized cell are cells in which a particular function is emphasized more than other life functions. In such cells, the structures performing such specialized functions have enhanced development and adaptations for the functions they perform.

5.0 Summary

In this unit you have learnt about cells and their types; whether they exist on t heir own, or as part of an organism. In subsequent units, we will proceed to learn more about cells in an indirect way. You will see it as indirect because we will be studying organisms which you will realize get progressively more complex and more specialized in their cells. Remember every organism is made up of cells. We will study cells when we study the plant kingdom. We will also learn about them in the next few units as we will study the animal kingdom. So we will start by studying both plants and animals that are made up of one single cell. Then we will progressively study more complex ones. You will also realize that even though there are so many organisms in the living world, there is a pattern which can easily be understood when you study biology.

6.0 Tutor Marked Question

Describe the structure and function of the parts of an animal cell. Illustrate your answer with a well labeled diagram.

7.0 References and Other Resources

Berril, N.J. (1979) Biology in Action. London. Heinemann Educational Books, Ltd.

Stone, R.H., Cozens, A.B, Ndu, F.O.C. (1999) New Biology for Senior Secondary Schools Lagos. Longman Nigeria Plc.

Soper, R. et al (1997) Biological Science Cambridge, Cambridge University Press.

UNIT 5

Fungi

Table of Contents

1.0 Introduction

Plants that belong to the kingdom fungi belong to three phyla: Zygomycota (e.g. mucor), Asconycota (RegPenicillium) and Basidomycota (mushroom). The fungi are plants that do not have chlorophyll and so do not carry out the processes of photosynthesis. They therefore live either as parasites or saprophytes. Some start life as parasites and later become saprophytes as it is the case with pythium, which causes damping off in plants seedlings. The body of fungi is made up of a mass filamentrous hyphae called mycelium. The hyphae are both straight and branched fluffy threads sent both into the substrate as well as carrying spores into the air. You will here therefore understand how the spores of the mould can be found everywhere and why food easily go mouldly. You can also see why fungi are important to us. They reproduce asexually by spores that are easily air borne and germinate in damp places. They belong to the group called thallophyta, that is the group of plants which are not differentiated into leaves, stems and root. Others in this group include the algae, bacteria and lichens. However while fungi are either saprophytes or parasites, lichens are thallophytes made up of both fungus and algae – living together in a mutual benefit. Before we go on to study the fungi, let us look at what we should be learning in this unit.

2.0 Objectives

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

1. Describe the structure of fungi
2. State the similarity and differences between bacteria and fungi
3. State the differences and similarities between fungi and algae.
4. State how fungi are adapted to their habitat.

3.1 Structure of Fungi

Structurally, fungi could be made up of one cell (e.g yeast) or several cells (e.g. mushroom). Some are motile moulds, while others are not motile. They can also be cellular or acellular. By this statement you will understand that it is sometimes difficult to describe a fungus as being made up of cells or one single cell. This is the case with the slime mould which has a large slimy sheet of protoplasm, not divided into cell but contains several nuclei. This fungus move about like amoeba does but move rapidly. It could be colourless, red, yellow or violet with a finely branched net-like structure. Here it will strike you that there is some similarity, metabolically, between bacteria and fungi. You will remember that it is difficult to describe bacteria as animals or plants. Both fungi and bacteria flourish where some kind of organic material provide food since they cannot photosynthesize. Both bacteria and fungi are neither metabolically independent or are they significantly motile.

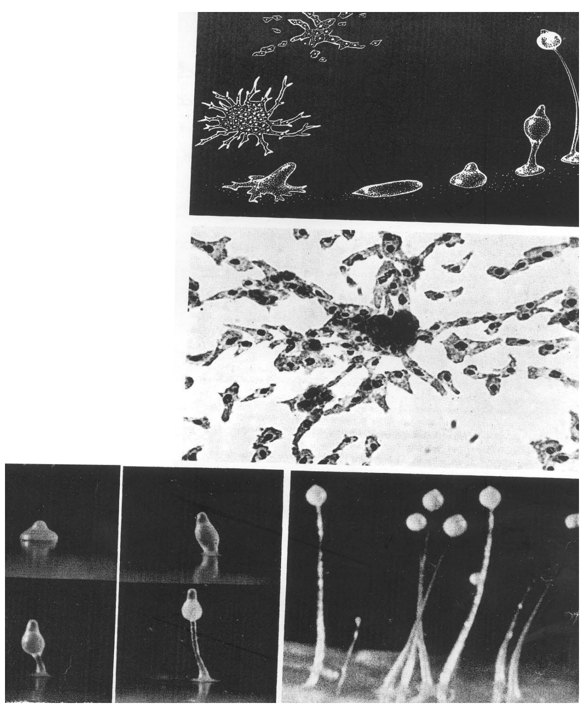


Fig. 5.1. Aggregation of amoeboid cells of the cellular slime mold, Dictyostelium, and the transformation of an aggregation mass into a sporangium. (Photographs by J.T. Bonner)

Some true fungi, like the mushroom and the toadstools have their distinctive umbrella shape on a thick stalk. Their vegetative body is made up of both straight and branched hyphae. In some fungi, these threads are divided by cross walls into cells while in others they are not. In some fungi the hyphae form loose fluffy mass (as in mucor) or get closely woven together to form structures like that of the mushroom.

Keep a slice of bread moist and covered on the table in your room for about two days. You will observe the growth of some silky white threads. Using a hand lens, you can look at this growth more closely.
Draw what you see and compare it with Fig. 5.2 Mycelium of mucor.

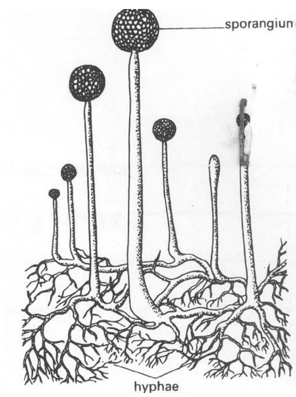


Fig. 5.2. Mycelium of mucor

Self Assessment Exercise

After several practice at drawing and labeling the diagram, draw it on your own. This will help you understand the structure.

Penicillum is one of the commonest saprophytic moulds which can be found on rotten foods, fruits, a damp brad and other kind of organic matter on the piece of bread for example. Penicillum will appear later than the mucor and will give the bread a blue green colour. The hyphae are divided into cells by cross walls and each cell so formed contain several nuclei visible only when special stems are applied.

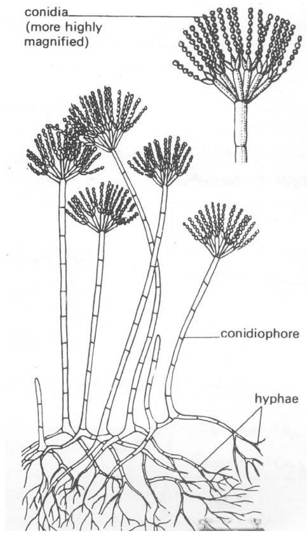


Fig. 5.3 Penicillium; part of mycelium

The unicellular fungus – the yeast is naturally found in overripe fruits and solutions contain sugar like the palm wine. By feeding on these substrates, yeast causes fermentation. In these suitable substrates they feed and multiply by budding off very fast to form chains of cells. Structurally, each yeast cell contains a nucleus and nuclear vacuole contain chromatier thread, while the cytoplasm contains granules and glycogen.

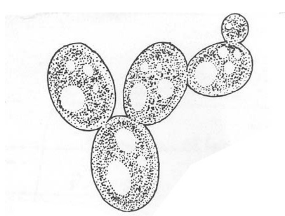


Fig. 5.4a Yeast multiplying by budding

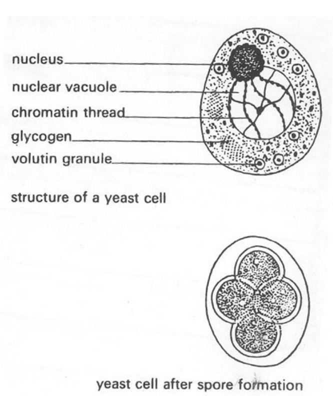


Fig. 5.4b Yeast cell

So in this section we have seen that there is a remarkable variation in the degree of organization of the hyphae of fungi. While some hyphae like that of the mucor or penicillum is made up of a single filament; the yeast's filament is modified into ellipsoidal cell each separate from the other. The mushrooms and toadstools represent perhaps a more advanced organization into definite shapes and much larger sizes. Many remarkable characteristics of the fungi concern their nutrition and growth. Let us now study the facts of the nutrition and growth.

Self-Assessment Exercise

Practice drawing the structure of the yeast cell. After your practice, close your study unit and try to draw and label it on your own.

3.2 Nutrition and Growth

It is during the invisible vegetative stages that fungal hyphae truly grow. They generally secrete a strong supply of enzymes which rapidly decompose their substrates from which they then derive the requirements for their own growth. They absorb these nourishment into the hyphae. Many fungi also synthesize vitamins. Some of the enzymes produced by fungi include: diastase, for converting starch to sugar; sytase, for converting cellulose to sugar; peptase, for converting proteins to peptones and amino acids; lipase, for converting can sugar to simple sugar; zymase, for converting grape sugar to alcohol and Co_2. You can well see why fungi are important to man. They are a source of many enzymes. Fungi and bacteria are known to be a source of antibiotics. Each fungus and bacteria produce its own antibiotic substance, which primary nature must have made possible as a means of self protection for these organisms. There is therefore a real chemical warfare among soil bacteria and fungi – each producing substances to discourage the growth and development of other species within its territory.

3.3 Reproduction

Generally, reproduction in the fungi are of two types, sexual and asexual. The sexual involves the coming together of the tips of two hyphae of different mycelia (as in mucus). However in Neurospora a mycelium can produce both the plus and minus sexes, but cross making with plus and minus it, hyphae of another mycelium must take place. Genetic changes take place and spore sacks are formed. These can eventually germinate to form new fungi. Some specie of yeast also reproduce sexually by produce similar to conjugation and produce spores which germinate when conditions are favourable.

Asexual reproduction in the fungi usually happen by the production spores at the end of reproductive hyphae. At the right times, the spores are dispersed by the wind. Like the bacteria, growth and reproduction is very fast, sometimes a generation reaches maturity in a few hours.

3.4 Adaptation

Fungi need damp (moist) conditions to grow because they absorb both water and nourishment through their surfaces. As they do not use light to manufacture their food, they can live both in light and dark. However many of them need light to form spores. Their chemical secretions help them not only to digest the elements in their habitat for absorption but also to create a defence for themselves as other species as other species are unlikely to inhabit others territories. They are either saprophytic or parasitic. Fungi are therefore different from algae which must generally live in light because they are photosynthetic by feeding habit. Bacteria and fungi are very comparable in the way they are able to cause disease and decomposition of organic matter. Fungi are particularly effective in the breakdown of cellulose. When this happens, there is a quick increase in fungal materials including carbonaceous and nitrogenous end products. These again help rebuild life just as is the case with bacteria.

Self-Assessment Question

So how are fungi and bacteria similar in the way they affect our lives. You will say they are similar because they both have a sort of stabilizing or balancing impact on the living system. By their activities the build up life through forming the basic material for growth (the carbonaceous and nitrogenous and products). They also ensure breakdown or decay of the dead.

4.0 Conclusion

In this unit we have studied those essential features of the fungal group. We have also learnt to distinguish between fungi and other lower organisms like the bacteria and algae with which they share some affinity. You have come to know that fungi, like bacteria play very important role in maintain natural equilibrium because of their ability to flourish only where some kinds of organic material are available since they are unable to photosynthesize.

5.0 Summary

What you have learnt in this unit refer mainly to factors of adaptation of the fungi to their peculiar habitat and facts responsible for the survival of organisms. In later units, we shall see other organisms do the same in their peculiar ways.

6.0 Tutor Marked Assignment

Using a variety of examples describe the range of structural differences in the fungal group. Show what the various examples you have used have in common in terms of nutrition, growth and reproduction. You should answer this as comprehensibly as possible making diagrammatically illustrations. The maximum length of your assessment should be 10 pages typed, A4, double spaced, 12 points, Times New Roman including diagrammatic illustrations.

7.0 References and Other Resources

Berril, N.J. (1979) Biology in Action. London W.C. B_3HH. Heinemann Educational Books, Ltd.

Gottfried, S., Madrazo, G.J, Moz, L., Olenchalk, J., Sinclair, D., Skoog, G. (1985) Biology Englewood Cliffs, New Jersey, Prentice-Hall.

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MODULE 2

UNIT 6

Algae

Table of Contents

1.0 Introduction

Algae are classified as Protoctista, and described as ancestors of plants. They have definite plant characteristics of possessing chlorophyll and being able to photosynthesize. They are also eukaryotic although some are unicellular. In this unit you will see how, within this kingdom there is a variation in structural type to the extent that some algae could be described as more complex than others. To guide you in this study, let us set the following objectives.

2.0 Objectives

As you go through this unit, you will be able to:

1. Give the characteristics of algae
2. Distinguish phyla chlorophyta and phacophyta.
3. Describe the structure of spirogyra

4. Draw and label spirogyra
5. Describe the structure of focus
6. Draw and label focus
7. State the adaptations of spirogyra to its habitat.
8. State the adaptations of focus to its habitat.

3.1 General Characteristics

Almost all algae are adapted to living in water. They exist in a wide range of sizes and form. There are unicellular, filamentous, colonial and thalloid forms. A thalloid is a body that is not differentiated into true roots, stems, and leaves. True vascular system (i.e xylem and phloem). When features appear like roots, stems and leaves but lack vascular tissues they are described as not being true. The thallus is often flat, photosynthetic and eukaryotic. You remember the many characteristics of eukaryotic organisms which we treated in unit 1 of this course (see Table 1.1) as we were classifying organisms. You will notice here that the algae have a wide range of variety. They are divided into two main groups. Before we see the two groups, let us list clearly the main characteristics of algae again.

3.2 Self-Assessment Exercise 1

Would like to do so in the space below as in about four simple sentences?

1. ……………………………………………………………………………
2. ……………………………………………………………………………
3. ……………………………………………………………………………
4. ……………………………………………………………………………

There are two phyla in the kingdom algae.

3.3 Classification into Two Groups

The Phylum Chlorophyta (green algae) and t he phylum phaeophyta (the brown algae). We will first study the green algae. The kingdom is separated into two phyla mainly by the colour of their photosynthetic pigment and the way they store their carbohydrates. While in the phylum chlorophyta the pigment chlorophyll (a and b) is dominant; the photosynthetic pigment of the phaeophyta is fucoxanthin (chlorophyll a and c).

Secondly, whereas the chlorophyta store their carbohydrates as starch, the phaeophytes store it as soluble laminarin and mannitol. They also store fats. The other difference are that chlorophyta are mostly fresh water habitants with a large range of variety including unicellular, filamentous, colonial and thalloid types. The phaeophytes on the other hand are nearly all manic types. They are only filamentous or thalloid and usually large.

3.4 Self Assessment Exercise 2

Put in a tabular form the characteristic features of the chlorophyta and the phaeophyta. You have enough information in section 3.3 of this unit to make your table.

3.5 Structure of Spirogyra

You will remember you have seen this plant under microscope in your course 104. You are therefore familiar with the structure as shown in Fig. 6.1a and b.

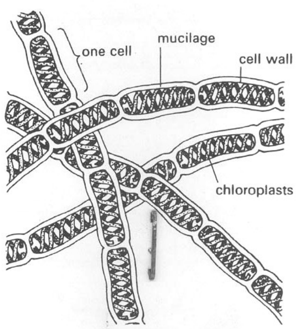


Fig. 6.1a Parts of four spirogyra filaments (x20)

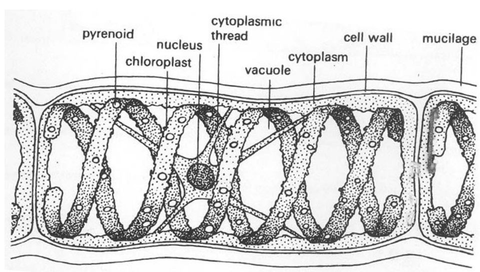


Fig. 6.1b Single spirogyra cells; highly magnified

Each filament consist of several cylindrical cells placed end to end. Each cell is about 75mm long. It has a thick cellulose cell wall covered with shiny mucilage on the outer surface. The inner living of the cell wall is made of cytoplasm which encloses a central vacuole in which cell sap is stored. The nucleus could be suspended by strands of cytoplasm or be suspended by strands of cytoplasm or be embedded in the cytoplasm which also has chloroplasts. The nucleus also has a nucleolus. The chloroplast is a spiral strip wound round the inside of the cell. It has some colourless patches of pyrenoids associated with the formation of starch.

3.6 Adaptation of Spirogyra

It is found floating on the surface of water with air bubbles bentrum strands. It grows by cell division along its length but not in width. The mucilage on its surface could have a protective function against weather and preys. The nucleus not only control cell activities, but also initiate cell division. Since all spirogyra cells are similar in structure and carry out all life activities. It could be described as a colony of cells all fixed together by the mucilage. Spirogyra by its level of differentiation is simply multicellular. It does not have special cells performing specific functions.

Now let us study focus to determine its structure and adaptation.

3.7 Structure of Fucus

Fucus is a brown alga. It is relatively large and more complex. Its body is called thallus which is differentiated into holdfast, stipe and frond. These look like root, stem and leaf respectively but they are not true ones because there are no vascular tissues.

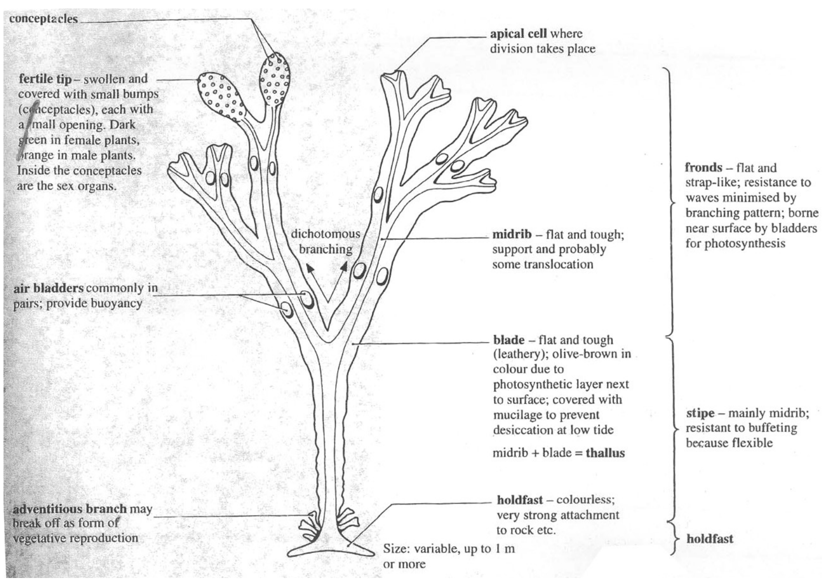


Fig. 6.2 External features of Fucus vesiculosus, with notes on structure, particularly adaptations to environment

3.8 Adaptations of Fucus

Fucus inhabits intertidal rocky shores where the conditions change with the arrival and recession of the tide. This result is great differences in temperature and exposure to air. Fucus therefore needs to be protected from drying out. A cold sea may run into a hot rock pool causing drastic temperature changes. Saturity may also increase as water dries out or increase when rain causes a sudden increase in the level of water. The plant must be physically adapted to stand the tug and surge of tidal waves as well as the effect of crashing stones as the waves break on them.

For all of these, the Fucus has a strong holdfast which anchors the plant onto the rock so firmly that in the process of trying to remove focus by the holdfast, the rock can break before the holdfast. The thallus branches dichotomously (i.e. branching into two at each branch point). This device creates little resistance to water. It tough but flexible and its mid rub is also strong and flexible. It possesses air bladders to enable it float in water. This is a device to get enough light for photosynthesis. The plant has chloroplasts on its surface layers so that it can get maximum exposure to light for photosynthesis.

However, the lower layers use the dominant photosynthetic pigment, fucoxanthin under water. Fucoxanthin absorbs blue light which penetrates water further than does the red light or those of longer wave lengths. The large quantities of mucilage secreted by the thallus prevents desiccation because they partly fill spaces within the thallus and cover the surface as well. By this the thallus retains water. The solute concentration is higher in the thallus than in the surrounding so that water is not lost to the surrounding through osmosis.

Even the sexual organs are squeezed when the tide recedes. The sex organs are protected by the drying out of the conceptacles, yet they remain stuck together by the mucilage. When the tide advances, it bring water which now dissolves the mucilage and release the gametes. The motile chemotatic male gametes are attracted by the chemical secretion of the female. The zygote develops immediately to reduce its chances of being swept out into the sea.

3.9 Self Assessment Exercise 3

You have done very well following your studies to this point. You must now do some practice so that you can gain more by putting in more time to cover your work. At this point it will be wise for you to learn to your and label the two algal examples we have studied. You must always remember that you start by look at your study units and virtually copying the diagram and labeling it. You pay attention to as possible details so that when you want to draw from memory you will remember.

4.0 Conclusion

In this unit we have studied the structure and adaptations of a green and brown alga. You will already guess that the brown alga shows an advancement over the green one because the cells are complex and more differentiated. However, they both still belong to a low level in the classification hierarchy. They do not have vascular tissues and are both still aquatic.

5.0 Summary

In the last unit we studied the fungi which are not classified as plants. Now we are studying the algae which are definitely plants although still primitive. The Bryophytes and Pteridophytes in Unit 7 will further clarify to you what we mean by complexity. Now you can already know that by increased complexity we mean greater number cells, differing in structures some adapted to specific functions/

6.0 Answer to Self Assessment Exercises

1. General characteristics of algae:
   You are right if you said some things like these:
   - Almost all are adapted to life in water.
   - Exist in a wide variety of size and form
   - Do not have true roots, stems or leaves.
   - They are photosynthetic and eukaryotic.

2.

Phylum Chlorophyta	Phylum Pheophyte
1. Dominant photosynthetic pigment is chlorophyll. They are therefore green in appearance. Contain chlorophylls a and b as in plants	1. Dominant photosynthetic pigment is brown and called fucoxanthin chlorophylls a and b present
2. Store carbohydrates as insoluble start	2. Store carbohydrates as soluble laminarin and manitol. Also store fat.
3. Mostly fresh water	3. Mostly marine (only the fresh water genera.)
4. Large range of types, e.g. unicellular, filamentous, colonial, thalloid.	4. Filamentous or thalloid, often large
e.g. – chlorella – unicellular non-motile - Chlamydomonas – unicellular motile - Spirogyra, filamentous alga - Ulva, a thalloid, marine alga.	e.g. Fucus, a thalloid, marine alga. Laminaria, large thalloid, marine alga. One of the kemps.

7.0 Tutor Marked Question 6

Why would you say focus is more complex than spirogyra? While they are both multicellular. Illustrate your answer with diagrams.

8.0 References and Other Resources

Berril, N.J., (1979) Biology in Action London. Heinemann Educational Books Ltd.

Stone, R.H., Cozens, A.B., Ndu, F.O.C. (1999) New Biology for Senior Secondary Schools Lagos. Longman Nigeria Plc.

Soper, R. et al (1997) Biological Science Cambridge. Cambridge University Press.

UNIT 7

Bryophyta and Pteridophyta (Filicinophyta)

Table of Contents

1.0 Introduction

In the last unit we learnt about algae. In this we are to learn about bryophytes and pteridophytes. In the present unit you will see how plants gradually become more complex; from the simple water plants algae to those who can stay on land but are still dependent on water for a vital function fertilization. You will see an increase in the structural complexity as well. You will note that the essence of this course is to help you learn about structures in organisms and how these structures adapt the organism to its habitat. To achieve the aim of this unit, the following objectives are set. Try to achieve them.

2.0 Objectives

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

- Write down the general characteristics of bryophytes.
- Distinguish between the two classes of the bryophytes – the mosci and liverworts.
- Draw and label a generalized cycle of the bryophytes.
- Write down the general characteristics of pteridophytes.

- Describe the evolutionary trend between the bryophytes and pteridophytes.
- Highlight the importance of the emergence of vascular tissues in pteridophytes.

3.1.1 General Characteristics

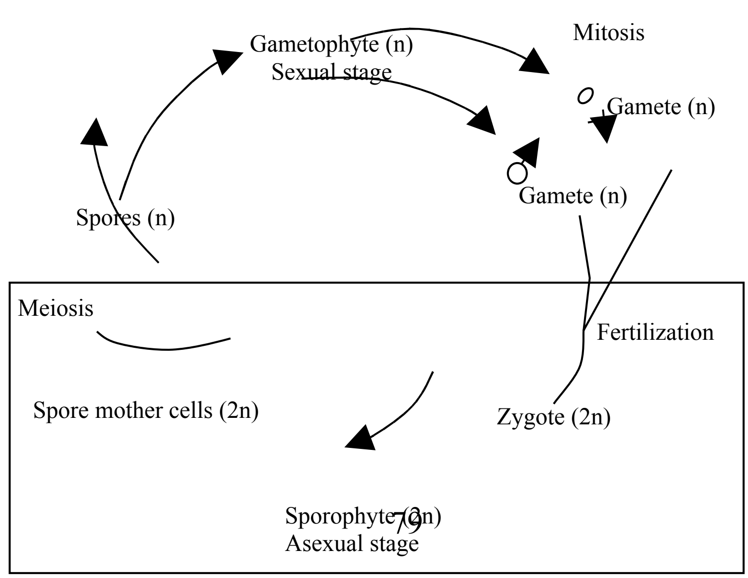
The bryophytes are the simplest of land plants. It is likely that they evolved from green algae. They contain two classes, the Liverworts (Hepaticae) and the Mosses (Musci). They are not well adapted to life on the land. So they inhabit damp shady places.

They are small, simple. Their strengthening and conducting tissues are either absent or poorly developed. There is no true vascular tissue. You will remember that the vascular tissues are the xylem and the phloem tissues. They do not have true roots, stems and leaves. This is because all of these in their true forms have vascular tissues which are absent in bryophytes. They are anchored to by thin filaments called rhizoids which grow from the stem. So rhizoids serve mainly as a means of anchorage. Water and mineral salts are absorbed from the whole surface of the plant. The rhizoid do not function like plant roots either. The plant surface is delicate and has not cuticle. For this reason they are at risk of loosing water. This is why they can survive only in dark shady places. However some have been found to survive long (up to a year) at up to 20^{oc} by a means not yet well understood. In net times they soon recover fully.

3.1.2 Life Cycles

In the bryophytes, two generations alternate in their life cycles. There is a haploid gametophyte generation and a diploid sporophyte generation.

Fig. 7.1: The Generalized Life Cycle of a Bryophyte



You will notice that the two generations are always alternating. The gametophyte is always haploid and produces its gametes by mitosis. The sporophyte is always diploid and produces its spores by meiosis so that there is a return to the haploid condition. The haploid spores give rise to the gametophyte generation which is more conspicuous and lasts longer. It is therefore the dominant generation. In the bryophyte the gametophyte is dominant. In all other plants the sporophyte (i.e.) the part which produces the spores. You also should understand that when you draw a life cycle, it is usual in biology to put the dominant generation on the top half of the diagram. You should further note that the diagram can also represent the summary of life cycles in all plants, flowering plants included. Notice that to produce gametes mitosis takes place and meiosis produces spores. In animals however it is meiosis that produces gametes.

External Features of Liverworts

Liverworts e.g. Pellia

The liverworts are more simple than the mosses and stay more confined to damp shady places, like river banks, damp rocks and wet vegetation.

The body is made up of a dull green flat thallus. It has a midrib which is more obvious on the lower side. It has unicellular rhizoids also arising from the lower side. Often branches dichotomously at the tip.
When it has absorbed sufficient nutrient, a vertical seta begins to grow from the top and this seta later carries the black capsules containing the haploid spores produced by meiosis. The capsule later split into four to release the spores which germinate to form the thallus.

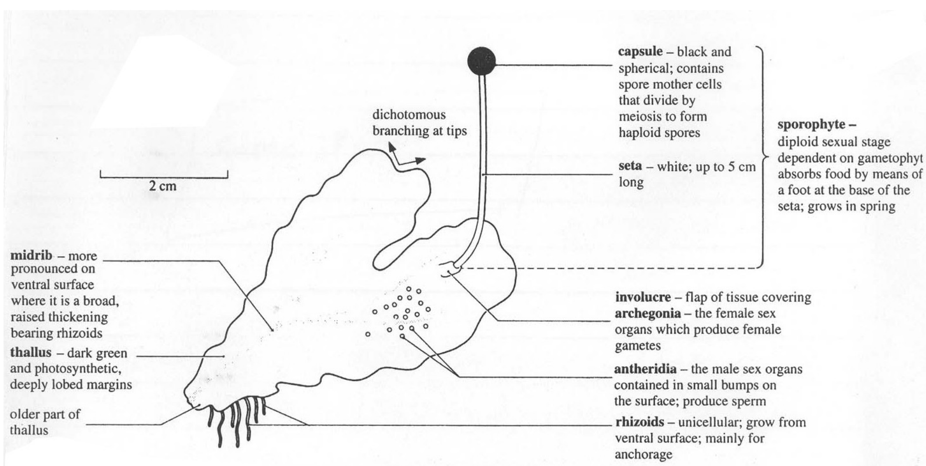


Fig. 7.2 External features of Pellia, a liverwort. The gametophyte is shown with the dependent sporophyte generation attached.

3.1.4 The Moses

Like the liverworts, they also live in damp shady places. However they are a bit more differentiated because they have multicellular roots, stem, and spirally arranged leaves. Like liverworts, the mosses need water for fertilization. When the plants' surface is wet, mature antheridia absorb water and burst, releasing the male gametes (sperm) onto the surface. Each of the sperm have two flagella. With the help of these, they swim towards the archegonia, each of which contains one female gamete or ovum. Fertilization takes place in the archegonium. A diploid zygote is therefore formed. This grows out of the archegonium to become a new sporophyte.

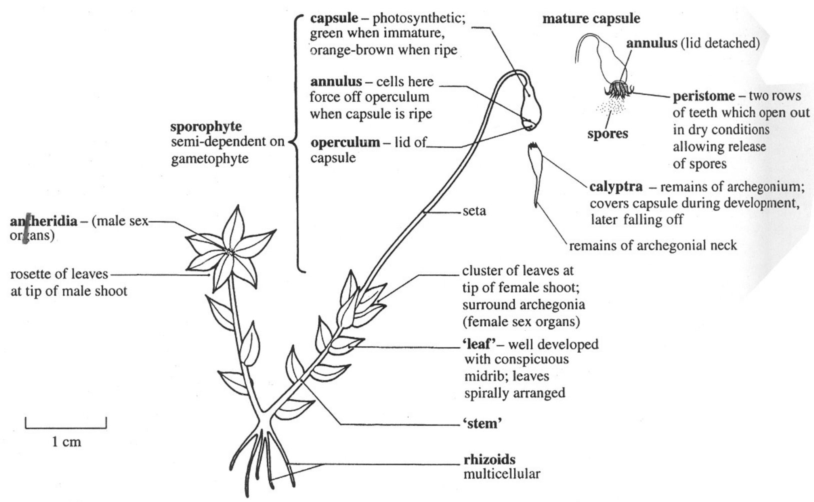


Fig. 7.3 External features of Funaria, a moss. The gametophyte is shown with the semi-dependent sporophyte generatic attached.

In this section we have studied the phylum bryophyte. You will notice that within the phylum, we can say that the class musci is more advanced than the Hepaticae. Mosses have structural differentiation that are not evident in the liverworts. Mosses can withstand drought as they live as epiphytes on other trees.

However plant in this group are not of significant economic importance to man.

Exercise: Draw the generalized life cycle of a bryophyte. Label it showing the alternating generations.

3.2 Pteridophytes – Ferns (Filicinophyta)

3.2.1 General Characteristics

Ferns are usually restricted to damp shady places. They are common in tropical rain forests like we have. Only few of them can grow in full sunlight.

3.2.2 Structure

Structurally ferns are more developed than mosses. This is because they have vascular tissue made up of xylem and phloem. The vascular tissues transport water and nutrient round the plant body. The xylem carries water and mineral solutions like sugar. You will note that the emergence of a vascular tissue is an important evolutionary step above the bryophytes and algae. This vascular tissue is found in the sporophyte generation.

Let us emphasize the importance of vascular tissue in the evolution of plants. When water and mineral resources as well as organic matter like sugar can be carried into plants, it means that they can have sufficient supply of these materials. They can afford to grow big and complex without being cut-off supply since there is a transport system.

Secondly, these tissues provide hardness because they contain lignified cells which have great strength and rigidity. Other lignified tissue, the Schlerenchyma also develop in vascular plants and further adds to the mechanical role of the xylem.

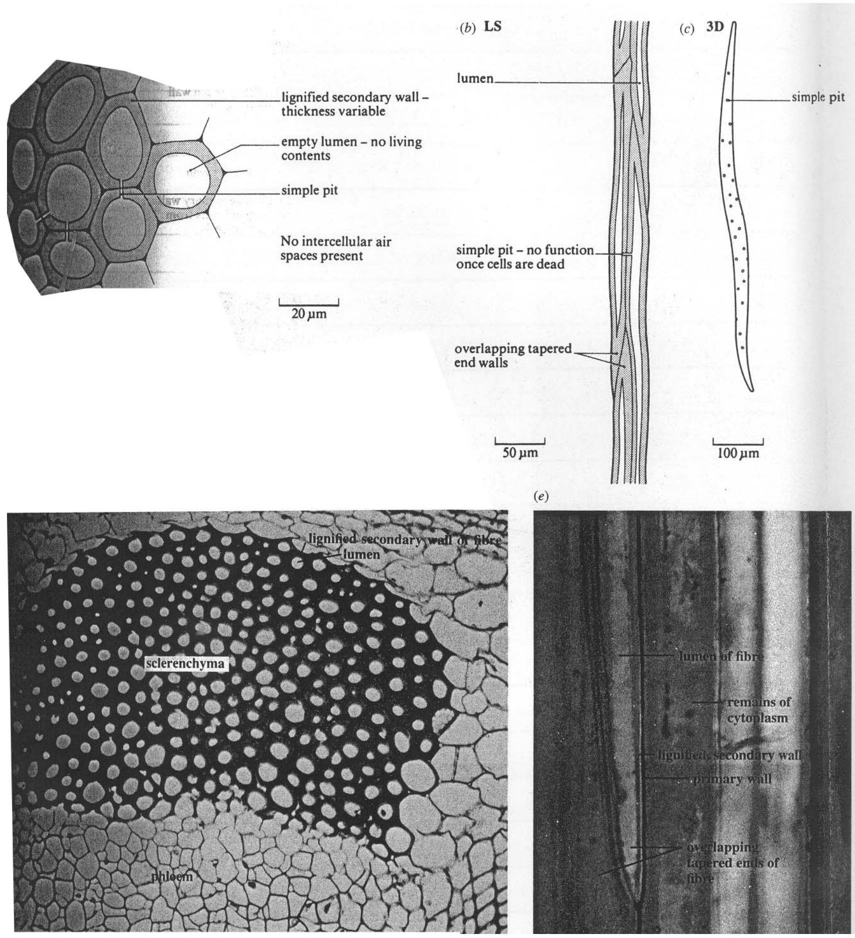


Fig. 7.4 Structure of sclerenchyma cells. (a) TS, cells are polygonal in outline (b) LS, cells are elongated (length very variable, commonly 51mm up to 250mm reported). (c) Three-dimensional appearance. (d) TS sclerenchyma from Helianthus stem. (e) LS sclerenchyma from Halianthus.

The figure shows the structure of the cells of the vascular tissue. Notice that the walls of these cells are thick and laden with lignin. In a later unit we will study the internal structure of vascular in greater detail. However do not forget that it is in the pteridophytes that we have them for the first time in the evolution of plants.
Now let us return to our study of the structure of the fern. The sporophyte generation possesses true roots, stems and leaves. This generation of fern therefore has the advantage of support; food, water and minerals supply; ability to grow big and strong and even to struggle for light.

However, the fern is still handicapped because the gametophyte generation which is still small and susceptible to drying out than the bryophyte gametophyte. The gametophyte generation of the fern is called the prothcillus. It produces the sperm which must swim to reach the female gametes.

3.2.3 External Features of the Tree Fern

The frond (leaves) of the sporophyte can be up to a metre tall. It has thick horizontal stem or rhizome which bears adventitious roots. It can reproduce vegetatively by breaking of branches from main stem. These give rise to separate plants. The bases of the fronds are covered with scales called ramenta which project younger leaves from frost or drought. The young leaves are characteristically rolled up. The main axis of the leaf is called rachis and the leaflets on either side are called pinnae and the small rounded subdivisions of the pinnae are called pinnules.

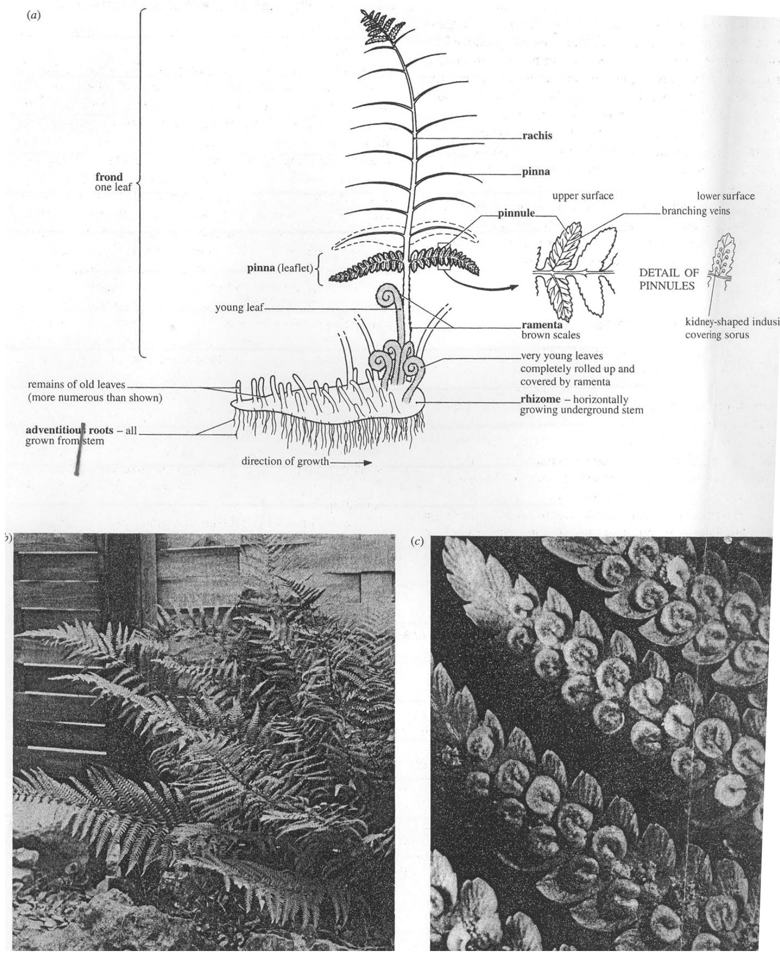


Fig. 7.5 External features of the sporophyte generation of Dryopteris filix-mas, the male fern. (a) Diagram with details of one pair of pinnae; others have the same structure. (b) The fronds. (c) Underside of frond showing sori (some covered with indusium). (d) and (e) opposite.

3.2.4 Reproduction

When spores are produced, they are first green but become brown when mature. The arrangement of spores on the frond vary from fern to fern.

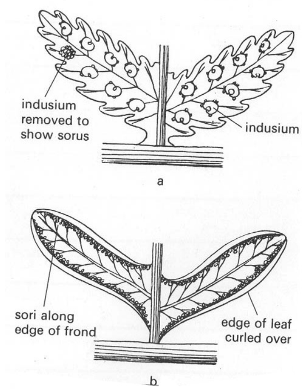


Fig. 7.6 Arrangements of sporangia on underside of fronds (a) in sori and (b) along edge of leaf

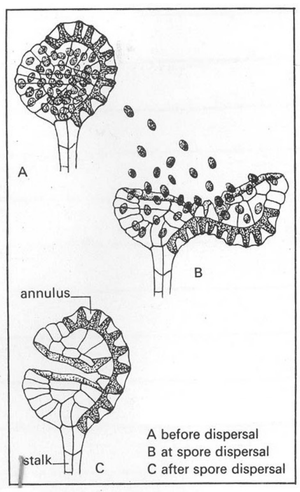


Fig. 7.6b Sporangium

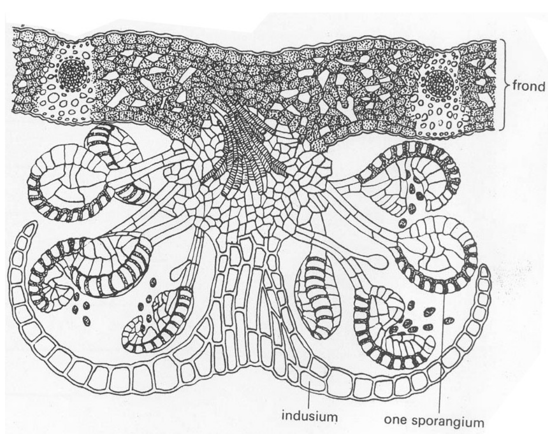
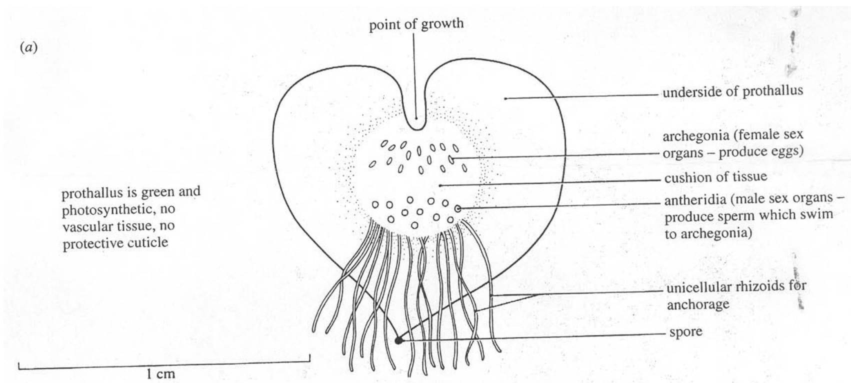


Fig. 7.7 Vertical section of fern sorus

Sporangia develop in clusters called son which are covered by the indusium. Inside each sporangium is the diploid mother cell which divide by meiosis to produce haploid spores. When mature, the indusium shrive and drops off to expose the sporangia walls which begin to dry out, they eventually rupture to release the spores. These spores germinate to form the gametophyte generation.

The gametophyte is a thin heart-shaped plate of cells about 1cm in diameter.



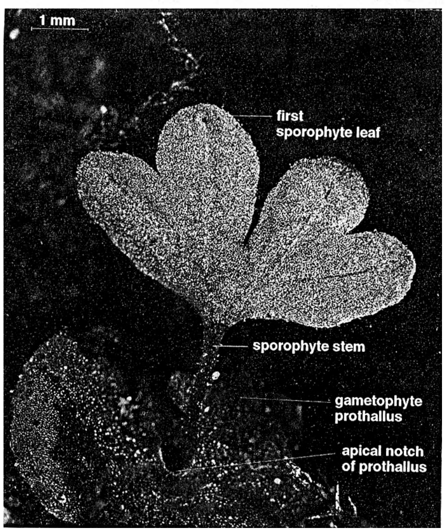


Fig. 7.8 External features of the gametophyte generation of Dryopteris, known as the prothallus. (a) The prothallus is green and photosynthetic. It has no vascular tissue and no protective cuticle. (b) Prothallus with the first frond of the next sporophyte generation growing from it. At first the sporophyte is dependent on the gametophyte for water and minerals but it soon becomes an independent plant and the gametophyte dies.

It is green and photosynthetic. It is anchored by unicellular rhizoids to the soil. The delicate prothallus has no cuticle and is prone to drying out. It can only survive in damp places. It produces simple antheridia and archegonia on its lower surface. These are sex organs which protect the gametes within them. The gametes are produced by the gamete mother cell.

The archegonium produce the ovum while the antheridium the sperm. Al do so by mitosis as in bryophytes. The sperm has flagella with which it swims to fertilize the ovum. The diploid zygote so formed develops into the sporophyte generation. You must note here too that the fertilization is dependent upon the presence of water. The young zygote continues to get nourishment from the gametophyte until its own root and leaves can take over the role of nutrition. Then the gametophyte withers and dies.

4.0 Conclusion

In this unit we have seen that the bryophytes are simplest among all land plants. We have also seen that the pteridophytes are the first group of plants to emerge with vascular tissues.

We also know that pteridophytes are handicapped because they have a gametophyte generation that have no vascular tissue. You should need to take note of these vital points because they will help you in your understanding of the evolutionary trend and the facts of adaptation. Remember these are the main aim of this course.

5.0 Summary

Now we are ready to see how flowering plants have come to dominate the earth. Note that the fact that they are more shows that they have adapted so well on land. Those that must grow near water sources are limited by such conditions. The next unit will treat flowering plants.

6.0 Tutor Marked Assignment 7

How is it that the pteridophytes are considered more evolutionarily advanced than the bryophytes? What do they still share in common with bryophytes?

Explain important factors of adaptation of pteridophytes to their habitat.

7.0 References

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UNIT 8

The Conifers
(Spermatophyta – the Seed-Bearing Plants)

Table of Contents

1.0 Introduction

The seed bearing plants are the most successful of all plants. They are the group with which we are most familiar. They are also so abundant and diverse. They are everywhere – in our gardens and out in nature. They are also very important to man.

Seed bearing plants have a dominant sporophyte generation. The gametophyte generation is reduced. So the idea of alternation of generation is not evident here as you saw in the bryophytes and the pteridophytes. The sporophyte produces two types of spores microspore (the pollen grain) and the megaspore (the embryo sac). The embryo sac is completely enclosed in the ovule. When the ovule is fertilized, it develops into a seed. They have complex vascular tissues in the roots, stems and leaves.

There are two phyla in this kingdom, the conifer phyta and the angiospermophyta. We will now start with the coniferophyta (conifers). To study the structure and ecological adaptations of the confers. The following objectives should guide you as you go through this unit.

2.0 Objectives

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

1. Give the general characteristics of conifers
2. Describe the external structure of the pine (a conifer), and the adaptive features in the conifers and why they are among the most successful plants.
3. Draw and label the following features of the sporophyte generation of Pinus Sylvestris (the Scots pine):
   - A diagram of the vegetative morphology.
   - The first-year cone before pollination.
   - The second-year cone at fertilization.
   - Group of male cones.

3.1 The Characteristics of the Coniferophyta

Let us itemize these so that you can easily remember them:

- Conifers usually produce cones on which sporangia, spores and seeds develop.
- Seeds are not enclosed in an ovary. They remain on the surface of specialized leaves called ovuliferous scales in the structures called cones.
- They produce no fruits because they have no ovary.

3.1.1 General Appearance and Habitat

You will notice that the main diagnostic feature of the conifer is the production of cones. Others are the fact that the seeds lie on the surface of leaves and are not enclosed. A diagnostic feature is a feature by which you can identify an object.

Since they are also seed producing, they are among the most successful group of plants. They are widely distributed and form a third of the forest in the world. Mostly they are evergreen trees or shrubs. They occupy places that are quite high above sea level. They are found more in the northern hemisphere. They are of commercial importance. Conifers are used as timber, resins, turpentine and wood pulp. They include pines, larches, firs, spruce and cedars. A typical conifer is the Pinus Sylvestris (Scots Pine).

The Pinus Sylvestris is found throughout central and northern Europe, Russia and North America. It is native to Scotland but has been introduced to other parts. It is planted for its timber and as an ornament it is stately, tall (up to 36m), with a characteristic pink or orange-brown bark. Because it grows on sandy soils on mountains, the roots are shallow and spreading.

Their main branches and trunk grow yearly from the apical bum. This growth has been described as unlimited. The younger branches on top are shorter while the older ones further below on the stem are longer. The branches are arranged in a whorl of spiral around the stem. As the older ones drop, they leave the stem bare, from the base upwards.

The branches and the trunk have spirally arranged scale buds which develop into very short branches called dwarf shoots (with limited growth) with two leaves at their tips. These drop after two or three years leaving scars.

Self Assessment Questions

Take a very close look at the supplementary pictures of Plants (in their habitats): Video clips/print.

Answer the following questions:
1. What are the diagnostic features of conifers?
2. Where are conifers commonly found?
3. Of what economic importance are conifers?

3.1.2 External Morphology and Adaptations

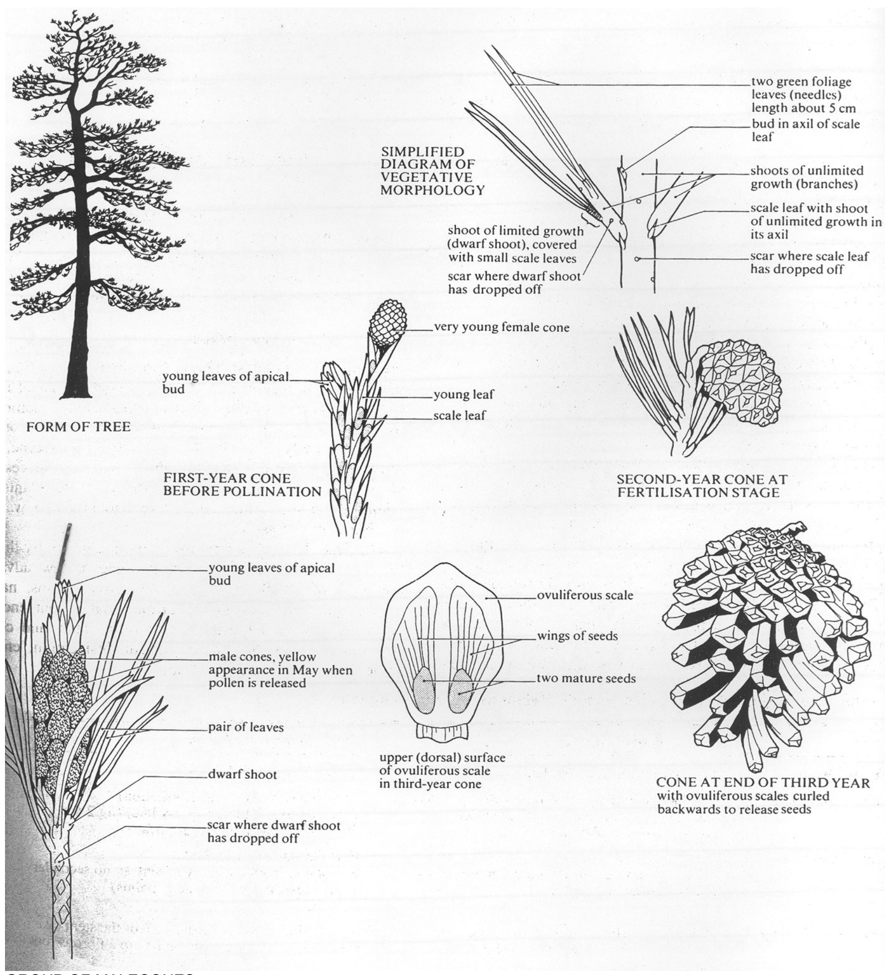
Once the shoot has grown, the scale leaves drop off to leave scars. Conifers have needle-like leaves which reduce the surface are for water loss. The leaves are also covered with thick waxy cuticle. The stomata of the leaves are sunken to further conserve water. Such features are called xenomorphic features. They ensure the conservation of water in the plant in hard times for example when there is snow or drought.

In warm weather, the tree which is the sporophyte generation produces male and female cones on the same tree. The male cones grow behind the apical bud at the bases of new shoots in clusters. They are rounded and about 0.5cm in diameter. They develop at the bases of scale leaves in place in dwarf leaves. The female cones grow at the axils of scale leaves at the tips of new strong shoots. They are some distance away from the male cones. They vary in size by their age from 0.5-6.0cm in a tree because it takes them up to three years to mature. The younger ones are green while the older ones are reddish brown. Both male and female cones have spirally arranged; closely packed sporophylls around a central axis.

The sporophylls of the male cone have sporangia (pollen sacs) inside which meiosis takes place to form haploid pollen grains (microspores). Haploid – describes the product of nuclear division in gamete formation.

The pollen grains contain the male gametes. A pollen grain has two large air sacs which help in wind dispersal. In May, the cones become yellow because of the cloud of pollen grains which they release. They drop off as then whither at the end of summer.

The female sporophyll is made up of a lower bract scale and a larger upper ovuliferous scale. On the upper surface of the ovuliferous scale are two ovules arranged are produced inside these ovules. The ovules are polluted in the first year but fertilized in the following spring when the pollen tube grows. The fertilized ovules become winged seeds which continue to mature through the second year until they are dispersed in the third year. By this time the cones have become woody with scales bending outwards to expose the seeds for dispersal by wind. See Fig. 8.1



GROUP OF MALECONES

Fig. 8.1 External features of the sporophyte generation of Pinus sylvestris, the Scots pine.

The external features of the sporophyte generation of Pinus Sylvestris (Scots Pine).

Self Assessment Questions

1. What phase of the conifer is the tree?

2. Describe the outward appearance on the Scots Pine.

3. Draw and label a part of the vegetative stem showing buds and leaves.

4. What are the adaptive features of the sporophyte of the Pine?

Answers to Self Assessment Questions

Note the following points again.

1. If you say that the diagnostic features of the pine are:
    a. The seeds are not enclosed in an ovary
    b. The seeds lie on the surface of specialized leaves called ovuliferous scales in cones. You are correct.

2. You are also correct if you say that conifers are commonly found most in the northern hemisphere, throughout north and central Europe, Russia and North America. They are native to Scotland and have also been introduce to Britain. They grow on sandy soils on high mountains.

3. You will also remember that conifers are of great economic importance. Apart from being useful as timber and ornamental plants because of their stately beauty, they are used as resins, turpentine, and wood pulp.

4. The sporophyte, the dominant phase is the tree.

5. The tree looks conical as a whole. This is because the lower older branches are longer them the newer ones which are formed at the top by the apical bud. The younger parts of the tree are green but the older ones are pink or orange-brown to brownish red. The branches grow in a whorl round the stem and leave scars on the trunk as the older ones fall off. Yearly the whorl of lateral branches grow into a whorl of branches. The main trunk, often described as of unlimited growth continue through the action of the apical bud to a height as much as 3.6m tall. On this main trunk are spirally arranged scale leaves in which axils contain buds that develop very short branches

(2-3mm) called dwarf shoots, grow two need-like leaves with sunken stomata . The leaves also are covered with waxy cuticle. In May the trees bear the male and female cones some distance from each other. These cones contain sporophylls/modified leaves) spirally arranged round a central axis. They contain the pollen sac in the male and the egg sac in the female. These contain the gametes, products of meiosis. The male cones release their pollen by wind dispersal which are yellow in the first year, to the egg sac which is not fertilized until the following spring when the pollen tubes grow into the ovum. The fertilized ovum then completes its growth into seed in the third year. Meanwhile, the male cones have withered and dropped after releasing the pollen.

The mature seeds in the female cone and dispersed during the third year when the old cones have become woody and bent backwards to expose the two winged seed.

3.1.3 Drawing and Labelling the Features of Pinus Sylvestris (sporophyte generation)

You will practice drawing the main features of the conifers shown in Fig. 6.1. Remember to use sharp pencils when you practice drawing. It will make you get so used to doing so that it becomes a part of you. Also label with ruled guidelines and always endeavour to spell all biological terms correctly as you practice. When you draw, you first copy from your course unit looking at the details as you copy the drawing. Then you put away your practice book and course unit and try to reproduce the drawing from out of yourself.

4.0 Conclusion

You have seen that conifers are among the most successful of plants because certain adaptive features. They have hard trees and branches which bear the reproductive structures that grow and mature without the for water. Fertilization is not water dependent also. The leaves are thing a device to reduce the surface area from which water can be lost in the plant. The stomata of the leaves are sunken. The pollen and seeds are dispersed by wind. Each pollen contains two large air sacs. The seeds are also winged for the same purpose. The branches carry the cones high and wide so that they have enough space to develop and disperse their seeds. These are all the adaptations of the conifer which make them successful in highly cold area of the world.

You have also learnt that conifers produce seeds on specialized leaves called sporophytes which are arranged in spiral whorls around a central axis to form cones. They are adapted to areas of cold and high attitudes. They are of great economic importance to man.

5.0 Summary

Conifers have seeds like the flowering plants but they differ from the later in that they produce cones. We will see other reasons why they differ from flowering plants when we study the later. Our next unit will treat the flowering plants.

6.0 Tutor-Marked Assignments

1a) What are the diagnostic features of the conifer?

b) Describe how conifers are adapted to life in their habitat.

c) Illustrate various aspects of these adaptation with well labeled diagrams.

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UNIT 9

The Angiosperms
(Spermatophyta – the Seed-Bearing Plants)

Table of Contents

1.0 Introduction

In this unit, we will continue the study of seed bearing plants. In the last unit we studied the conifers which are also seed bearing. They however belong to a different phylum from the angiosperms which will be studying here in this unit. You will soon know why they are put in different phyla even through they belong to the same kingdom. The angiosperms are even described as more successful on land than the conifers. They have since become the dominant land vegetation worldwide. They inhabit a wide range of habitat including salt water and fresh water. Before we look at their characteristic features let us set some objectives to guide thus study.

2.0 Objectives

By the end of this unit you should be able to

1. Write down the main characteristic (diagnostic) features of angiosperms.

2. Distinguish between the two main classes within the phylum angiospermatophyta.

3. Describe the various adaptive features in angiosperms for life on land.

4. Illustrate these adaptive features with the aid of well labeled diagrams.

3.1 General Characteristics

The general characteristics can be named as follows:

1. Angiosperms produce flowers in which sporangia, spores, and seeds develop.
2. The seeds of angiosperms are enclosed in an ovary.
3. After fertilization, the ovary develops into a fruit.

3.2 Adaptive Features

Angiosperms have developed flowers instead of cones. These flowers attract animals like insects, birds, bats, and a host of others as their agents of pollination.

The flowers are attractive. Most are brightly coloured, scented and sometimes offer pollen or nectar as food to visiting organisms. The flowers have become very important and even indispensable to some insects who through evolution have become so dependent on them. The flowers themselves become very structurally adapted to enhance pollen transfer by insects. This process of pollen transfer by insects has proved more reliable than wind pollination. So plants pollinated by insects produce less pollen because less are wasted as opposed to wind pollination.

The single problem plants have as a result of living on land is that of loss of water resulting in drying out or desiccation. If a plant is protected by way of a waxy cuticle, it would not then dry out so quickly and die.

When this is done the next problem is that of achieving sexual reproduction. Earlier plants needed water and lived in water like the algae. A few more advanced algae evolved structures in which their gametes grew with these they moved out of water and were able to survive on land as their gametes were protected from drying.

So let us now look at what lands plants like the angiosperms have to do in order to survive on land.

3.2.1 Avoiding Desiccation

They have means of getting water and conserving it. What is very important to life. Water is absorbed by roots and transported through the stem to leaves all of which internal structures have been adapted through the possession of vascular cells in land plants.

3.2.2 Means of Reproduction

Their delicate sex organs must be protected and non-motile male gametes must now evolve and get a means of reaching the female gametes. Having a non motile male gamete is an advancement because it makes pollination independent of water.

3.2.3 Need for Support

Our of water, land plants must find a means of support as air gives none. This they get, through the hard nature of the strengthening cells in the entire plant-roots, stems and leaves.

3.2.4 Nutrition

Plants need light and carbon dioxide for photosynthesis. So some part must be borne above ground where the light and air could be obtained whilst some other must be at ground or below ground level to get water and mineral salts to make efficient use of them in photosynthesis.

3.2.5 Gaseous Exchange

Is necessary for respiration and photosynthesis. Oxygen and carbon dioxide must be exchanged with the atmosphere. Stomata and special cells operating in them exist to perform this function.

3.2.6 Environmental Variable

Water produces a constant environment which the air does not provide. The presence of specialized epidermal cells help land plants in this respect. Living on land will necessitate a struggle with ever changing temperature, light intensity, ionic concentration and PH.

3.2.7 Presence of Flowers

In angiosperms flowers, once fertilized, the megaspores in seed plant remain within the megasporum (ovules) and are known as seed. This seed bring a number of advantages to the plant. Its gametophyte is totally protected by the parent plant and not susceptible to desiccation. Besides, after fertilization, the seed develops a food store supplied by the parent sporophyte. This store in the seed is food for the period of germination. The seed is encased in hard structures and can remain dormant until conditions are suitable for germination. Sometimes the seed may be modified to facilitate its own dispersal. The seed is a complex structure. It contains cells from three generations: the parent sporophyte, the cells of the female gametophyte and the embryo of the next generation.

Now it is time for, us to review what we've learnt about angiosperms and their adaptation.

Self Assessment Questions

1. What are the main diagnostic features of angiosperms?

2. Name the three main advances made by seed plants over non-seed producing ones.

3. What are those advances made by land plants over the other plants.

You will be correct if you say that the main diagnostic features of the angiosperms are:

1. They produce flowers in which seeds develop
2. The seeds are enclosed in the ovary
3. The ovary develop into fruits after fertilization.

You will also be correct if you said that the
1. Development of two types of spores (heterospory)
2. The development of non-swimming gametes
3. The development of seeds are the three main advances of seed plants above non-seed producing ones.

You are correct if your answer to the question on the advances made by land plants over others are like this:

a) Land plants develop true roots which enable water in the soil to be reached by plants on land.

b) They are protected by a waxy or cuticle laden epidermis or by cork after secondary thickening.

c) The epidermis of aerial parts, particularly leaves has small holes called stomata, which allow gaseous exchange with the atmosphere.

d) Land plants show varying adaptations to heat and dryness.

3.3 The Monocotyledoneae and the Dicotyledoneae

The phylum angiospermaphyta is divided into two classes – the monocotyledoneae and the dicotyledoneae. They are shortly called monocots and dicots respectively. The monocots are believed to have evolved from the dicots. Both groups produce flowers but differ mainly in the anatomy and morphology of the roots and stems as well as in the leaf morphology and number of flower parts.

While the leaves of dicots have net-like (reticulate) venation, those of the monocots have parallel venation. The leaves of the dicot have petioles (leaf stalk) and lamina (leaf blade), while the monocot leaves are not so differentiated. They are long thin grass-like structures. The dorsal and the ventral surfaces of dicot leaves are distinctly different but they are the same in monocots.

The vascular bundles in the dicotyledonous stem are arranged in a ring while in the monocots they are scattered. There is usually a cambium which gives rise to secondary growth in the dicot while there is none in the monocot. There is a primary root from which a secondary one could arise in the dicot. In the monocot there are only adventitious roots. There are fewer xylem groups in dicots roots while they are many more in monocot roots. The dicot embryo has two cotyledons while the monocot embryo has only one.

The flower parts in dicots are usually in fours and fives while those of the monocots are in threes. There are distinct petals and sepals in dicots, but in monocots there are none. Monocot flowers are often wind pollinated, while dicot flowers are often insect pollinated.

Fig. 9.1a shows the vegetative and floral morphology of the monocot, while Fig. 7.2a shows the vegetative and floral morphology of the dicotyledonous plants.

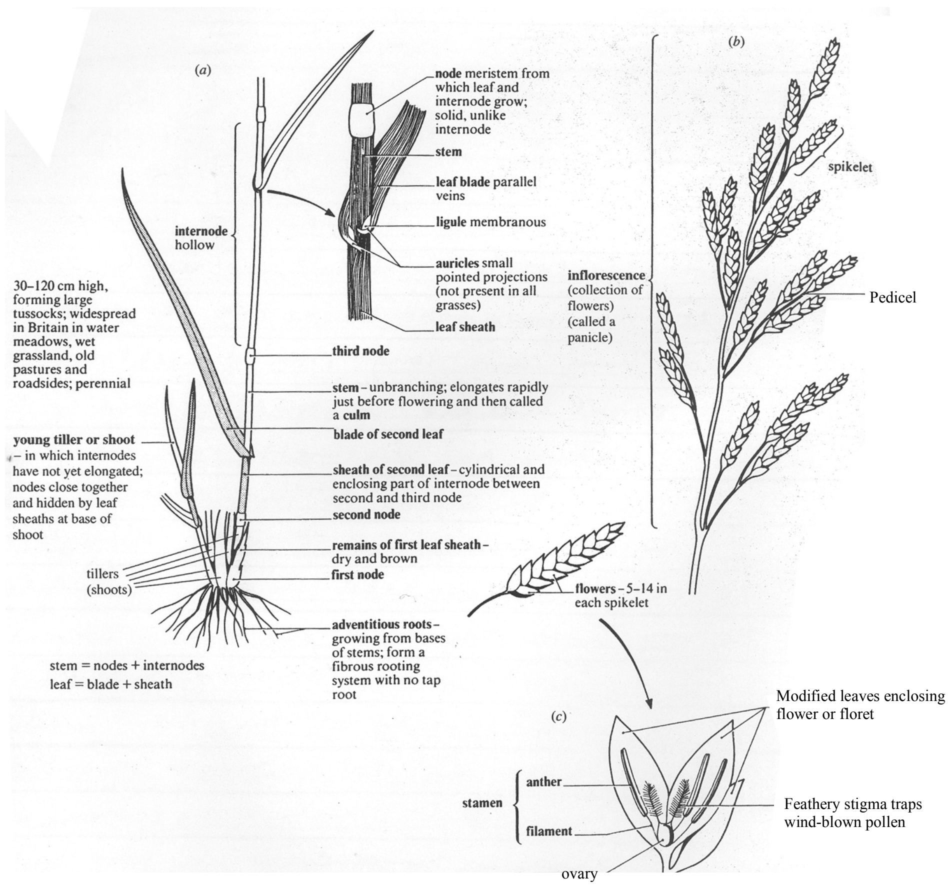

Fig. 9.1 Vegetative and floral morphology of the grass meadow fescue (Festuca pratensis), an herbaceous monocotyledon. The second leaves are shaded. Leaves are typically in two rows, alternating on opposite sides of the stem. (a) Vegetative morphology. (b) Floral morphology – the inflorescence. (c) Detail of one open flower or floret: two small petal like structures (lodicules) which enclose the ovary have been omitted.

Fig. 9.1b Live picture of paddy rice (Oriza sativa) – local monocot for comparative study.

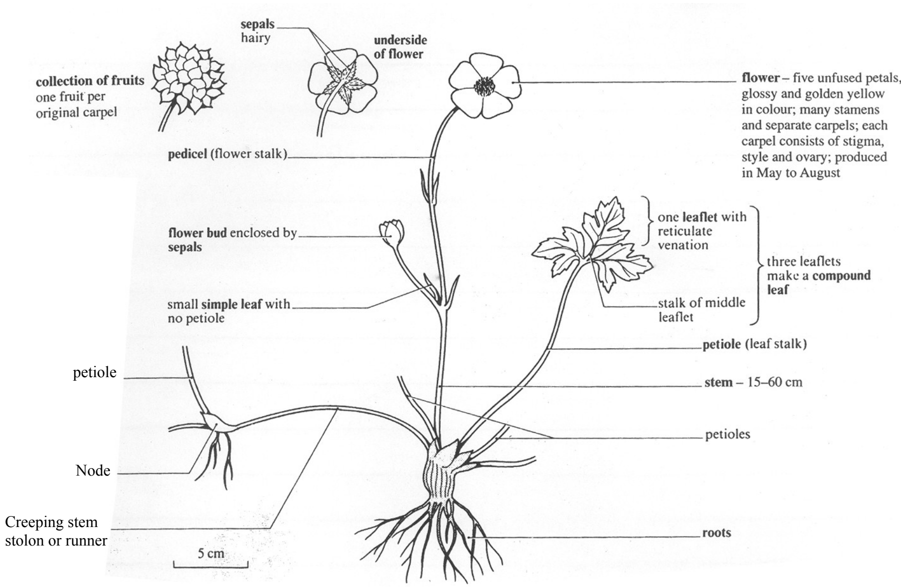

Fig. 9.2 Vegetative and floral morphology of the creeping buttercup (Ranunculus repens), an herbaceous dicotyledon. It is a common perennial plant throughout Britain, found in wet fields, woods, gardens and on waste ground.

Try and identify the labeled parts of Figs. 9.1a and 9.2a on the examples shown in Figs. 9.1b and 9.2b. Endeavour to pick up such local examples for a live study on your own. Draw and label your own life specimens.

Self Assessment Questions

1. Make a table showing the differences between monocotyledonous and dicotyledonous plants.

2. How do you think the flowers on Fig. 9.1 and 9.2 will be pollinated and why?

3. Look at the drawing below and label each as either representing a dicot or a monocot.

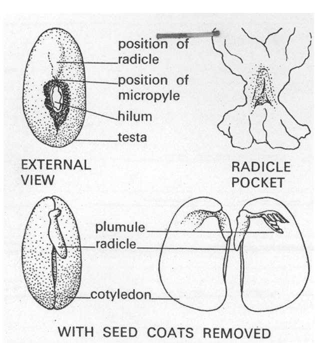

Fig. 9.3

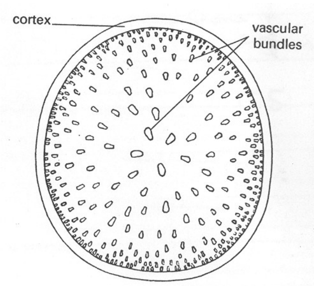

Fig. 9.4

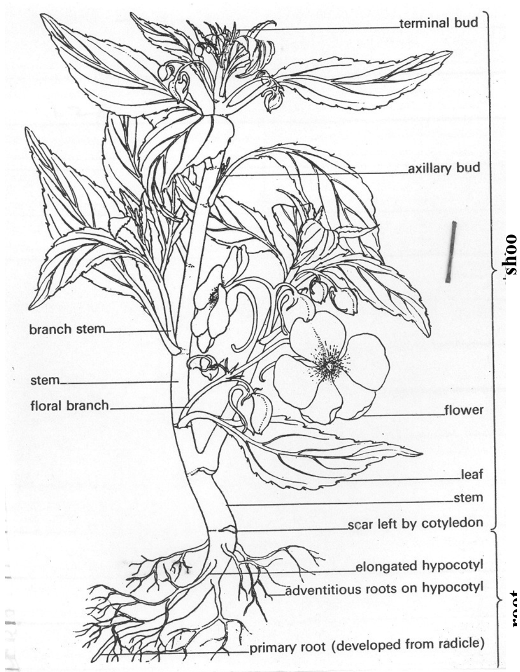

Fig. 9.5

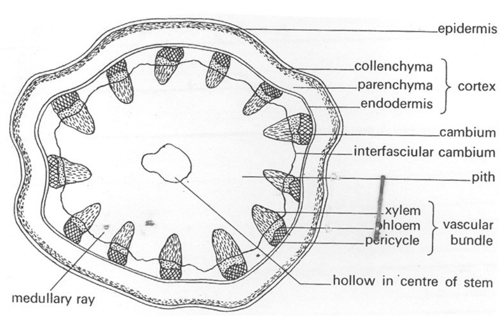

Fig. 9.6

Your table of differences between Monocotyledonous and Dicotyledonous plants should be correct if you present your answer like this:

Table 9.1: Differences between Dicotyledoneae and Monocotyledoneae

	Class Dicotyledoneae	Class Monocotyledoneae
Leaf morphology	Net-like pattern of veins Lamina and petiole Dorsal and ventral surfaces differ.	Veins are parallel. Typically long and thin identical dorsal and ventral surfaces
Stem Anatomy	Ring of vascular bundles vascular cambium usually present giving rise to secondary growth.	Vascular bundles scattered vascular cambium usually absent, no secondary growth with few exceptions.
Root Morphology	Primary root persist as tap roots that develop lateral roots (secondary).	Adventitious roots from the base of the stem take over from primary root, giving rise to a fibrous root system.
Root Anatomy	Few groups of xylem (2-8) vascular cambium often present giving rise to secondary growth.	Many groups of xylem (up to 30) vascular cambium absent – so no secondary growth.
Seed Morphology	Embryo has two cotyledons	Embryo has only one cotyledon
Flowers	Parts mainly in fours and fives usually distinct petals and sepals often insect pollinated.	Parts usually in threes. No distinct petals and sepals. Sepals and petals combine to form "perianth segments" often wind pollinated.

2a) The flower in Fig. 9.1 is that of a monocotyledonous plant. There is no mention of colour in the diagram. It is likely to be wind pollinated. Did you say so? Then you are right.

b) The flower in Fig. 9.2 is said to be coloured golden yellow. Coloured flowers belong most times to the class dicotyledoneae and are insect pollinated. Again you are right if this is what you wrote.

3a) Fig. 9.3 belongs to a monocot because the vascular bundles are scattered.

b) Fig. 9.4 belongs to a dicotyledonous plant because there are two seed coats (cotyledons).

c) Fig. 9.5 belongs to a dicot because vascular bundles are here arranged in a ring.

d) Fig. 9.6 is the vegetative part of a dicot. You can see the net like venation on the broad leaves. You can also see the main tap root and its small branches.

You have done very well to have given these answers. If you did not get any one right, don't worry. It only shows you need to spend more time on studying this unit. So, do not go on to the Tutor-Marked Assignment yet. Take a break and go thoroughly through this study unit again. Ensure you get all your self assessment questions correct. This will help you do your tutor-marked assignments successfully.

4.0 Conclusion

In this unit, we have done a lot. We have learnt to distinguish the flowering plants from other seed producing plants by their special ability to produce flowers. We have seen the advantage created by the production of flowers. The pollen in angiosperm do not need a water medium to swim because they are not flagellate. A pollen tube has emerged which grows and delivers the male nuclei to the ovule.

Once fertilized, a seed and fruit is formed which can withstand hard conditions until the conditions are favourable for the new generation to emerge at germination. All of these are the additional adaptation on the adaptation to inhabit the land which angiosperms possess as well.

We have also seen that the phylum angiospermatophyta is made up of two classes – the monocotyledoneae and the dicotyledoneae. We studied the differences between the two groups. We also looked at examples of these.

5.0 Summary

Now we have gone through the whole of the plant world. We have seen the progressive evolution of plant life from water to land. We have seen that the main factor of evolution is the ability to carry on life processes with less and less danger of water loss and more and more ability of water conservation.

Now we are ready to study the animal group.

6.0 Tutor-Marked Question 9

Carefully analyze the problems of adaptation of plants to life on land.

7.0 References

Berril, N.J., (1979) Biology in Action London. Heinemann Educational Books Ltd.

Soper, R. (Ed) (1998) Biological Science Cambridge, U.K. Cambridge University Press.

Stone, R.N., Cozens, A.B., Emina, F.I., (1972) New Biology for Tropical Schools London, Longman Group Ltd.

Pictures of Paddy rice (Oriza Sativa and water leaf (Talinum Traingulare) showing the examples of a local monocot and dicot for live specimen study (to be shot by NETC for print and computer based utilization.

UNIT 10

Protozoa - Ciliophora

Table of Contents

1.0 Introduction

The aim of this module is to enable you study the animal kingdom with the aim of learning about the variety in structure and adaptations through the kingdom. You will remember that we learnt about the prokaryotic group to which belong mainly the bacteria. We have also learnt that the eukaryotic group include the protoctists, fungi, plants and animals. The protoctista is believed to be the ancestor of plants, animals and fungi. The protozoa refers to the unicellular group of organisms that supports itself by feed in on other smaller plants and animals. The phylum protozoa means the first animals. We will now begin with these first animals and follow the structural and adaptational trend to the lat group in the animal kingdom. Some people place this group among the porotoctista.

2.0 Objectives

By the end of this unit you should be able to:

1) Give the general characteristics of the protozoa
2) Describe the structure of a typical protozoan.
3) Identify and explain the adaptive features of the protozoa and their position in the hierarchy of classification of living things.

3.1 General Characteristics

They are unicellular, animal-like cells with heterotrophic nutrition. There are said to be over 50,000 species. They are found anywhere water is present. They are mostly free living with varying methods of locomotion, some like Plasmodium are parasites. There are three phyla in this subkingdom, the Ciliophora, Rhizopoda and Apicompleae.

a protozoan paramecium is free living. You should understand free living here as not parasitic. The class ciliophora (ciliates) are covered with rows of minute, contractile protoplasmic cilia which are miniature editions of flagella. The second class the Rhyzopoda or Sarcodina has a naked undifferentiated surface. The third class the sporozoa specialize in producing spore to ensure infection to their host..

The protozoa are distinctly animal in their feeding, obtaining their nutrition from ready made sources including other animals. For their size, they can only prey on others smaller than themselves. There are those that live on bacteria, others feed on diatoms and small protozoans.

3.2 The Structure of Paramecium – a typical Protozoan

Paramecium lives in stagnant or slow-flowing fresh water that contains organic decaying matter. The structure of the cell of Paramecium is complex because it has to perform all life activities. It has a characteristic shape – a blunt front part and a tapered back part. This shape is maintained by the presence of the pellicle, a thin flexible outer region of the cytoplasm. It is covered with cilia which occur in parts. The cilia are arranged diagonally round the body. As the beat to cause motion, the body rotates as it more forward. Between the cilia are holes leading into chambers called trichocysts. Trichocysts discharge sharp fine threads which probable serve as anchor as the animal feeds. There is a clear layer of ectoplasm in form of a gel. Basal bodies are found here. They are the structures from which cilia are formed. A network of find fibre run between the basal bodies. These may serve for coordinating the cilia as they beat. The bulk of the cytoplasm is the endoplasm which is in a more liquid state than the ectoplasm. Most of the organelles are found in the endoplasm. There is also an oral grove at the lower surface of the organism near the front. It tapers back in a narrow tube-like gullet. At its end, the endoplasm is open at a mouth-like cystosome. The oral grove and gullet are all lined with cilia which beat to waft in food particles in suspension. They go into the food vacuoles formed in the endoplasm. Undigested material are sent out through the anal pore. There are two fixed contractile vacuoles in the endoplasm for osmoregulation, since water constantly enters the organism by osmosis as it lives in fresh water. The contractile vacuole collect water from radiating canals regularly and send them out to prevent the animal from bursting.

The cell has two nuclei – a beam-shaped polyploidy macronucleus. Polypoloid means it has more than two sets of chromosomes. It controls all other activities except reproduction. The small diploid micronucleus controls reproduction and the formation of other micronuclei cell division. Paramecium reproduces sexually by conjugation and asexually by binary fission.

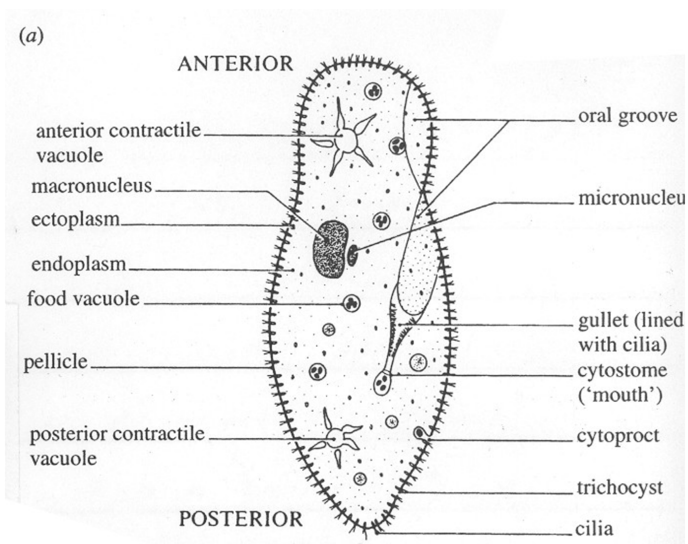

Fig. 10.1 (a) Paramecium caudatum – structure visible under the light microscope. (b) Paramecium caudatum as seen with a light microscope (x 832).

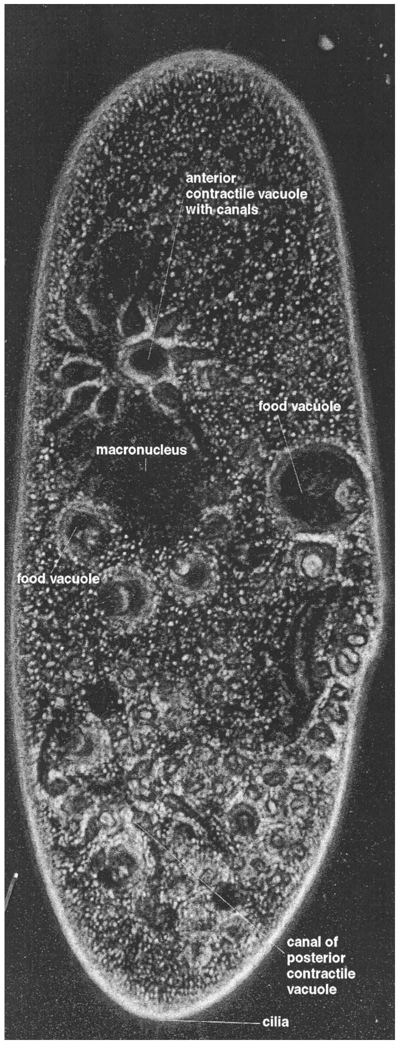

Fig. 10.1 (b) Paramecium caudatum as seen with a light microscope (x 832).

3.3 The Adaptive Features of Paramecium

Here you are presented with a list of structural features and how they serve the animal to live in its particular habitat.

3.3.1 For Movement in Water

- The slipper-like shape – tapering behind makes movement in water easy.
- The spiral spin as the cilia bit is an effective means of movement – it spells progress among minute organisms of its size.
- The spiral arrangement of the cilia.
- The basal network of fine fibres (which reflect he shape of the animal) connected by corresponding row of basal granules.

3.3.2 For Feeding

- Oral groove and gullet lined with cilia
- Bacteria contained in water driven by ciliary action into the gullet to the anterior end where they are swallowed by pinocytosis
- Digestive enzymes breakdown the substance of the bacteria into small organic molecules for building up its own kind of living matter.
- Egestion of undigested matter through a spot on the cell surface.

3.3.3 For Osmoregulation

- The presence of contractile vacuoles.

3.3.4 For Reproduction

- The nuclei for reproduction.

You will note t hat, but for these features this organism will be unable to live in the particular habitat or will unable to survive living there.

3.4 The Position of Protozoans in the Classification Hierarchy of Living Things.

Earlier classifications have put protozoans as the first animals. However, more modern ones have grouped protozoans with others like the plant-like, photosynthetic and aquatic algae, the early fungi and the slime moulds; into a phylum called protoctista. This group seem to be the link between the prokaryotea (the smallest group of organisms with cellular structure) and the eukaryote plant and animals, usually multicellular).

You have seen how this unicellular perform all life structures in a single cell. By their small size, lack of specialization of cells, absolute dependence on water for the execution of life processes, they are considered quite low (indeed the lowest) of all animals.

Now let us remember what we have learnt in a few self assessment exercise. You must be reminded that these exercises should first be done without making references to the relevant sections of this unit. You will then be able to tell yourself that you are doing well or need to pay more attention to details you have not noticed.

3.4.1 Self Assessment Questions

1. List in the space below, the characteristics of protozoa.

2. Draw and label the structure of a typical protozoan in the space below:

3. Itemize in the space provided, those features which enable the protozoan perform the following life functions:

   Feeding:

   Osmoregulation:

   Locomotion:

   Reproduction:

4. Why are the protozoans considered as the first animals?

3.4.2 Answers to Self Assessment Questions

Remember that the characteristics of protozoa can be listed as follows:

1. They are unicellular organism which cannot manufacture their own food but feeds on others – plant or animals. They live mainly in water. They can live anywhere so far there is water. They are mostly free living, only a few are parasitic and disease causing. They have various means of moving in their liquid environment e.g. cilia, pseudopodia (as in amoeba) or flagella (as in plasmodium). You can read more about these other protozoans mentioned here in any of the references at the end of this unit.

2. Practice drawing Fig. 8.1 now. Look at the drawing. Study it closely. Look at all the lines drawn and how they lead one to the other. Then look at the labels. How a guideline leads you from the name to the object so labeled. Look at the labeled object and assure yourself that you now know and understand it. Then it is time for you to demonstrate what you have known. Close the page on which Fig. 8.1 has been drawn in this unit. Some back to the space provided for you to do your self assessment question. Try to draw the animal as far as you can. Label also the much you can. Try again to ensure that you have put in all you have in your memory about this drawing. Then go back to the Fig. 8.1 in your study unit. Compare them, fill the

necessary gaps and be pleased with yourself for what you have achieved. You may have to try a few more times to get the drawing 100%. If so, do exactly that because it is important that you are 100% correct. This attitude will help you pass this course if you make it a habit.

3. Remember that for the adaptive features of the paramecium we stated the followings for the processes named:

Feeding:

- Oral groove and gullet lined with cilia for taking in food particles.

- Food particles contained in water driven by ciliary movement into gullet and anterior end of animal where they are swallowed into the animal by pinocystis.

- Digestive enzymes in the animal breakdown the food particles into absorbable matter for the animal.

- The undigested parts are egested through a particular spot on the cell surface.

Osmoregulation:

- This is a very important function in the unicellular organisms that live in fresh water because through osmosis water is continuously moving into the animal and the animal must protect itself from bursting by sending the water out.

- Process carried out by contractile vacuole at regular intervals.

- In paramecium the contractile vacuole is star-shaped with 'arms' stretched out to collect water into the main 'bowl' of the vacuole.

Locomotion:

- The tapering cylindrical shape of the animal facilitate easy movement in the water.

- The spiral arrangement and the beating of the cilia result in spiral rotating movement through water.

- The basal network of fibres keep the shape of the animal and seen to serve a coordinating function in movement.

Reproduction:

In time past it was thought that both the macro and the micronucleus were involved in reproduction by both dividing to form daughter cells in binary fission. Now it is believed that only the micronucleus is involved in reproduction.

Paramecium also carries out what could be regarded as sexual reproduction called conjugation. Two paramecia of different strains unite at their grove and exchange nuclei material from each other. They then separate and each divides into four animals. The nuclei are therefore the features for reproduction in the protozoa.

4. The protozoans are the first animals because they appeared early in the evolutionary history of animals. Since life began in water and they are still dependent on water, they could be so considered.

4.0 Conclusion

In this module, we have seen the characteristics of protozoans. We have also seen how, within one single cell, animals try to perform all life functions. We have noted that the main reason why they are considered as lower animals is their dependence on water for their life activities.

5.0 Summary

We can now proceed to see why other animals should be considered higher than the protozoans. Remember that we said that modern scientists classify protozoans in the group of Protoctista – those organisms that are seen as ancestors of plants animals and fungi. Essentially the meaning is the same. They are early forms of animals. So by these modern classifications therefore, the kingdom animalia which we will be treating next is reserved for multicellular animals.

6.0 Tutor-Marked Question 10

Draw and fully label the paramecium. State why it is described as a lower animal. List the adaptive features of the protozoan you have drawn.

7.0 References

Berril, N.J., (1979) Biology in Action London. Heinemann Educational Books Ltd.

Soper, R. (Ed) (1998) Biological Science Cambridge, U.K. Cambridge University Press.

Stone, R.N., Cozens, A.B., Emina, F.I., (1972) New Biology for Tropical Schools London, Longman Group Ltd.

MODULE 3

UNIT 11

Protozoa 2 – Phyla Rhizopoda (Amoeba)
Apicomplexa (Plasmodium)

Table of Contents

1.0 Introduction

You remember that the unicellular organisms can be distinctly animal or plant by their mode of feeding. The protozoa are animals by their mode of feeding and digestion. In the last unit we learnt about paramecium a member of the phylum cilliophora. In this unit we want to study two more of the groups protozoa. These are those belonging to the phyla sarcodina (Phylum-Rhizopoda) and Sporozoa (Phylum-Apicomplexa). The reason why you need to study these examples is to provide you with the knowledge of a wide variety of adaptations to life. It is also to help you know why they are classified into different phyla.

2.0 Objectives

So let us set the following objectives for you as you go through this unit. You should be able to:

1) Give the characteristic features of the members of the phylum sarcodina.
2) Draw and label the amoeba fully.
3) Give characteristics of the phylum sporozoa.
4) Draw the life cycle of plasmodium.

3.1 Characteristics of the Phylum Rhizopoda, (Sarcodina)

These possess the general characteristics of protozoa. If you cannot remember, look back to Unit 10 and refresh your mind. The protozoa is made of three phyla. We have learnt that paramecium is an example of protozoa in the phylum ciliopora. In this unit we are to discuss those features which distinguish some protozoa into the sarcodina.

Sarcodinians have essentially naked surface without any differentiation. It is a phylum of free living protozoans. They have apparently simple structure. They have a peculiar mode of locomotion (by streaming protoplasm) which is one of their most distinctive feature. Typically they possess both external or internal skeletal structures of a mineral nature. Amoeba is the only exception to this skeletal structure.

3.1.1 Amoeba

Is found in the bottom of ponds. It can reach .025cm and may just be visible to the naked eye as a white speck. Under the microscope, there is a clear outer ectoplasm and a granular jelly-like mass of protoplasm. There is a dense nucleus in the endoplasm. It is surrounded by fine membrane. There are also larger particles – the remains of amoeba's food, enclosed in food vacuoles in the endoplasm. Food and water surrounded by the pseudopodia form the food vacuole. The food substance of amoeba are usually diatoms. Fig. 11.1 show the typical structure of Amoeba.

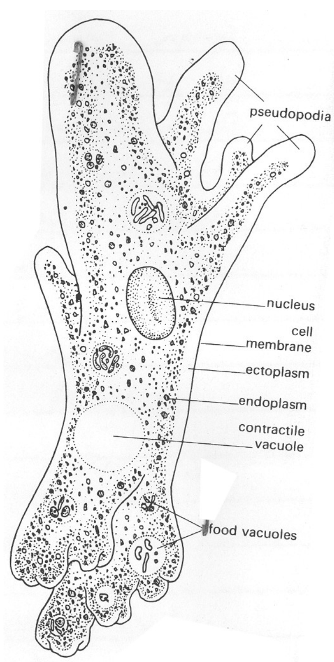

Fig. 11.1 Amoeba (x 500)

Amoeba has no permanent shape. Its shape is constantly changing as it pushes lobes of its protoplasm (called pseudopodia or false feet) in various directions. The amoeba in the direction to which it extends its pseudopodia by pulling the rest of its protoplasm from behind towards the pseudopodia formed.

The amoeba also have large clear vacuoles containing liquid called contractile vacuoles. These vacuoles slowly enlarge until they burst open to release their content when they reach a certain size. This is the method by which regulates bodily ionic content.

Life Processes

Respiration and excretion take place by diffusion through the general body surface. Dissolved oxygen and carbon dioxide are exchanged between the animal and the surrounding water by diffusion. Similarly within the organism, gasses and nutrients diffuse through to all parts of the animal.

The new protoplasm is sensitive to the environment even though amoeba has no sense organs. It will withdraw from a dilute acid or alkali solution. It will also withdraw its pseudopodia if touched with a needle or a weak electric current is passed through the water in which it has. It grows by absorbing its food nutrient to form new protoplasm until it is about .025cm in diameter. It then divides by binary fission. In the process of binary fission, the nucleus become elongated constricts and the centre then divides into two. Then the surrounding protoplasm similarly divides into two.

Each protoplasmic mass surrounds a nucleus. If the pond in which amoeba lives dries up, the amoeba withdraws its pseudopodia, becomes round and forms a cyst around itself until when it is favourable again. The cyst bursts when it is wet again and amoeba then becomes active again.

Sometimes within the cyst, the animal divides into small portions each containing a part of the nucleus. These are then called spores which become small amoeba when water comes.

3.1.2 Self Assessment Exercises

1. Practice drawing and labeling the amoeba. Make sure you take note of all the advise you've been given about making biological drawings.

2. What are the peculiar features of the Phylum Sarcodina.

3.2 Phylum Apicomplexa (Sporozoa)

The protozoa in the phylum Apicomplexa possess a pellicle and so the cells have a definite shape. You know this is unlike what we have in the sarcodinans which have no definite shape. They have no pellicle. Their main distinguishing characteristic is the production of spores during sexual and asexual reproduction. An example of the sporozoa is the malaria parasite, Plasmodium. There are four species of this sporozoan. Only two of them cause the malaria fever.

The parasite is injected into the body of the mammal when the vector, the female annopheline mosquito infected with the parasite goes to feed on man. It pours out the plasmodium parasites along with its saliva into the blood stream of man. It enters the blood and is carried round the body where it affects various organs especially the liver. Here it multiplies and infect other liver cells until they eventually leaves the lever, enters the red blood cells. They then form gametocytes. When infected human blood are sucked up by mosquitoes. In the stomach of the mosquito the malaria parasites plasmodium, escape being digested. The eggs are fertilized to form zygote which bores through the wall of the stomach of the mosquito and finds its way back into the salivary gland of the mosquito to start the cycle again. The infected mammal suffers from disabling fever at intervals which coincide with the time the parasites multiply in the blood.

Fig. 11.2 shows the life cycle of the plasmodium

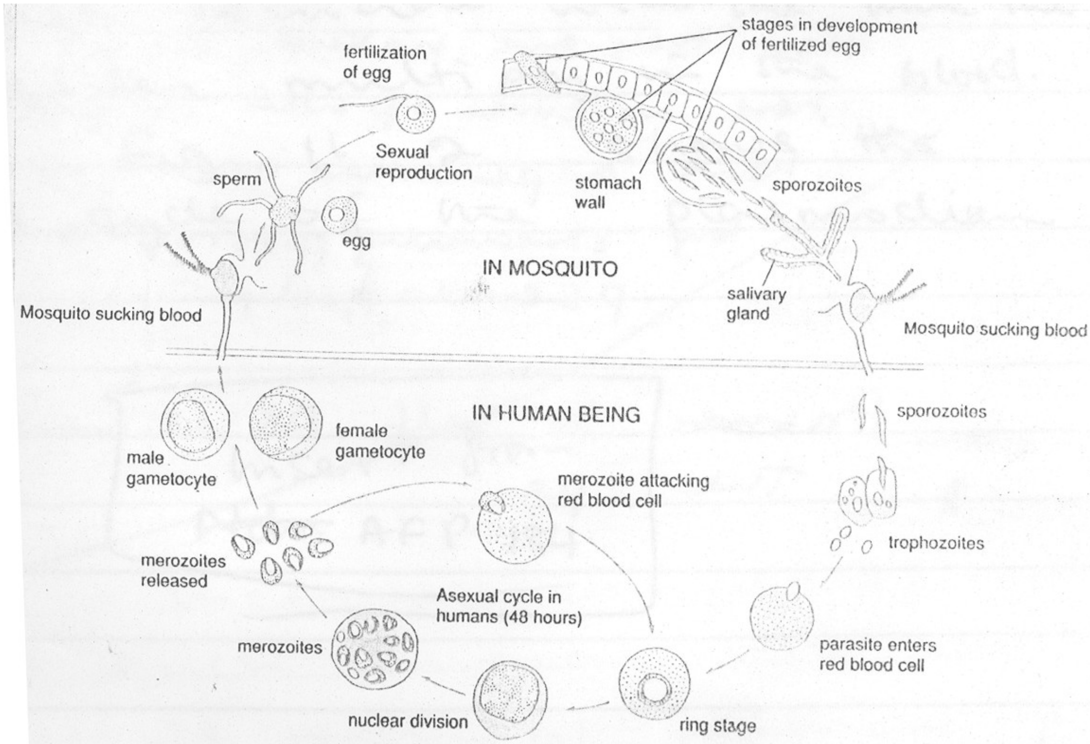

Fig. 11.2 The life cycle of the malaria-causing protozoan, plasmodium vivax

4.0 Conclusion

In this unit, like the previous unit you studied the structure and adaptation of protozoa. You now have studied three examples of the group protozoa each belonging to a different phyla. The ciliopora and sarcodina (Rhizopoda) are mostly free living, while the Apicomplexa are parasitic. You have seen that the main adaptative feature of the parasitic one is the production of numerous spores. The structure of the Plasmodium the example in the saprophytic Apicomplexa is basically simple with almost no specialized organelles compared to the free living paramecium or Amoeba.

5.0 Summary

You have seen that even in unicellular organism, a degree of complexity can be evident. You have also realized that animals get adapted not only to their environment but to the style of life they live. In subsequent units we will be studying multicellular organisms. You will expect that as the number of cells in the organism increase, there is increased complexity and that such animal will have to devise means of managing the larger size likely to arise.

6.0 Answer to Self Assessment Exercises

1. Drawing and labeling the amoeba. Remember to use sharp pointed pencil. Make clear lines that are neither way nor wooly. The outermost line the cell membrane should be neat and continuous. You should project out the protoplasm to show the pseudopodia. Inside the cell membrane should be a clear ectoplasm inside which is the granular endoplasm. Put the nucleus contractile vacuole, food vacuoles in the endoplasm. Label your drawing with parallel lines.

2. The peculiar features of the sarcodina's is that they are naked. The cell membrane has no cover of cilia or peticle. They have a peculiar means of movement by streaming protoplasm into their pseudopodium

7.0 Tutor Marked Question 11

a) Draw a large labeled diagram of the Amoeba.

b) State the function of the parts you have labeled.

c) Draw and label the life cycle of the plasmodium.

d) How do these two animals differ in their nutrition.

8.0 References

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UNIT 12

Porifera

Table of Contents

1.0 Introduction

This unit for us is the beginning of the study of the evolutionary tends in the animal kingdom. This is because animal-like unicellular organisms have been placed in the protoctista. As we now study the animal kingdom we will look at the evolutionary trend and how they have become more and more complex in their levels of organization. We will start with the Porifera (Sponges) which do not form true tissues. A tissue is a group of cells usually similar in origin, structure and functioning. Many different tissues, performing different tissues, performing different functions can be working together to form an organ. A group of organs involved in performing a life function, is called a system. There are various systems in the most advanced animals. In the next few units we shall see the evolutionary development of more complex forms from this very simple beginning in the porifera and cnidaria.

To guide our study, let us set the following objectives.

2.0 Objectives

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

1) Give the general characteristics of the Porifera.

2) Describe the structure of Sponges.

3) Analyse the adaptations and the evolutionary position of sponges.

4) Discuss complexity that arises with larger size.

3.1 General Characteristics

- There is some cell differential but no organization of the tissues.
- Body has two layers (some authors say there are three cell areas).
- All live in the sea or river bottoms.
- Their body has no symmetry.
- There is only one cavity.
- Have numerous openings (pores) all over the body wall.
- Has a skeleton made up of calcium silica or horny fibres.
- There is no differentiated nervous system
- Fresh water ones reproduce even sexually.
- Reproduce asexually by budding and the aggregation of cells to form gemmules.
- They are all hermaphrodites.
- Have great regenerative power.

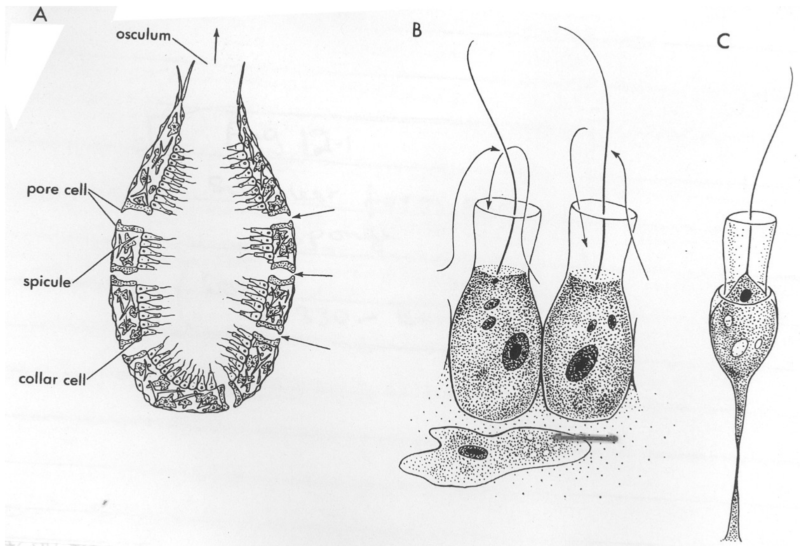
This is described as dead end phylum. It is believed that they have not given rise to any other group of organisms.

3.2 Physical Structure

Usually an extensive sheet of shapeless tissue. Few are vase-shaped attached by a narrow base to their base in sheltered waters occur in many colours. Have the odour of sulphur. Some are small others are massive. Some have supporting tissue made of calcium, silicon or horny tissues.

The simplest form of the sponges is a vase-shaped living tissue attached by its base to the bottom of the sea. It has an internal cavity with an opening on top. The body wall is made up of cells situated in the outer, the inner and the middle, between the outer and inner cells. Each of these three groups of cells perform different functions. The cells lining the cavity have flagella which beat to drive out water through the aperture of the vase called the osculum. Food particles and water get into the cavity through the many pores on the body wall. The pores are maintained by the pore cell whose protoplasm can expand to close up or contract to open the pore. The spore also controls the rate of water inflow into it through this process also. The other way is to narrow or close the osculum. See Fig. 12.1

Fig. 12.1 A. The simplest form of a sponge, showing internal chamber lined by choanocytes, or collar cells, an outer layer of epidermal cells, a middle layer containing mesenchyme cells and skeletal spicules, and the entire body wall perforated by the canals of pore cells. Water passes in through the pore cells and out through the osculum. B. The choanocyte, or collar cell, characteristic of all sponges, with amoebocyte below. C. The choanoflagellate, a protozoan which has the general characteristics of a sponge collar cell.



These two mechanisms are not controlled by the body of the animal but function as dictated by the external conditions e,g, acidity of the water around. Collar cells with the flagella beat independently and continuously in response to the temperature of water within the sponge. Other cells simply line the out body of the sponge.

Only some of the body cells and collar cells get food by diffusion of the digested particles. There is a need for food to be transported to other cells not within the vicinity of where the food is digested. The non-feeding cells are other cells apart from the collar cells, some body cells which obtain food materials directly and are in position to digest it. These non-feeding cells need to be supplied with food transported from the site of digestion, or be close to the feeding cells, to get food by diffusion.

The middle cells in the intermediate region, lying between the inner flagellate layer and the outer epidermis contain several kinds of cells – the wandering amoebocytes and the archeocytes. The amoebocytes more in the amoeboid manner. The archeocytes are unspecialized and are capable of taking on several roles. These two groups of cells serve as distributors of nutritive material to those cells of the sponge that are unable to move about or get the food directly. So you see that to a large extent, the cells in the sponge cooperate in a communal way.

3.3 Organic Structure

You will expect that, an organism beaten by water currents continuously should have an adaptation to withstand this current. This is done by the sponge's skeleton made up of fibrous organic substance called sponging. In some it is formed by calcareous or siliceous crystalline spicules secreted by specialized cells called sclerocytes. Adjacent spicules grow to form particular structural arrangement which result in extremely complex architectural support within the sponge wall. Some like the glass sponge develop a spiral course for their fine siliceous ties in their skeletal frame work. Thus in a light structure, a tough most times beautiful skeletal frame is created for the sponge for withstanding water currents.

3.4 Reproduction

Fresh water sponges reproduce sexually by producing eggs and sperm. They also do so by producing small round masses of cells called gemmules (in cold or drought) in protective cases called spicules. These develop into new sponges when the conditions are favourable.

The archeocytes are responsible for forming the gemmules by aggregating together. They are also responsible for forming the outside layer and the water channels of a new sponge as they first come out of the spicules in favourable condition. The archeocytes that come out next form the collar cells. The last archeocytes remain within and persist as archeocytes.

You will therefore notice how cells here performed special functions by their position. You will also notice the versatile nature of the archeocyte to become any kind of cell that is needed. Cells also aggregate to form new sponges when in experiments a mature sponge is broken into its constituent cells. Here however, the cells of the epidermis for example, in the former animal congregate to form epidermal ones in the new aggregate and so on. This is a good ability to regenerate itself. You will therefore see here that it is not position that determines the function as is the case in the formation of gemmules.

The sponges have been successful for at least 500 million years living at the bottom of water. We can see advantage in those that have developed into large size – to such an extent that they can wave in enough food for themselves. They are simply a multicellular group with little or no coordination. The elongated contractile cells around the oscular respond independently to external condition to slowly contract to close the opening. There is no nervous connection between or among cells. Therefore no nervous system. The sponges stand on their own. They do not seem to have given rise to any known multicellular group.

3.5 Self Assessment Questions

1. What are the main characteristic features of the sponges?

2. What are the adaptations of the sponge for the following:

   a) Feeding.

   b) Water regulation

   c) Response to stimuli
   d) Movement

3.5.1 Answers to Self Assessment Questions

1. You will remember that sponges
   - Have two to three layers of cells that are not so organized into tissues.
   - The adult is strictly not motile
   - They have no shape or symmetry
   - They have only one cavity but numerous pores round the body by which water and food particles go into the main cavity.
   - To withstand water current, specialized cells called sclerocytes secrete calcareous or siliceous crystalline spicules which form their skeletal structures.
   - Sponges have no nervous systems.
   - Reproduce both sexually and asexually
   - Are hermaphrodites
   - They regenerate quite a lot through aggregation.

2. You will be right if in your answer to the adaptations of the sponge you have given that for:

   Feeding – the sponge is equipped with the choanocyte cells which have flagella. These continuously beat to send water out of the cavity. This activity along with the opening caused by the contraction of the pore cells, let in small food particles with water through the pores. Enzymes within the cavity digest these food particles. This is how the sponges are adapted to feed in their under-sea habitat.

b) The activity of the choanocytes and the contraction and relaxation of the pore cells and that of elongate cells around the oscular opening help to control the water in the cavity of the sponges. If you say this, then you are correct.

c) The sponges have not developed a nervous system or any sense organ. Spread out at the bottom of the sea, where they are anchored (you remember?). They have no need for any movement or any degree of coordinated activity. The local effector action of the elongated cells around the oscular opening which result in the slow closure of the opening is an independent effector reactor to an external stimulus such as touch. There is no nerve interplay involved. The contraction follows a mechanical or chemical stimulation. A local stimulus, transmitted from cell to cell by the epidermal cells is present and slow. It is not comparable to that through nerve cells.

d) You will remember too that there is also no muscular development even of a primitive type for movement. The sponge is basically not mobile.

Having reviewed these adaptive features, you will no doubt agree that the sponges are very primitive and should really occupy the lowest part in the ladder describing the development of animals. There are no tissues, nor systems. There are simply groups of cells, doing things by virtue of where they are located. Their main advancement is that by having many cells, and so larger in size, we expect more complexity than in the single celled animals.

3.5.2 Self Assessment Exercise

1. You will look back at Fig. 9.1 and study the drawing of the simple sponge. Notice the special cells. You will understand the story of the sponges better.

2. Take note of the new words in this unit. You are meeting words like: Osculum, spicule, archeocytes and sclerocytes for the first time. Take time to know what they stand for. Ensure that you can spell them correctly what other new words did you find? Learn them.

3.6 Size and Complexity

Sponges represent animals of great antiquity. Many basic problems arise with larger size that we could have easily studied from the sponges. With increase in size, there is a need for support for the protoplasmic mass involved in the size. We may assume that this has been taken care of by the presence of the skeletal re-enforcement of organic fibrous material called sponging, as in the horny sponges; other types of skeletal material are of silicon or are calcaneous.

b. Large organisms often need to move about to ensure they can locate the right type and quantity. This the sponge does not do. It managed to spread out below the sea and with this mass spread manages to get enough to survive.

c. Remember too that the sponge has no systems for even digesting the food it take in. It is contented with the services of mobile cells within carrying digested food to those cells that are not feeding cells. How come nature allowed such increase in mass without commensurate specialization for functioning? No digestive or circulatory systems.

d. The same amoebocytes are responsible for forming gemmules in adverse season.

e. Very importantly an animal that should survive and flourish should be sensitive to its surroundings and have a means of self defence. All of these are at very primitive level or non-existent at all.

These are all the reasons why sponges are regarded as primitive and a dead end.

4.0 Conclusion

We have seen why the sponges are at the lowest end of the ladder of development in the animal kingdom, even though they are multicellular animals. They have remained simple and cells largely unspecialized and no true tissues, organs or systems. They have remained in this state for millions of years without giving rise to any other forms.

5.0 Summary

Sponges are therefore a dead end. The next group which you will study, the Cnidaria, even though simple show some differentiation as you will see.

6.0 Tutor-Marked Question 12

Why in your opinion is the sponge a 'dead end'? Illustrate your answer with the aid of a diagram.

7.0 References

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UNIT 13

Kingdom Animalia
Cnidaria

Table of Contents

1.0 Introduction

In this unit, we will start to study multicellular animals. You will observe that, eve though small, they are beginning to get complex in structure. As we proceed in subsequent units, you will also appreciate what larger size necessitate. The cnidaria's position in the classification ladder is important because they offer biologists the opportunity to understand cell differentiation and specialization in a few cells. To guide this study in this unit, lets get some objectives.

2.0 Objectives

As you go through this unit, you will be able to:

1. Define cell specialization or differentiation.
2. Give the general characteristics of cnidaria.
3. Name an example of cnidarians.
4. Draw and label the section through the column of the hydra.
5. Describe the nature, form and ecological adaptations of the hydra.

3.1 General Characteristics

Cnidarians are diploblastic. This means that their body wall is made up of two layers of cells: the outer ectoderm and the inner endoderm. Both layers are separated by gelatinous structure-less layer called the mesogloea. This mesogloea may however contain cells which migrate from other layers. You will remember that the poriferans also have this characteristic. You remember the archeocytes and amoebocytes in the group porifera? You remember they are cells that more about to distribute nutrients? The diploblasts can be described as reaching tissue level of organization. This is because the two layers of cells are definite and perform permanent functions. The endoderm cells are the feeding cells from which nutrients diffuse to the ectodermal cells which are responsible for gaseous exchange and from which gases can diffuse to the endodermal cells. The presence of two layers of cells and the structure-less mesogloea are the characteristic features of this group. Cnidarians also have a radial symmetry. Thus means that it can be cut into two equal halves, across any diameter. Animals that show a radial symmetry tend not to more about. Instead it is those that have bilateral symmetry that have good adaptation for locomotion. Bilateral symmetry gives a more compact and streamlined shape as well allows a greater specialization of the parts of the body.

Basically their bodies of cnidarians are sac-shaped with only one opening which serves both for ingestion and egestion. This opening, the "mouth" leads to a cavity within the sac-shaped body called the enteron in which digestion takes place. Some cnidarians are sessile (polyps) while others (medusac) swim freely.

3.1.1 Self Assessment Questions 13 (1-4)

1. What are diploblasts?

2. How would you describe their level of differentiation?

3. What are the characteristic features of phylum cnideria.

4. Which is the better adapted symmetry for locomotion, radial or bilateral? Explain.

3.2 The Nature, Form and Ecological Adaptations of the Hydra

Hydra belongs to the class of cnidarians called hydrozoa. It is a fresh water coelenterate. It has a thin supple, hollow body about 1cm long which is fixed to its substrate by a sticky secretion produced by the basal disc, or foot. The opposite (distal) end is a conical projection (called the hypostome) at the apex of which is the mouth. From the base of the hypostome, extends a whorl of tentacles. Like all coelenterates, the wall of the hydra consists of two layers of cells arranged back to back and separated by a thin layer of colloidal mesoglea. The two layers of cells is made up of mostly the musculoepithelial cell which is cuboidal in shape. Each cell has a nucleus. It joins with the neighbouring musculoepithelial cell to form an epithelium which form both the inner and the outer layers of the body. The basal part of this cell spread out, at tangent with the cell axis and have small muscle fibres. The basal muscle fibres of the epidermal cells run parallel to the aboral-oral axis while that of the endoderm run in a circular or transverse plane. So the epidermal ones contract to shorten the animal while those of the gastodermis (the cells lining the endoderm) lengthen it.

The hydra has a nervous system made up of neurons which are greatly elongated and are connected with each other. They are much more at the hyposture where the control the activity of the tentacles. The epidermis has a variety of stinging cells called nematocysts which help the animal to capture food organisms. Little cells found at the base of the epidermis help to replace cells. They are called interstitial cells. So we can say that the epidermis is made up of five types of cells:

- The nematocysts or stinging cell (Fig. 13.1)
- Sensory cells – specialized for special function.
- Interstitial cells – not specialized and can replace others.
- Musculoepithelial cells.
- Neurons.

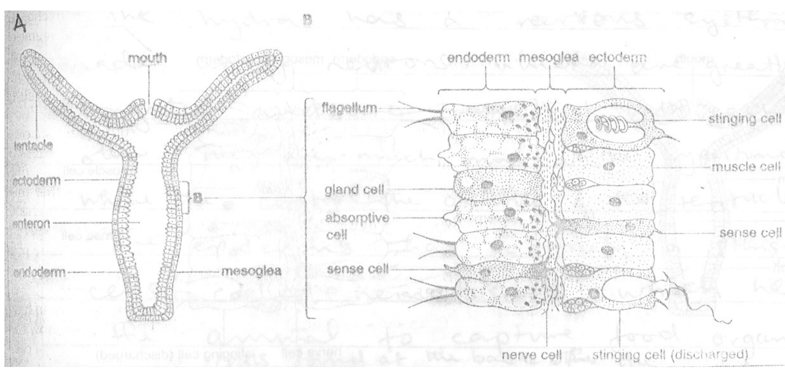

Fig. 13.1 A Hydra in section
B Part of body wall more highly magnified (x 300). There are two layers, the ectoderm and the endoderm, with a jelly-like secretion, the mesogloea, between them.

In the gastrodermis the musculo-epithalial cells which form the main cells here are more versatile. They are equipped with flagellum at their free ends. They need these here to wave in food particles. Furthermore, there are small brownish or greenish algae that thrive inside the hydra. There are also many glandular cells full of secretory granules in the hypostomal region and scattered in between the muscuo-epithelia cells of the gastrodermis.

Sex cells, ova and spermatozoa are produced by the epidermal cells under special.

3.3 Self Assessment Question 5

5) Name the basic cells of the hydra and give their functions

Exercise: Practice drawing and labeling a section through the column of the hydra. You must take good note of the right spellings of the word you use.

3.4 Cell Differentiation and Specialization

So you see that there are less than ten different types of cells in the hydra. These cells, whether jointly or individually perform their special functions. Hydra, though simple, shows us all grades of cell specialization. The individual cells have distinctive features for specific functions. Examples are sense cells. Particular cells carrying out the same functions are grouped together and are interdependent. Examples here are the sense cells which are sensitive to touch; the stunging cells, for capturing hydra's food; glandular cells for digesting these food; absorbing cells for absorbing digested food, and nerve cells for coordinating the work of the other cells. All of these are groups of cells of the same type doing one function. This is a tissue level of organization. So you see that, Hydra, though multicellular, and differentiated, does not have specialized organs like most other coelenterates of its type.

Other multicellular animals have special organs or systems which carry out each life process as you will see in subsequent units. In man for example, the kidneys are for excretion, the ears for hearing and so on. So you will remember that for this reason, Hydra is said to be at the tissue level of organization.

Movement

Let us consider further the dynamic form of hydra. It is active as shown by the fact that it moves about by 'looping' and 'somersaulting'. These are a result of the contraction and relaxation of its column and the attachment of the tentacles to the substrate; releasing and reattaching them.

Response to Stimuli

Hydra can expand its mouth to several times the size of its own diameter to swallow prey. The presence of some complex amino acids in most animal tissues can cause it to open its mouth to such an extent as to turn inside out.

Nutrition

There is a continual chain of chemical activities resulting in processes like digestion, assimilation, utilization and excretion; all of which are linked.

Growth

Through growth and continual self renewal, the hydra maintains its characteristic shape. It also has a high power of regeneration when cut into parts, it can regrow the missing part for form a whole hydra in a few days.

Reproduction

When well fed, the hydra produces projections from its body about two thirds down its column. This protuberance is made up of the two layers of cells. These are buds which become young hydra attached to the mother hydra. They appear youngest always on top and the oldest further below until they are detached.

You will remember too that earlier in this unit we mentioned that when split into two it can regrow the missing longitudinal half. Occasionally it does this on its own by producing two mouths from the one, each later surrounded by its set of tentacles, and gradually acquiring its own body (or column). All of these are evidences of growth and reconstruction of parts.

Apart from what appears to be asexual reproduction, there is the sexual reproduction. Under different conditions of temperature and pressure, different species of hydra become sexual. They produce from their interstitial cells spherical protrusions containing eggs and conical ones containing sperms. By the time the eggs are fertilized, the hydra disintegrates. Only the fertilized egg survives to continue the species.

Understanding the simple form of hydra and the few number of cells is important. However hydra throws light for the understanding the differentiation and complex forms in larger animals. The only thing you cannot learn from hydra, which you must learn from larger animals are the issues arising from large size. Hydra is small. Because it is small, it has little self maintenance problems that large animals have.

3.5 Answer to Self Assessment Questions

1) If you said that diploblasts are animals with two layers of cells, you are correct.

2) Diploblasts can be described as having reached the tissue level of organization. This means that there are several cells in the animal. It also means that a group of these cells cooperate to perform a particular function.

3) The presence of two layers of cells and the structure-less mesogloea are the characteristic features of cnidarians.

4) You need to understand why the bilateral symmetry is better adapted for locomotion. It helps to keep a compact streamline shape. It also allows for greater specialization of parts of the body.

5) You can tabulate the basic cells of the hydra and their functions as follows:

Cells	Functions
Sensory Cells	For sensory perception. More around the tentacles.
Nerve Cells	Coordinate the network of other cells.
Stunging Cells	For capturing hydra's small animal foods
Epidermal musculoepithelial Cells	These can be simply called muscle cells. Responsible for movements
Interstitial Cells	Help replace cells
Flagellated musculoepithelial Cells	Draft in food into the gastrodermis
Glandular Cells	Secret digestive enzymes
Sex cells	Produces sperms and ova for sexual reproduction.

4.0 Conclusion

You have learnt about cnidarians in this unit. You now know that they have layers of cells like poriferians. They are different from them however because the middle mesogloea is not cellular. Hydra, the example of cnidaria we studied is small with nearly ten different types of cells. However it is a good example in which we have learnt of cell differentiation for different functions. This means there is a division of labour among the cells inspite of this development, hydra is described as only reaching a tissue level of organization because it has no organs and systems as larger animal necessary have.

5.0 Summary

Cnidarians are important because they allow us have in them the opportunity to study few cells and yet understand cell differentiation and organization in bigger and more complex animals we will be studying later.

6.0 Tutor-Marked Assignment 13

a) What is a cell differentiation?

b) Explain why hydra is a cnidarian.

c) What is its level of organization and why?

d) Illustrate with a diagram

7.0 References

Berril, N.J., (1979) Biology in Action London. Heinemann Educational Books Ltd.

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UNIT 14

Platyhelminthes

Table of Contents

1.0 Introduction

The platyhelminthes have an additional layer of cells over the cnidarians. For this and a few other reasons you will see later, they are therefore more complex. In this unit we will continue our study of animals, we will study the structure and adaptation of the platyhelminthes (flatworms). As usual, as we do so, we will emphasize structural adaptations, and their position in the hierarchy to classification. So we can state the objectives of this unit below.

2.0 Objectives

As you go through this unit, you will be able to:

1) Explain the general characteristics of the platyhelminthes.
2) Differentiate between its three classes.
3) Draw and label the life cycle of fasciola hepatica – the liver fluke.
4) Draw and label the life cycle of the tape worm
5) Draw and label the external features of planana.
6) State why members of this phylum are important to man.

3.1 General Characteristics

Platyhelminthes are triploblastic and bilateral in symmetry. They are not segmented. They are aceolomate, flat in shape and have only one opening, the mouth without an anus. You will ask, what is the meaning of triploblastic and acoelomate? You should already have an idea of bilateral symmetry from our study of the cnidria in the last unit. Let us now consider the details of these terms so that you can explain them.

3.1.1 Triploblastic Condition

In platyhelminthes, the embryo divides into three instead of two as it does for cnidarians. You will remember that this is why cnidarians were described as diploblastic.

With this additional layer of cells, called the mesoderm, the platyhelminthes:

- Have an increase in size
- There is then a separation of the alimentary canal from the body wall
- A variety of organs are now formed
- There is a movement towards the organ-system level of organization.
- With it muscles are beginning to develop. Cilia and flagella are becoming to irrelevant for the larger sizes evolving.

3.1.2 The Acoelomate Condition

When animals are larger, the problems of how to transport valuable life sustaining materials to all parts arise. You remember we had the same problems when we were studying plants. As plants grew to their enormous sizes, the vascular tissues which serve for transportation had to evolve. Here with the mergence of the mesoderm, the problem of how to get materials from the ectoderm to the endoderm and vis versa has arisen.

In the platyhelminthes the mesoderm completely fills the space between the ectoderm and the endoderm as is demonstrated in Fig. 14.1.

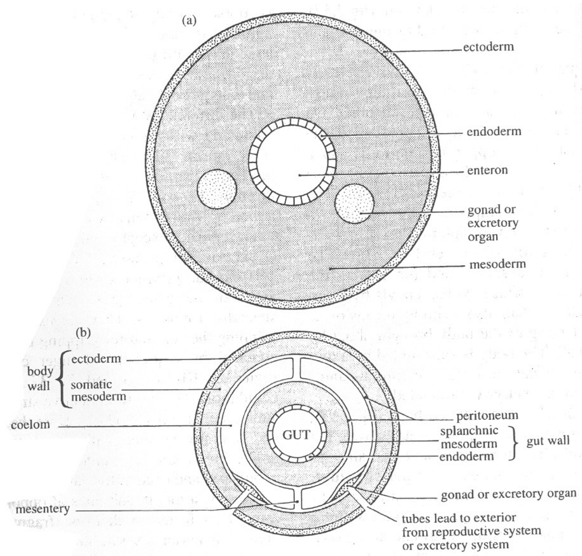


Fig. 14.1(a) Transverse section of a generalized acoelomate. (b) TS generalized coelomate.

This filling of the whole space between the ectoderm and the endoderm with (by) the mesoderm is the acoelomate condition. The animals in this group do not have a choice but be flat to present a large surface area for diffusion to satisfy the metabolic requirements. This is why they are called flatworms. In other animals, a space develops inside the mesoderm. This space is called the coelom. Such animals will therefore be described as coelomates as we will see later.

Platyhelminthes are the first group of animals to evolve the organ – system level of organization from the mesoderm. However most of the mesoderm remained undifferentiated into cells and tissues. The mesoderm here simply forms a packing tissue called the mesonchyme. It supports and protects the body organs. Before you forget, you will want to take note of some important points by answering these questions.

3.1.3 Self Assessment Exercise

1. What is the major difference between platyhelminthes and cnidarians.

2. What does the possession of mesoderm mean to the platyhelminthes.

3. Describe what you understand by coelomate and acoelomate conditions in animals.

3.2 Classification of Flatworms

Flatworms have three classes. Their characteristic features are presented in table 14.1 below.

Table 14.1: Classification and characteristics of the phylum Platyhelminthes (flatworms)

Phylum Platyhelminthes		
Characteristic features Triploblastic Bilateral symmetry Unsegmented (like nematode worms, unlike annelid worms) Acoelomate Flattened shape Mouth but no anus		
Class Turbellaria (turbellarians)	*Class Trematoda* (flukes)	*Class Cestoda* (tapeworms)
Free living; aquatic	Endoparasitic (live inside host) or ectoparasitic (live on outer surface of host).	Endoparasitic (live inside host).
Delicate, soft body	Leaf-like shape	Elongated body divided into proglottides which are able to break off
Suckers rarely present	Usually ventral sucker in addition to sucker on 'head' for attachment to host	Suckers and hooks on 'head' (scolex) for attachment to host
Outer surface covered with cilia for Locomotion; cuticle absent	Thick cuticle with spines (protection); no cilia in adult (locomotion not needed because not parasitic)	Thick cuticle (protection); no cilia in adult
Enteron present	Enteron present	No enteron (no digestion required – absorbs predigested food from host)
Sense organs in adult	Sense organs only in free-living larval stages	Sense organs only in free-living larval stages
e.g. *Planaria*	e.g. *Fasciola* (liver fluke) Schistosoma (blood fluke) – cause of schistosomiasis (bilharzias) in many tropical countries	e.g. *Taenia (*tapeworm)

Read through the table carefully. You will not have to learn off head, the contents of this table, but we will often refer to them. Before we begin to study the structure of examples of the individual classes you will need to know the following points:

That flatworms have not developed the transport systems. They are maintained a large surface volume area occasioned by their flatness. Many of them even increase their large surface area by developing branched guts and excretory systems.

3.3 Examples of Platyhelminthes

3.3.1 The Class Tubellana

As you have seen from the table 14.1 the tubellarians are the only free living class in this phylum. Planaria, a tubellarian, is free living through carnivorous. It is found in fresh water streams and ponds. It carries out only at night to feed and hides under stones during the day. Its body is soft and black. It is flat, wider towards the head end and narrower at the other. It can measure up to 15mm long. It has a pair of eyes at the top of the head. There is also a mouth at the under part of the body, at the end, opposite to the head. It is bilaterally symmetrical. It feeds on small crustaceans, worms and dead bodies of larger animals.

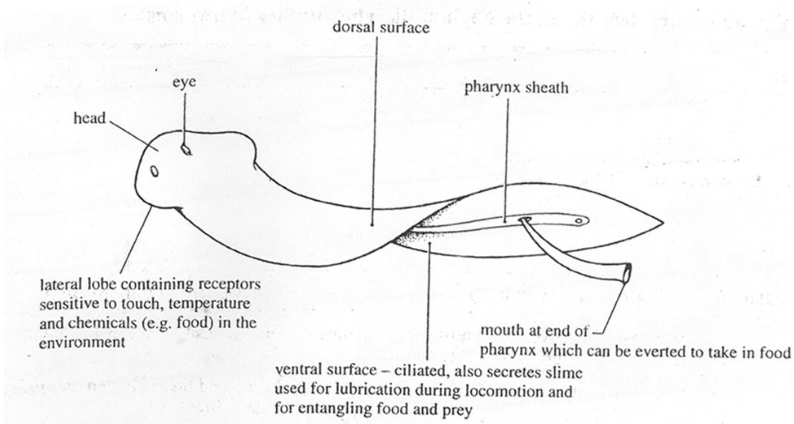


Fig. 14.2 Planaria showing external features

Exercise: You are to practice drawing and labeling planaria.

Now let us also study the external features of the second class of platyhelminthes the Trematodes. The example is fasciola hepatica.

3.3.2 Class Trematoda

Fasciola is an example in this class. It is an endoparasite. It lives in the bile duct of its primary host which could be sheep, cattle or even man. As an endoparasite, it has features that are very different from the free living planaria. It has oral and ventral suckers with which it clings to its hosts. It has a complex life history which involves three larval stages.

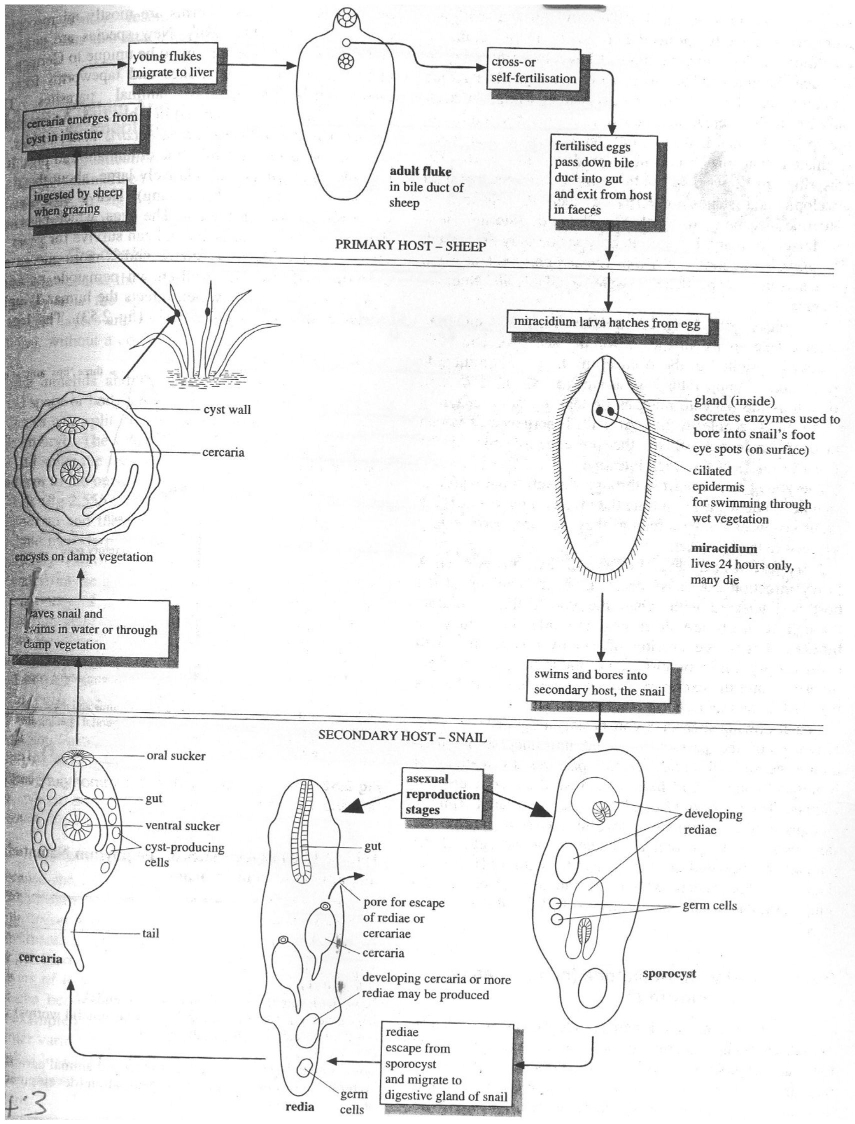


Fig. 14.3 Life Cycle of Fasciola hepatica, the liver fluke.

These provide opportunity for it to increase in number considerably. These large numbers are necessary to offset loses that must necessarily occur as it tries to find new hosts. Snail is its secondary host. In each stage, the animal develops features with which it suited to living in its host. Some of them are identified in Figure 14.4.

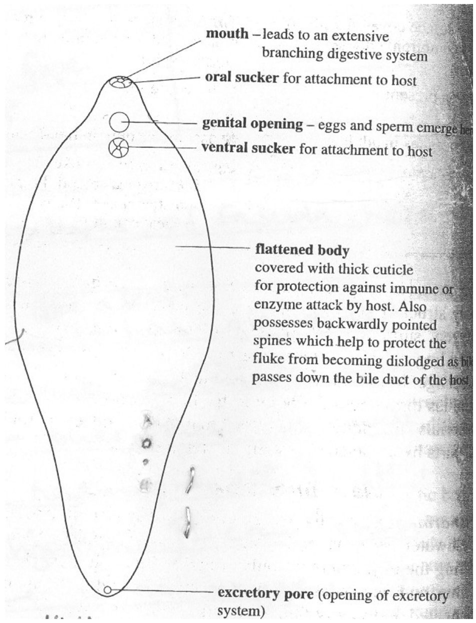


Fig. 14.4 External features of Fasciola hepatica, the liver fluke. The fluke lives in the bile duct of the host.

Structure Adults

It is flat and thin, like a leaf. It has gland cells in its body wall which secrete materials against its hosts antitoxins. Each liver fluke is male and female put together (hermaphrodite). It reproduces by self or cross fertilization. It can survive anaerobically if there is no oxygen. The body is covered with thick spiny cuticle for protection. You notice that Planaria did not have such protective features. These are important for fasciola because of its endoparasitic mode of life. You will also note that the outer surface of the free living tubellarians. Tubellarians have cilia for moving to get their food. You will notice too that the adult fasciola has the sensory organ. Only the free living larval stages have.

Before we discuss why members of this phylum are important to man, let us look at the structure and life history of the cestodeass cestoda.

Structure

The example we are studying here is Taenia (the tape worm). It is also endoparasitic. It is flat and long and its body is divided into proglottides that can break off. Each proglottide is essentially composed of reproductive organs to ensure that it reproduces in large numbers and continue to perpetrate itself in the host. It also has strong suckers and hooks on its head with which it attaches itself to the host. The body has thick cuticle for protection. As you would expect it has no cilia. Since it does not need to digest its food and lives within a host most part of its life history, it does not have a digestive system or sensory organs. Only the free living larval stages have. It however has a nerve ganglia at the head which sends down nerve cord down its sides. There are also excretory canals along its sides.

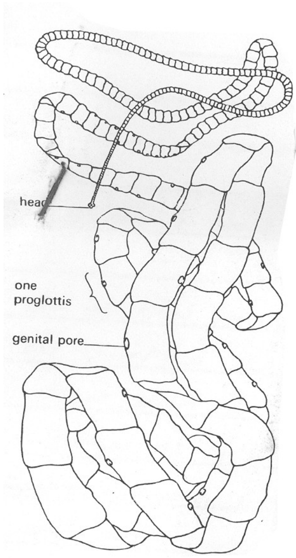


Fig. 14.5A Tapeworm A *T. saginata has no hooks.

Fig. 14.5B Heads of tapeworm: (right) Taenia saginata, (left) Taenia solium.

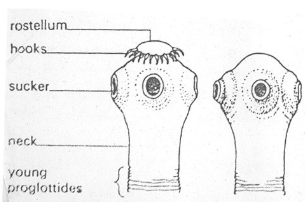


Fig. 14.5C Section through mature section of tapeworm.

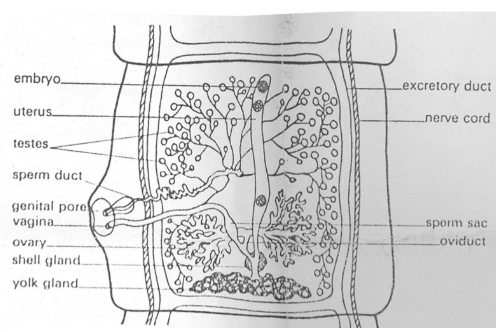


Fig. 14.5D Single flame cell.

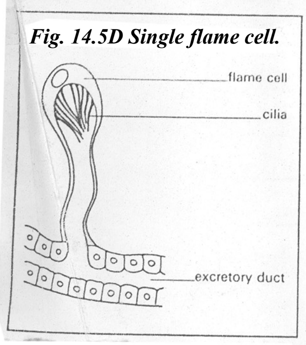
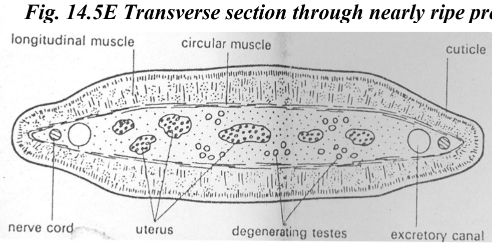


Fig. 14.5E Transverse section through nearly ripe progottis of tapewormI.



Exercise: Practice drawing and labeling the external features of the tape worm.

Life Cycle of Tape Worm

The adult worm host. As indicated earlier, each proglottide is filled with sexual structures. The opening of the female system is situated close to the cirrus which is the male organ. This cirrus introduces the sperm into the vagina. The sperms are conducted to the sperm to fertilize the eggs. The fertilized develop and fills the proglottide which can now be detached and comes out of the host's gut with the faeces. These are then taken up by the secondary (intermediate) hosts like cow and pig in their own feeding. Once in the host, the embryo inside the egg is liberated. This embryo is already equipped with hooks by which it bores its way through the wall of the intestine of its host unto the blood system. The blood now carries it round the body to the connective tissues of muscles where it settles and becomes a bladder or cyst full of fluid. This cyst also has a head with four suckers on the wall. The head is at first in this stage turned inside out. Cattle or pig so infected carries this bladder worm in its tissues, tongue, jaw and heart, If they are now eaten by man (the final host), the head of the bladder worm turns out and with the suckers, it attaches itself into the wall of the gut and the cycle begins again.

Life cycle of Taenia

Now we have studies the structure and life cycle of the examples of the three classes of platyhelminthes. We can now look close at their adaptations and try to understand why they are placed in their position in the hierarchy of classification.

Structurally, flat worms are all flat and soft. However the two parasitic classes have cuticles on their body to protect them from the enzymes of their host. The free-living tubellarians do not have such protection. Because of their parasitic modes, the cestodes and tremode have devices by which they attach themselves to their hosts. The free living tubellarians have a good regeneration power which the parasites don't seem to have. They also reproduce profusely to ensure continuity. Sense organs are not found in the encoparasitic classes. They only exist in the free living stages in the life cycles. Instead these parasitic forms branched internal organs to facilitate efficient absorption and excretion in their host.

3.4 The Importance of Platyhelminthes

The phylum are very important to man because of their disease causing groups, which infect both man and livestock. They cause the loss of a lot of financial resource in the treatment of their infection. They also cause pain and disability to man.

4.0 Conclusion

We have seen that platyhelminthes are another significant step in the evolution of animals. They have the mesoderm as a third layer of cells which fills the space between the two (outer and inner layers). This results in increase in size which in turn necessitates the emergence of a transport system to carry essential materials to cells. The member of this phylum have three classes two of which are adapted to parasitic modes. Because of the parasitic life of the majority in this group, they are very significant to the economy and well being of man.

5.0 Summary

In the last unit, we studied diploblasts. In this unit we have come across bilaterally symmetrical triploblast aceolomates. In the next unit we shall be studying triploblast with bilateral symmetry. We have learnt to know that bilateral symmetry is an advantage of movement because it give s more compact and streamlined shape. The platylhelminthes have a definite head and tail region as well as a dorsal and ventral part. Because they are in the main parasites, they have not yet developed a transport system. In the next unit we shall study the Nematodes. You will then understand why even though they are all worms, the Nematodes belong to a different kingdom.

5.1 Answer to Self Assessment Questions

You are correct if your answers are like these:

1) The major differences between the cnidarians and the flat worms is the emergence of a third layer of cells called the mesoderm which lacking in the diploblastic cnidarians.

2) The presence of the mesoderm means an increase in size. It also means a need for a transport system between the ectoderm and endoderm. It spells the beginning of the organ system level of organization. It also provides a basis for muscular activity.

3) Some triploblastic animals develop a hole in their mesoderm which is called coelom. These animals are described as being coelomate. In the flat worms there is no such development. So flatworms are aceolomate.

6.0 Tutor-Marked Question 14

Why is the tapeworm a platyhelminthe? How is it different from planaria. Illustrate the differences between them with the drawing of their external features.

7.0 References

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UNIT 15

Nematodes

Table of Contents

1.0 Introduction

Nematodes are ordinarily called roundworms. As the name implies, they are round in shape. They taper at either ends. They are also triploblastic like flatworms and have no blood system. They are seen as midway to being coelomates. So they are described as neither being coelomate or acoelomate. In this unit, we will see their relatively simple structures and adaptations. Ascaris lumbricoides found in the gut of man and the pig. Let us set some objective for this unit.

2.0 Objectives

As you go through this unit, you will be able to:

1. Give the general characteristics of nematodes.

2 Give the structure of Ascaris Lumbricoides.

3. Describe the evolutionary relationship between platyhelminthes and nematodes.

3.1 General Characteristics

Roundworms are threadlike in form. They have chitenous external coat. The digestive canal is open at both ends. This means there is a mouth and an anus.

Round worms are triploblastic, bilaterally symmetrical, elongated at both ends even though there is some degea of head development. They are not segmented. The sexes are separate. There some free living ones. Their main diagnostic feature is that the roundworms are elongated at both ends (have pointed ends). There are a few free living variety in the soil. There are also parasitic species. Because of their chitinous coat and eggs, they survive digestive enzymes of their hosts. Each species of roundworm is adapted to living in one or several specific host and has evolved complex life cycle of larval and adult stages that enables it to succeed in a particular host. They are responsible for a variety of parasitic infestations including hookworm, trichinosis and guinea worm. They are all cause disease and are of importance to man.

Roundworms are poorly evolved for locomotion and their parasitic modes does not encourage much movement.

3.2 Ascaris – Structure

Is a typical roundworm or nematode. It is pink or while in colour. It is pointed at both ends. They sexes are separate and resemble each other except that the male is characteristically curled at the posterior end.

3.2.1 Life Cycle

The fertilized egg pass out with the faeces of the host. They are very resistant and can survive for years in unhygienic conditions. They find their way back into the alimentary canal of another organic host.

In the stomach of the new host the eggs hatch into small larvae which bore through the wall of the intestine into the blood stream. In the blood they pass through the liver, heart, lungs and back finally to the intestine through the wind pipe, gut and stomach. Back in the intestine they grow into adult forms and begin to lay eggs again. Because the adult is permanently in the nutrition of its host, it has not need for any adaptive features except an egg producing mechanism. Up to 100 million eggs can be produced in the life time of a nematode. They cause loss of appetite, weakness and lack of interest in work. In children they retard growth.

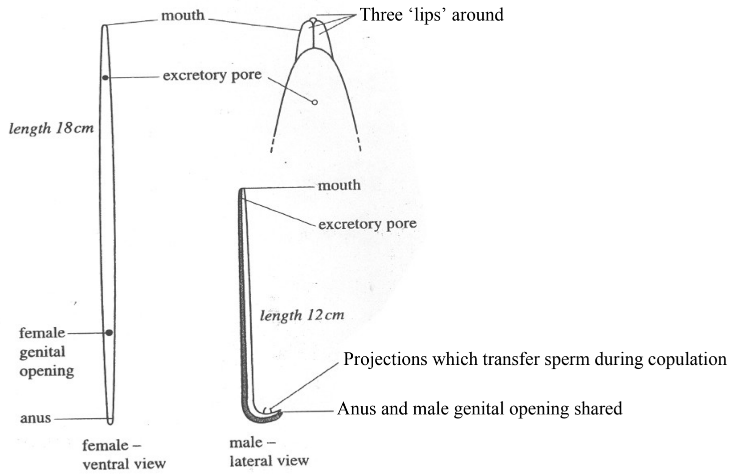


Fig. 15.1 Ascaris lumbricoides, a common gut parasite of humans and pigs

3.2.2 Self Assessment Questions

1. In what ways are Nematodes like platyhelminthes?

2. In what ways are platyhelminthes different from nematodes?

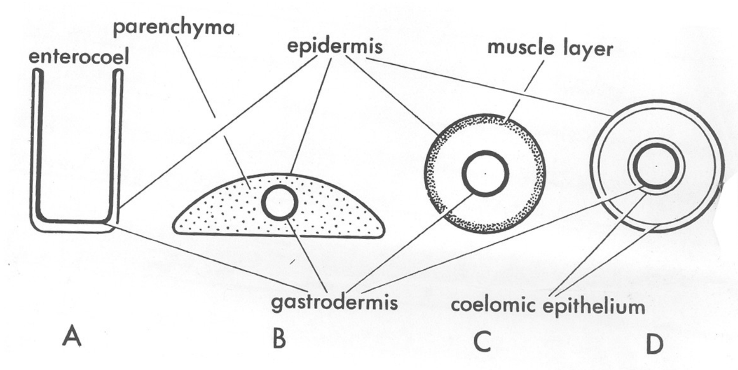
3. Looking at the structure of Ascaris Lumbricoides, how is the animal adapted to life as an endoparasite.

3.2.3 Relationships

You will notice that where nematodes like platyhelminthes are triploblastics. This means they have three layers of cells. Annelids are also triploblasts. While platyhelminthes are certainly acoelomates, nematodes are both acoelomate and coelomate. Nematodes have a digestive tube lying in the fluid-filled body cavity without coelonic lining. You can see that there is a cavity filled with fluid and there is no lining. This is why we say that nematode are acoelomate and coelomates at the same time.

If you are able to conceive of development as a continuous thing, you will see how from unicellular animals there is a gradual growth in size and completely. You will be able to understand why at one point – the point of transition between acoelomates and coelomates, why an organism or a group can seem to be both coelomate and aceolomate. We can see nematodes as transition organisms in the development of coelom.

Fig. 15.2 Body cavities. A. Enterocoel, as in coelenterates, with epidermis and gastrodermis more or less in contact and the digestive sac the only cavity. B. Enterocoel, as in flatworms, with epidermis and gastrodermis separated by cellular parenchyma. C. Digestive tube lying in fluid-filled body cavity without coelomic lining, as in nematodes. D. Coelom, or true body cavity, between digestive tube and outer body wall and lined on both its inner and outer side by coelomic epithelium, as in annelids.



In Fig. 15.2 – A represent the body cavity of coelomates. This is the group to which hydra belong. Here are only two layers of cells, the epidermis and the endodermis more or less in contact with the only cavity. B represents the situation in flatworms where the space between the two layers is filled with parenchyma cells, all of the same type and there is no fluid. C represents the situation in nematodes. Here a cavity is filled with fluid. D is the certainly coelonic condition with coelonic livings. These (D)are the types we expect to see from now on as animals become more complex and bigger.

3.2.4 Answer to Self Assessment Questions

You are correct when you give the following answers:

1. Nematodes are like platyhelminthes in the following ways:

- The two groups are triplolastic
- Have no blood systems
- They are both acoelomate when nematode is seen as acoelomate
- They are both unsegmented

2. Platyhelminthes are different from nematodes in the following ways:
   - Nematodes are round in their body while platyhelminthes are flat.
   - Nematodes have two openings for their gut – the mouth and the anus, platyhelminthes have only one – the mouth.
   - Platyhelminthes are mainly hermaphrodites while nematodes have male and female forms.

3.

- Ascaris has three lips around the mouth with which it sucks up nutrients from the gut of its host.
- The rest of its structure is mainly the reproductive organs with which it reproduces in very large numbers to ensure that it continues to survive.
- It has projections at the tail end of the male with which it transfers sperm into the female during copulation.

4.0 Conclusion

We have seen that nematodes are an important transition group. They have free living and parasitic forms which affect the lives of man and his livestock. In them we begin to see the sign of the development of a coelom. In the next unit we will see the definite coelomate state in annelids.

5.0 Summary

In their multicellular state animals continue to grow in size and complexity. As they do, more challenges are created which through the evolution of parts in adaptation animals become more and more developed.

6.0 References

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MODULE 4

UNIT 16

Annelida

Table of Contents

1.0 Introduction

In the last unit we studied the roundworms, Nematodes which were described as neither coelomates or aceolomates. In Unit 14 we found that the platyhelminthes were triploblastic but acoelomate. Here we are going to study annelid who are again taploblastic and definitely have a coelom. Since we are meeting animals with coeloms for the first time, we want to know the implication of the coelom is biological. In later studies (units) we will also follow the further development of the coelom in other organisms. To understand the position of nematodes in the evolutionary ladder and their special adaptations to life let us set some objectives.

2.0 Objectives

As you go through this unit, you should be able to:

1) Give the general characteristics of annelids
2) Describe the generalized coelomate structure.
3) Draw and label the generalized coelomate structure.
4) Give the biological importance of a coelom.
5) Describe what is meant by metameric segmentation.
6) Discuss the distinguishing features of the three classes of the annelids.
7) Illustrate the distinguishing features of annelids with diagrams.

3.1 General Characteristics

Annelids are generally triploblastic and coelomate. They are bilaterally symmetrical and metamerically segmented. There is a lip-like extension of the first segment called the prostonium. There is an outer covering of cuticle and hair-like, chitineous chaetae arranged segmentally in all except the leeches.

Before we study how they are classified let us explain the new biological terms you are meeting for the first time.

3.1.1 The Coelomate Body Plan

You remember when we were studying the platyhelminthes, we described the meaning of aceolomate as having no ceolom. The platyhelminthes, the third layer, the mesoderm which is also the middle layer completely filled the space between the ectoderm and the endoderm. This way a solid middle layer is formed.

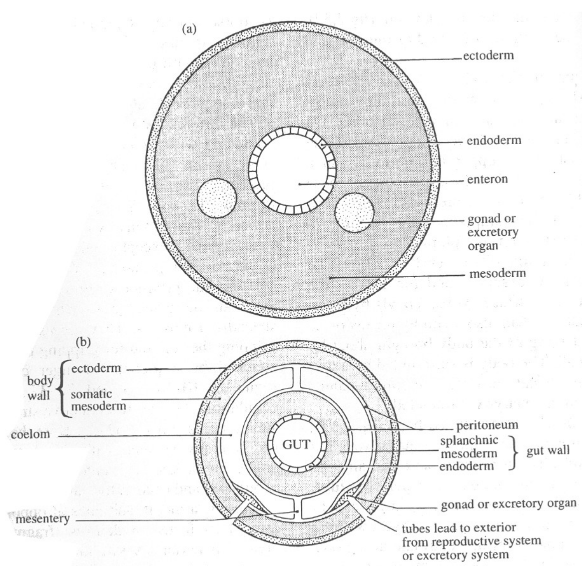

Fig. 14.1(a) Transverse section of a generalized acoelomate. (b) TS generalized coelomate.

Fig 16.1a is a diagrammatic illustration of this aceolomate condition in the platyhelminthes.

Fig. 16.b however illustrates the coelomate body plan we are trying to describe in this unit. In annelids, there is an internal space called the coelom. This space is formed from the splitting of the mesoderm into two layers – somatic mesoderm to the outer part and the splanchnic mesoderm to the inside Together with and attached to the outer wall, the somatic mesoderm from the body wall. While together with and attached to the endoderm, the splanchnic mesoderm form the muscular wall of the gut. So we can say that the coelom separates the body wall from the gut wall.

Most of the mesoderm which lives the coelom develops into the muscles. The one of the body wall allows the movement of the whole animal That of the gut causes a wave-like contraction of the muscles of the gut wall which forces food to move on along it. Transportation of all material between the gut and the body wall take place through the vascular system (which in the animal is the blood). You will recall we had also a vascular system in the plants. You will remember, they were made up of phloem and xylem cells. In animals, the hole (cavity) in the gut is the endoderm. The surface lining of the coelom is the peritoneum. These parts of which connects the wall of the gut to that of the body across the coelom are called the mesenteries. Organs like the reproductive or excretory organs which project into the coelom are surrounded by the peritoneum.

Before we learn the biological importance of the coelom, let us ensure that you understand the description of the coelom we have just made. You must still refer to Fig. 16.2 in the following description to understand. Picture a thick pipe. The space inside the pipe is the endoderm. The thick part that is the solid substance of the thick pipe, is the mesoderm which in platyhelminthes remains solid and makes them acoelomate. In annelids, this solid substance is cut open to carry a cavity. This hole is the coelom. The result of this is that there are now two cavities and two solid parts (layers) in the pipe. The holes and the solid alternate each other. The innermost hole is the original cavity in the pipe. The new one, the middle between two solid layers is the coelom. The mesentery however connects the two solid parts now formed by the split together. It is like a bridge (or a canal). The solid part attached to the ectoderm is called the somatic mesoderm. That attached to the endoderm is called the splanchnic mesoderm. The original cavity in the pipe, is the gut. From the somatic mesoderm, some organs protrude into the coelom. There are tubes from these organs to the exterior.

3.1.2 Self Assessment Questions

1. What is the equivalent of the enteron in the annelid
2. How is the coelom formed?
3. As a result of the formation of the coelom, how many layers of "solid" and how many "cavities" are formed?
4. From two opposite 'poles' the two solid parts are joined by what could be called a "bridge or canal". Biologically what is this bridge called?

If you find that you have been unable to answer these questions correctly, do not worry. Take a break and when you come back, start from section 3.1.1 and as you do, refer to Fig. 16.2. You will surely answer your self assessment questions correctly after this.

3.1.3 The Biological Importance of the Coelom

1. Because of the coelom now separated the gut wall from the body wall, the movements affecting the two parts are also separated. Organism can now have their movements independent of the external movements. In the annelids, the coelom serves as a hydrostatic skeleton (a fluid skeleton). Skeletons serve three purposes, that of protection, locomotion and support. Because of this incompressible fluid the class oligochaeta, the earthworms can change their shape without changing its volume. The muscles exert pressure on the body fluid to cause longer thinner and broader thicker portions of the body segment alternately. The fluid help dissipate external forces rapidly hence providing protection to the animal.

   With increased size and distances from different parts of the body, resulting from the presence of a coelom, is also the need for a transport system. This in turn means greater complexity of the body which needs to be coordinated by a nervous system.

3.1.4 Metameric Segmentation

This is the other evolutional advance in coelomates. Metameric segmentation is the transverse division of the body into similar parts. This division causes the development of a long body with similar segments. The division affects both the mesoderm and the ectoplasm. Externally this segmentally appear like constrictions of the body surface. Internally the segments are separated from each other by septa extending across the coelom. Every segment has its own block of muscles, blood vessels, nerve cells and in some groups reproductive organs. All the segments are not totally independent in annelids the nervous and the excretory system run-down all the segments.

The emergence of the coelom and segmentation set down the basic plan for evolutionary development, which come in different ways in the segments are group of segments. Specialization and division of labour can also take place. For example in cephalization several segments fuse together to form the head. In Arthropods it is a loss of cells. Externally segmentation is not as visible as internally. Even in chordates, only internal structures of like embryonic muscle blocks and the spinal nerves are evidences of segmentation.

3.1.5 Size, Surface, Area: Volume Ratio

Flat worms and other smaller animals including bacteria and viruses have very large surface area volume ratio. They can rely on diffusion for a lot of their life process – nutrition, gaseous exchange and excretion.

However as sizes increase, diffusion can no longer suffice, as the surface are – volume ratio drops rapidly. The coelomates must have special organs for gaseous exchange and transportation.

We have surveyed the general characters of annelids and the evolutionary advances they have over the platyhelminthes. Let us now look at how annelids are classified before we study our specific example.

3.1.6 Classification of Annelids

Annelids are classified into three classes – the Polychaeta, Oligochaeta and Hirundinea. Table 16.1 gives a summary of the characteristics of each group. Fig. 16.3 show a variety of annelids. Notice that they are all segmented.

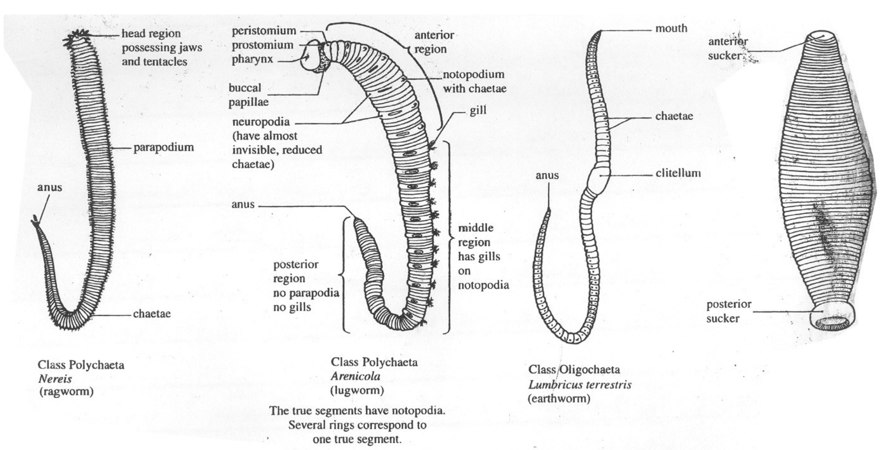

Fig. 16.3 A variety of annelids

3.1.7 The Earthworm

Let us now study the earthworm, an oligochaeta. The earthworm is very important to man because of the effects of its burrowing activities on the soil. The earthworm has not fully overcome all the problems of living on land. To prevent desiccation, it burrows into the damp soil where it can stay for along only coming out at night to feed and reproduce. It feeds on fragments of decomposing organic material by swallowing the soil. The majority of what comes out of the worm as faeces is indeed soil with which it forms its casts. This is very fertile.

Structure and Adaptation

The earthworm is elongated, cylindral and between 12 – 18 cm long. It is more pointed interiorly and more flattened posteriorly. It has a mouth at the front end and an anus at the tail. It has no projecting structures on the body which might impede its burrowing into the soil. There is a small rounded prostonium hanging over the mouth. Each segment has four pairs of chaetae, two ventrally and two ventrolaterally except the first and the last. The chaetae protrude from sacs in the body wall which can be protruded and withdrawn by specialized locomotory muscles. There are longer chaetae in segments 10 – 15, 26 and 32 – 37 which are used during copulation. The clitellum (a saddle formed by gland cells covered by the epidermis) is also found in segments 32-37. It is useful in copulation and the formation of the cocoon.

It keeps itself moist with the secretion of the coelomic fluid from its dorsal pores. Mucus also from the mucous gland also help keep the worms cuticle moist, prevent desiccation, facilitate gaseous exchange as well as serve as lubricant as the worm moves through the soil . There are also a network of looped blood capillaries in the epidermis through which the gaseous exchanges take place by diffusion over the epidermis kept moist by must and coelonic secretions.

There is also a pair of excretory and osmoregulatory tubes (neptiridia) located in every segment except the first three and the last one. They open on to the surface of the animal through the pores.

The earthworm is hermaphrodite. This means that it has both male and female sex organs in the same animal. Any two worms however copulate lying side by side but in opposite direction, exchange sex cells and both gets fertilized. The fertilized eggs are laid in cocoons, Fig. 16.4 shows the ventral view of the front end of the earthworm in which the reproductive organs are located.

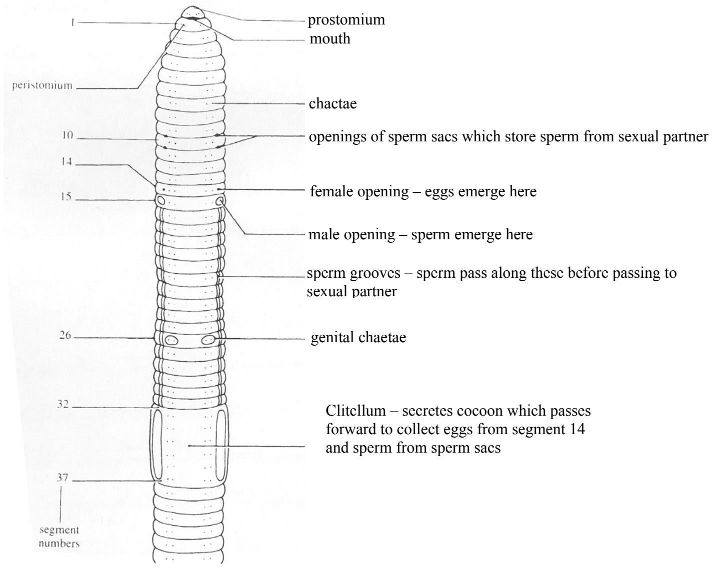

Fig. 16.4 Ventral view of anterior region of Lumbricus terrestris.

You will notice that the external features vary in the three classes in this phylum. Their basic differences can be attributed to their habitat. Nereis lives in the intertidal zone. It has projection on each of the segments with which it paddles through water.

These are called parapodia (singular parapodium). Nereis has other structural adaptations at the head and tail regions which are sensitive to touch Fig. 16.5 shows the adaptive features of the ragworm. You will need to notice the differences between the projections in each segment and the lack of projections in the earthworm.

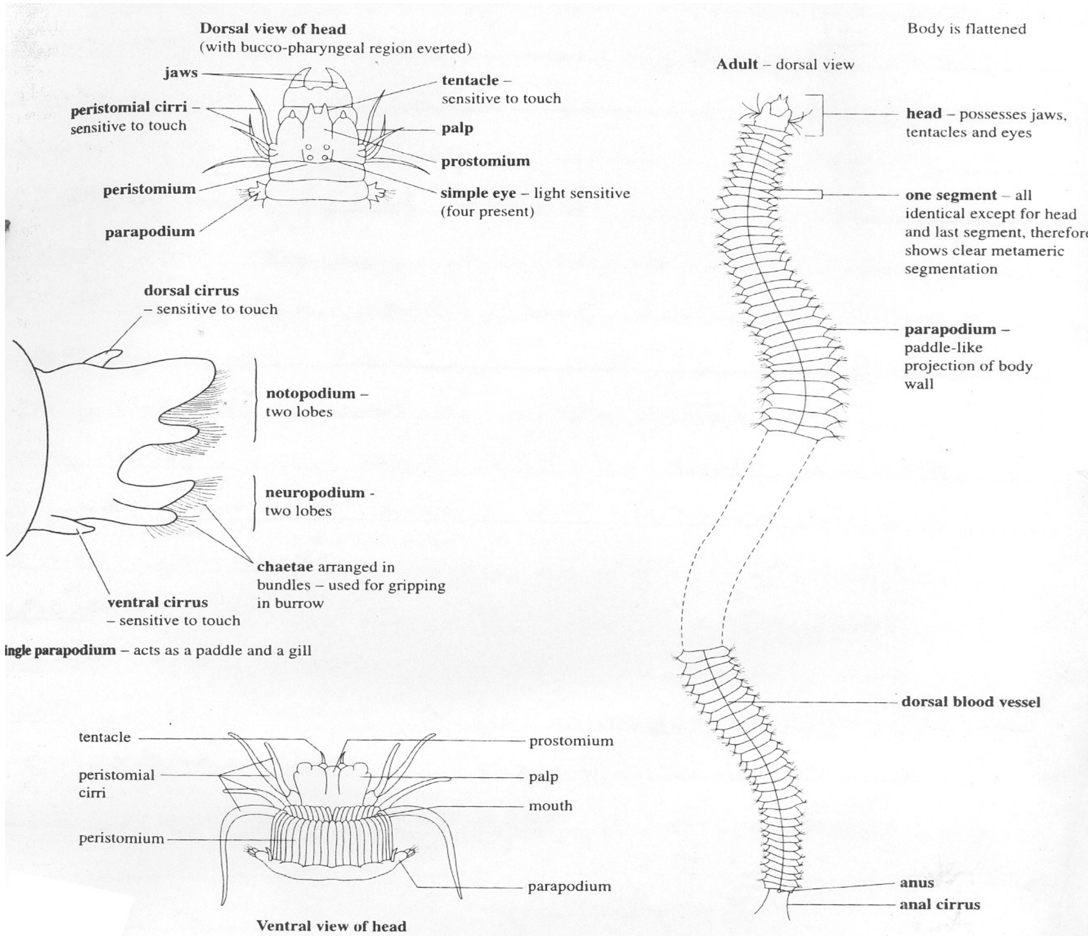

Fig. 16.5 Neresis, the ragworm

These parapoda are a diagnostic feature of the class to which Nereis belongs. The leech, the example of the class Hirundea is even more different. Where as oligochaetes have no parapodia, (a feature by which they are known), they have a few chaetae. The Hirundea have neither. Because they are ectoparasites, the leech are only equipped with suckers to attach themselves to their prey. This is the diagnostic feature of the class. You should need to get used to noticing such structural adaptation since they form the basis of classification also.

3.8 Self Assessment Exercise

Before we end this unit let us do some self assessment:

5. What are the implications of the development of a coelom in animals?

6. Draw and label the generalized coelomate structure.

7. Why is the transverse division of body of organisms into a number of similar parts or segments as seen in the annelids important?

8. Give the distinguishing feature of
   a) the Oligochaeta
   b) the Hirundinea
   c) the Polychaeta

3.9 Answer to Self Assessment Exercises

. If you gave your answers like these you are correct:

1. Gut.
2. By the formation of a hole in the solid substance of the mesoderm
3. Two layers of 'solid' and two cavities are formed
4. The mesentry.
5. The implications of the development of a coelom are as follows:
   a. Because a coelom separate the ectoderm and the endoderm, all movements of the two parts will be independent of each other e.g. movement in the gut cannot be separate from that of the limbs.
   b. The organism can now be bigger and more complex.
   c. The increase in size means that transport system must evolve to transport materials to various parts.
   d. The need to coordinate the activities of distant parts will also arise.
   e. Within the coelom, organs can grow, develop and function independent of each other.
6.

7. Segmentation is important because each segment form a basis for further development specialization and for a division of labour in the annelids, each segment is separated into its own block by a septic. Each block has its own block of muscles, blood vessels, nerve cells while an excretory and a nervous system run through the length of the animal.

8. The distinguishing feature of the:
   a) Oligochaeta is the absence of paradoda.
   b) Hirundinae is the presence of a fixed small number of segments and the absence of chaetae or parapoda.

c) Polychaeta have numerous chaetae on parapoda.

4.0 Conclusion

In this unit, you have not only learnt about the characteristics of annelids, you have also seen why they are put in three classes, the distinguishing features of each of the classes and well as a detailed description of the structural adaptation of the earthworm. We have studied the implication of the evolutionary advances made by the annelids – the two major ones being their metameric segmentation and the development of a choelom. We now have a wide range of anticipation about the possible development that could now take place with the emergence of coelom and segments. Weith segmentation and a basic plan, the pace is set for evolutionary development through grouping of segments, loss of segments, specialization and division of labour.

5.0 Summary

In the next units we will see how these happen in each animal phyla You surely must be enjoying the patterns that are unfolding. You can see the order in the world of living things.

6.0 Tutor-Marked Question 16

Without diagrams explain how annelids adapted to their different habitats.

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UNIT 17

Arthropods

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1.0 Introduction

The Phylum Arthropoda is the largest in terms of number of animal species. More than three quarters of known animals species are arthropdods and half of these are insects. Animals in this phylum are important because they inhabit every type of habitat on land and in water.

In this unit we shall study the general characteristics of arthropods. We will then study how members of the phylum are classified. You will need to pay particular attention to the trend in specialization of parts and the division of labour in the structure of arthropods from one group to another.

To guide this study in this unit let us set down the objectives you need to achieve.

2.0 Objectives

As you go through this unit, you should be able to:

1. State the general characteristics of arthropods.

2. Compare the basic general body plan of the arthropods with that of the annelid.
3. Describe the advantages and disadvantages of an exoskeleton in arthropods.
4. Explain the haemocoel condition in arthropods.
5. Enumerate the criteria for classifying arthropods

3.1 General Characteristics

Arthropods are triploblastic bilaterally symmetrical coelomates with metameric segmentation. Their main diagnostic features is the possession of chitineous and sometimes calcareous exoskeleton. This may be stiff, rigid or flexible. Each segment bears a pair of jointed appendages used for locomotion, feeding or as sensory organs. The coelom is reduced. The main body cavity is a haemocoel.

Exercise: Practice listing the characteristic features of arthropods. There are seven main points here. You are to learn how to remember them.

In the following sections you will see the details of the general characteristics summarized above.

3.1.1 The Basic Body Plan

The arthropod body plan can be described as based on the segmented body plan of annelids. The earliest arthropods possess many similar jointed appendages which probably served as gaseous exchange, food gathering, locomotion and detection of stimuli. In modern arthropods, different segments have become more specialized and a greater division of labour has resulted. The appendages have become fewer and more specialized.

Members of this phylum are believed to have specialized their basic structures for is known as the principle of adaptive radiation. The mouth parts of insects for example the basic mouth parts of the class insecta are a labrum (upper lip, a pair of mandibles, a hypopharynx (floor of the mouth), a pair of maxillae and a labium (fused second pair of mandibles lower lip). By enlarging, modifying, reducing and losing some of these structures, insects have adapted them for sucking, licking and biting, biting and chewing; and piercing and sucking. You must also note the various ways in which basic structures adapted for varying functions. Repeat them, write them down and try to remember them. The basic mouth parts are enlarged or reduced; modified and some lost. This high degree of adaptability of the basic structures reflects their success which has enable the insects to occupy a wide range of ecological niche. You may also conclude that all organisms with same basic physical or physiological structure may have the same evolutional ancestry. Fig. 17.1 illustrates the adaptive radiation of insect mouth parts.

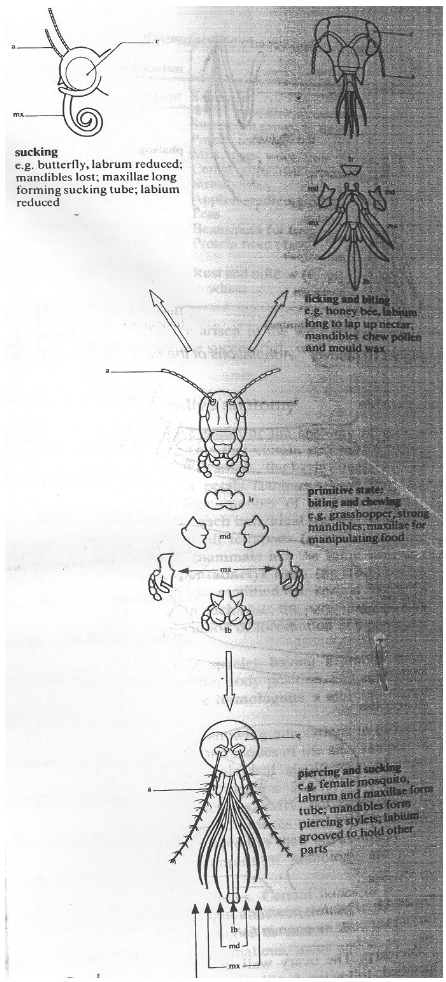

Fig. 17.1 Adaptive radiation of insect mouthparts a, antennae; c, compound eye; lb, labium; lr, labrium; md, mandibles; mx, maxillae.

3.1.2 Exoskeleton or Cuticle

The exoskeleton in arthropods is secreted by the epidermis. It is made up of chitin. Chitin is a nitrogenous polysaccharide which strongly resembles cellulose, the strengthening material of the cell wall of plants. Chitin has high tensile strength. This means that it is difficult to break them by bending from both ends. By combining chitin with other chemicals, like salts, (especially calcium salts) and proteins the exoskeleton can be made harder as in crustaceans. So you can see that a wide range of adaptation in the exoskeleton is possible. You can also see that both hardness and flexibility are important for limbs and joints.

At this juncture you must understand the important advantages of an exoskeleton which we are meeting so extensively in the animals for the first time.

Advantages of the exoskeleton

- It gives support particularly on land
- Forms a basis for attachment of muscles responsible for locomotion
- Protects body parts from physical damage
- As an additional waxy layer on the body, it prevents desiccation on land.
- The presence of elastic protein in the exoskeleton enhances insects abilities to fly and jump.
- It is not heavy. This is important for those insects that fly.
- Because of its hardness and tensile strength, it offers flexibility at the joints and between segments
- It can be modified to form mouth parts adapted for different types of feeding.

Disadvantages of exoskeleton

There are however two major disadvantages in exoskeletons:

- It limits the size that can be attained by an organism. Large animals do not keep exoskeletons. (The breatening mechanisms by diffusion through trachea is another factor that has limited the size of arthropods).
- It restricts growth, periodic moulting (ecdysis) is required for such animals with exoskeleton to grow. This renders arthropods vulnerable to predators attack at the time of moulting. They must therefore seek shelter before they go into the process.

3.1.3 Jointed Appendages

This is the diagnostic feature of arthropods. The word literally means jointed foot. These jointed appendages are used for a variety of functions such as locomotion, feeding and as sense organs.

3.1.4 Haemocoel

In arthropods and mulluscs, the coelom is filled with another cavity which develops from the vascular blood system and is filled with blood. So you see that many major organs are batted in the blood. This large volume of blood enable the animals to maintain a high metabolic rate. The space occupied by the haemocoel is so much that there is a high risk of loss of blood from injury to animal. The coelom is reduced to the excretory organs and reproductive ducts.

You will remember that in Unit 16 we drew a generalized structure for coelomates. (Fig. 16.2 refers).

If you compare Fig. 16.2 with Fig. 17.2 you will notice that the reproductive and excretory organs are protruding into the coelom (which forms about a third of the area) from the outer wall of the body in the generalized coelomates. However in the haemocoel condition of the arthropods, the coelom is very reduced in size.

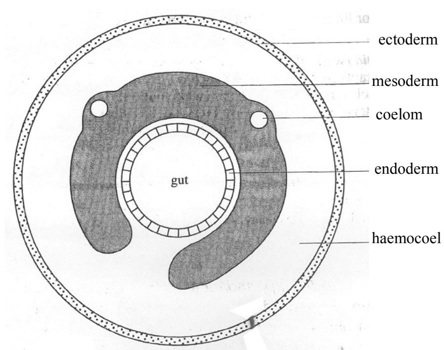

Fig. 17.2 The haemocoel condition.

3.1.5 Specialization of Body Parts

There is a greater division of labour in the arthropods than in the annelids. There is a head, thorax and abdomen. The head houses the sense organs the antennae, the eyes and the brain. It is the first to come in contact with the world as the animal moves, so you can see why this front end must be so specialized. In the annelids, the head is not so specialized. The sense organs are not so well developed.

3.1.6 Classification of the Phylum Arthropoda

Arthropods are classified into five classes. In this section only the criteria for their classification will be studied. In subsequent unit, we shall study the characteristics of each of the five classes:

- Super class Crustacean
- Class Insecta
- Class Chilopoda
- Class Diplopoda and
- Class Arachinda.

Arthropods are placed in the various classes mentioned above by their

- Habitat
- Structure of the head (whether defined or not)
- Number of antennae
- Number of pairs of mouth parts
- Number and type of eyes (compound or simple)
- How appendage are modified for their specific function
- Whether or not there are larval forms in the life cycle.
- Whether gaseous exchange take place through trachea, gills or lungs.

You will realize that many of the deviations in structural adaptations are likely to be influenced by the habitat. You will for example expect that an animal adapted to life in water will have gills for gaseous exchange. Similarly, the aquatic arthropod would hardly be expected to develop wings.

You will remember that the purpose of the study in this course is to enable you know the adaptations of the variety of organisms to their habitat. You are as well learn to place organisms in their appropriate position in the classification scheme. The criteria enumerate above can well serve as an identification key. You will remember that in your practical course (104) you learnt how to draw an identification key.

The range of development in the head region of arthropods include fusing together the head and thoracic segment to form a cephalothorac or keeping both separate. Sometimes the head is not so defined.

Arthropods are either terrestrial or aquatic by their habitat. They either have a pair, two pairs or no antennae.

Some have no true mouth parts while others could have one or three pairs of mouth parts. All arthropods have eyes. Some have only simply ones while others have only compound ones. Some combine both. While some have larval forms, others do not have.

3.1.7 Self Assessment Exercise

1. Give the nine characteristic features of the phylum arthropoda.

2. What is adaptive radiation?

3. What are the basic components of the exoskeleton of arthropods.

4. What are the advantages of the development of an exoskeleton in arthropods?

4.0 Conclusion

In this unit you have studied the general characteristics of arthropods. You have also learnt that the generalized basic structure of a ceolomate has been modified in the arthropod. By studying how arthropods are classified, you now have an idea of the variety of animals in the phylum arteropoda.

5.0 Summary

The stage is now set for your to study the actual varieties of arthropods. You now know that there are five classes in this group: Crustaceae, insecta, chilopoda, diplopoda and arachinda.

6.0 Answer to Self Assessment Exercises

If you gave the following answers to your self assessment questions, you are correct:

1. Arthropods are generally:
   a) Triploblastic
   b) Bilaterally symmetrical
   c) Metamerically segmented
   d) have an exoskeleton - which may be rigid or flexible
   e) each segment has a pair of jointed appendages
   f) the coelomates (coelom reduced)
   g) coelomates.

2. Adaptive radiation is a process by which different forms evolve from a single successful ancestral type to fill many different ecological niches.

3. The exoskeleton in the arthropod is basically made up of chitin – a nitrogenous polysaccharide which resembles cellulose. It can be made stronger when it is combined with calcium salts or protein.

4. There are several advantages in the development of the exoskeleton. The exoskeleton give support, forms the basis of muscle attachment for locomotion and protects the delicate parts of the body. It also prevents desiccation. With protein, it enhances flight in flying arthropods. Because of its flexibility, it also enhances the formation of joints. It allows modification to form various mouth parts. It can be transparent in parts to allow the penetration of light as in the eyes of arthropods.

7.0 Tutor Marked Question 17

1a. What is the meaning of the word arthropoda

b. State at least four biological advances shown by arthropods over annelids

c. Describe the haemocoel condition in arthropods.

d. by what criteria are arthropods classified.

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UNIT 18

Super Class - Crustacea

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1.0 Introduction

Crustaceans are a super class in the phylum arthropoda. In them we will see how the segmented body and the appendages attached to the segments are adapted to various aspects of aquatic life. Some are free swimming, others walking at the bottom of the sea, while others are sessile, fixed to their habitat. The adaptations are varied. In Crustaceans the number of segment are reduced, mostly by a fusion of the head and the thoracic regions. They also vary in shape and structure.

To study the details let us set the following objectives which you will try to achieve as you go through this unit.

2.0 Objectives

As you go through this unit, you should be able to:

1. Give the characteristic features of the crustaceans
2. Define the biramous appendage
3. Describe the nauplius larva.
4. Identify the adaptive features and functions in the appendages of the prawn (lobster).
5. Describe the division of labour among the appendages of the crab.

3.1 General Features and Characteristics

Crustaceans are mainly aquatic. The head region is distinct even though the head and the thoracic are not distinctly separate. There are two pairs of antennae and at least three mouth parts. They have a pair of compound eyes raised on stalks. Have varying numbers of appendages. The appendages are modified for swimming. They have larvae. Typically respiration is through gills which grow out of the body walls or limbs. Examples are water flea (Daphnia), crayfish (Astacus), prawns, crabs, lobsters and woodlice.

They live and walk on the sea floor.

Typically the body of the crustacean is divided into head, thorax and abdomen. The head and the thorax are frequently fused together forming the cephalothorax. In the head is found the specialized appendages while in the trunk you find the multipurpose ones. The abdomen either has none or reduced appendages except those of the tail.

3.1.1 Primitive Appendages

Consist of a basal joint and two jointed branches – the biramous or two oared appendage which may both become highly specialized.

3.1.2 Self Assessment Exercise 18.1

What do you understand by the term Biramous appendage?

3.1.3 The Head

It always consist of several fused segments. It carries appendages in form of a pair of stalk eyes, two pairs of sensory feelers called antennules and antennae respectively, and three pairs of specialized feeding appendages known as the mandibles, maxillules and maxillae. There may also be additional feeding appendages (the maxillipedes) posterior to other.

The appendages of the head are a good example of specialization of general types to serve different functions and for cooperative use.

3.1.4 Thorax

Thoracic appendages usually perform two or more functions at once. They are usually highly developed but may not be so highly specialized. Biramous appendage may retain its original form or be developed by expansion or subdivision of the base and its two branches without being obviously specialized a particular function. A single thoracic appendage may serve to beat and whip in surrounding water in such a way that :

1) a food bearing current of water is driven toward the mouth
2) gaseous exchange between the circulating blood and the current of water over surface of the limbs. Such generalized limbs may have in addition to their featherlike parts, blade-like or leaf-like parts which simultaneously serve as paddles and respiratory surfaces. The general surface of the appendages can be further increased by the formation of numerous chitinous hairs or setae which extend as a fringe from the edges of the various parts of the appendages. Several appendages work together to sift food particles as setae fringes overlap to form a grid-like filter. Even as an appendage serves several purpose at once, parts of it may be specialized for particular functions. In crustaceans a particular appendage may function predominantly in a particular way but in conjunction with other appendages, it functions may change.

The specialization of limbs have brought about the shortening of the body in crustaceans. The number of limbs also tend to reduce the more the specialization. These developments have in turn brought about a great deal of opportunities for exploiting the environment. The shape of crustaceans and the variety of limbs vary greatly.

3.1.5 Carapace

Another consequence of the specialization of limbs is the development of carapace (shield) which grows backwards to cover the sides and upper part of the thorax. It serves to set up respiratory and feeding currents as well as for protection. It is not present in all crustaceans.

Typically crustaceans exist in separate sexes although for some barnacles are monoecions while in some shrimps there is a change in sex half way through development.

3.1.6 Fertilization

Fertilization take place as they come out of the female to prevent them from hardening and make sperm penetration impossible later. So there must be copulation to make the sperms available as eggs are coming out of the oviduct. Once fertilized they are covered with chitin which make them sticky and get attached to the abdominal limbs where they continue to develop until they hatch into larva.

The nature of the larva and the time it takes them to develop to maturity depends on the size of the egg. Some crustacean eggs hatch into the nauplius larva (Fig. 18.1) a little form with only three pairs of biramous limbs and single simple median eye.

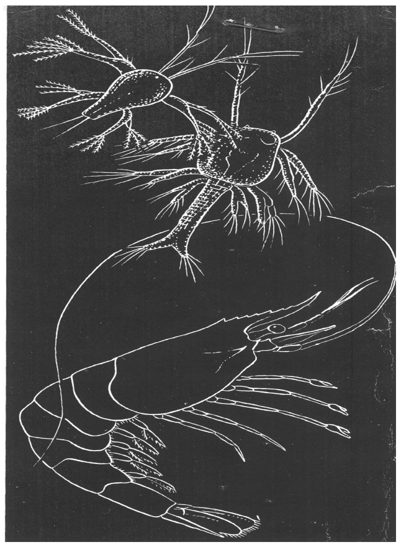

Fig. 18.1 Life cycle of shrimp. Nauplius larva and metanauplius larva above, and, on much smaller scale, the adult form.

The zoea larva of crabs are larger and have compound eyes. The larvae develop at the upper surface of the sea and come to the bottom after they have grown considerably. The crayfish grow into miniature forms without the larval stage. The crustaceans are diverse and can be put into three groups depending on the kind of aquatic life they live.

3.1.7 Self Assessment Exercise 18.2

Describe the nauphlius larva.

3.2 Categories of Crustaceans

Free –Swimmers (Copepod and Branchiopods)

These are the Copepods. They are the smallest of crustaceans but the most in numbers. They have the three body parts and typical set of appendages. They have prominent antennae and a forked tail. There is a single simple median eye. It carries its developing eggs in brood sacs behind them on either side of their abdomen. They release eggs as nauplius larvae. They form the beginning of a food chain. They feed on unicellular plant life and are in turn food to many kinds of fish.

In further development, some copepods have developed into fish parasites rather than allow the later feed on them. These have developed blood sucking tubes from their head processes for both sucking and anchoring themselves to their hosts. Such then loose their sensory and locomotion organs. Their eggs must however be produced in large number and develop into free living larvae to enable them find other hosts. So their females grow to a large size with very distended bodies laden with plenty eggs. The males remain small, and fertile with their locomotor organs to seek and fertilize anchor females. The chances of finding a mate are so slim that when in some species the male finds a mate, if encounter is made permanent and the male becomes a parasite on the female. Daphnia, the water flea and Artemia the brime shrimps are examples of free swimming Branchiopods.

3.2.2 Walkers (Decapods)

The primitive crustacean appendage are effective for swimming for small animals. With their increase for small animals. With their increase in size and additional weight of the exoskeleton, crustaceans must of necessity inhabit the sea floor. Their exoskeleton are therefore converted into heavy armour by impregnation with salts. They give up swimming for walking. The lobsters, shrimps and crabs belong to this group.

They have the general crustacean organization except that a branch of one of the mouth parts serves as a bailer pulling water respiratory currents forward under the side of the carapace and over the gills. Decapods are also noted for having a gastric mill within its chitin-lined stomach.

Now let us make a few comparisons to further help you understand the various adaptations in crustacean appendages:

Panulirus (common shrimp) has
2 pairs of antennae
6 pairs of variously specialized mouth parts

6 pairs thoracic appendages)each possessing a walking and a gill) first three end in clans for gripping.
6 pairs of abdominal appendages (all but one biramous) swimming type.
Last appendage join with last body segment to form telson lobster.

The lobster has all that the shrimp has. Except that the lobster has carried is specialization a bit further. Unlike the shrimp, it uses only five of the six pairs of thoracic appendages for walking. The first pair is enlarged greatly to form a claw at the terminal part. (See Fig. 18.2) for crushing the hard shell of bivalve mollusks on which it fees.

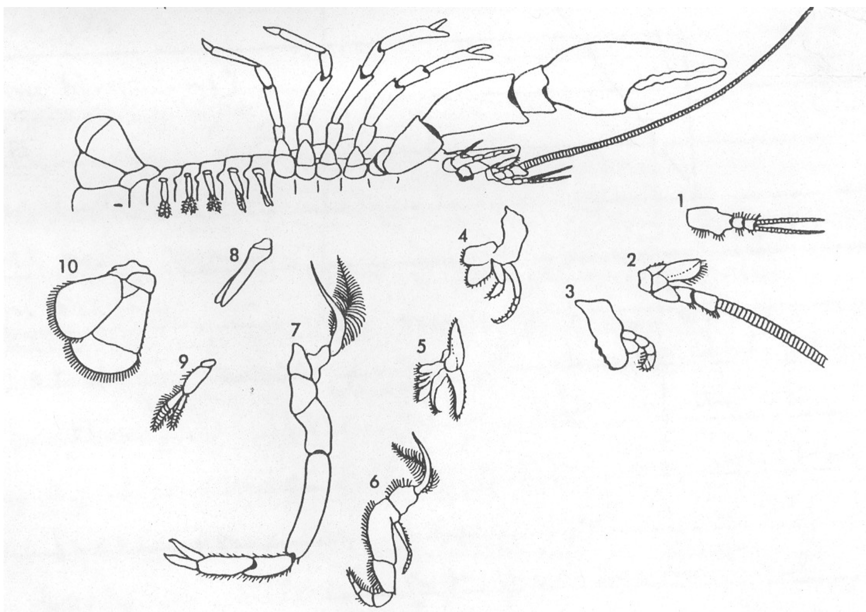

Fig. 18.2 Diversity and division of labor among appendages of lobster (or crayfish). A ventral view of a half animal is shown above, and the different kinds of appendages, all of which appear to be modifications of a biramous appendage, are shown below. 1. Antennule; 2. antenna; 3. mandible; 4 and 5. first and second maxilla; 6. the third of three maxillipeds, with gill and gill separator at upper end; 7. one of five walking legs, with gill and gill separator at upper end (the large claw, not shown separately, is an enlarged walking leg; 8. the first abdominal appendage of the male, modified to serve as a sperm transfer organ; 9. one of four pairs of abdominal swimmerets, with unmodified biramous structure; 10. the enlarged terminal appendage, or uropod, serving as the lateral part of the tail. Appendages 3 to 6, inclusive, together with the two maxillipeds not shown, comprise the six pairs of mouth parts.

Further of these two, one is larger and coarser and serves as a crusher, while the other is slenderer and serves as a cutter and nipper. Lobsters may be described as oversize shrimps.

The crab

The crab has everything that the lobster has. However, the crab has a wider thoracic and shorter abdomen than the lobster or the shrimp. In addition the crab has five pairs of walking legs articulated to allow walking side ways.

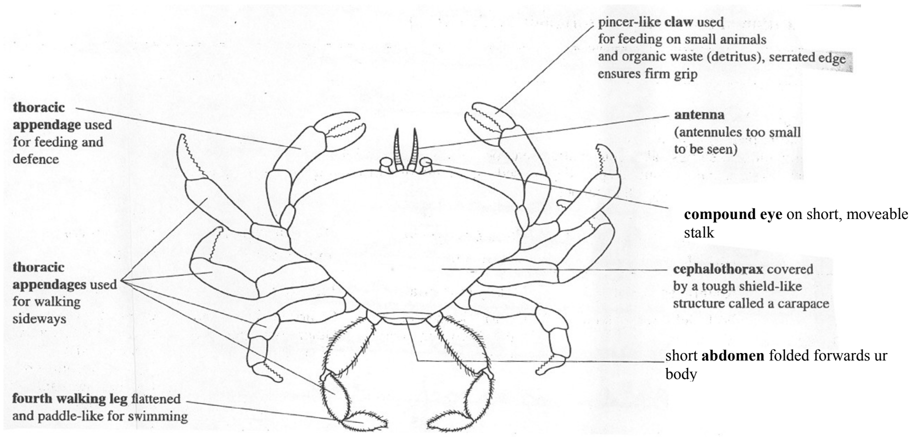

Fig. 18.3 A crustacean Carcinus maenas, the shore crab. Dorsal view. Common on rocky shores and beaches. Separate sexes occur. The head is fused to the thorax to form a cephalothorax. The first three pairs of thoracic appendages, maxillipeds, are involved in feeding but are not visible from the dorsal surface. Note that the appendages are jointed.

3.2.3 Sessile Crustaceans

The criripedes and barnacles are sessile. They live firmly attached to the rock surface or a shell of a mollusk, the carapace of another crustacean, the bottom of a ship, a floating bottle or on the skin of a whale. They are attached by their heads to their substrate and have virtually lost their senses.

3.2.4 Practice Exercise 18.1

The Diversity and Division of Labour among the appendages of the Lobster (crayfish)

The name and function of the appendages are here placed in a tabular form. Note that all information are derived from both diagrams

Table 18.1: Diversity and Division of labour among the Appendages of the Crayfish and Lobster.

S/N.	Appendage	Adaptation	Function	
1.	Antennule	Hairy branch Long sensory perceptive	Sensory	
2.	Antenna	Hairy structure branch. Long sensory perceptive		
3.	Mandible	Sharp serrated edge, chintinous blade like parts	For cutting	
4.	1st maxilla	Feather-like part chitinous feather like	Driving in food bearing current	
5.	2nd maxilla	Sharp chitinous structure feather-like	With other parts serve as sieve	Feeding
6.	3rd Maxilliped	Sharp chitinous structure with gills and separators (3 in number)	Respiratory and sewing	
7.	Walking legs	With gills and separators and enlarged claws for crushing 5 in lobsters, 6 in crayfish	Respire-locomotion	
8.	1st Abdominal	Branched into a pair of pointed chitinous structure	Transferring sperm into the female-mating	
9.	Abdominal swimmeret	Unmodified two jointed biramous appendage	For swimming	
10.	Uropod	Enlarged terminal appendage	For swimming quickly backward especially in escape	

3.2.5 Practice Exercise 18.2

You will here repeat what you did for the lobster. Looking at the diagram of the crab, make a list of the appendages in order from anterior to posterior end. State the functions of each of the appendage.

Table 18.2 Result of Practice Exercise 2

Diversity and Division of labour among the appendages of the crab.

	Structure	Adaptation	Function
1.	Antennules	Small projecting sensory	
2.	Antenna	Projecting sensory	Sensory
3.	Compound eye on stalk	Soft chitinous stalk to raise eyes above body	
4.	Thoracic claws	Pinder-like claws with serrated edge (some upto three pairs)	Feeding
5.	Thoracic Appendages	Serrated edge for gripping	Walking
6.	4th Walking leg (thoracic)	Flattened and paddle-like	Swimming

3.2.6 Answer to Self Assessment Exercises and Results of Practice Exercises

1. Answer to Self Assessment Exercise 18.1
   A biramous appendage is the two-oared appendage. It consists of a basal joint and two jointed branches. It is considered the primitive form from which all other adaptations arise in the crustaceans.

2. Answer to Self Assessment Exercise 18.2
   A nauplius larva is that tiny form produced when the crustacean egg hatches. It is equipped with only three pairs of biramous appendages and a single, simple median eye.

4.0 Conclusion

In this unit you have learnt that crustaceans are a group of arthropods that have shown a lot of adaptations in the use of their appendages. From a primitive biramous type, they modify both to suit their environment as well as share function among the limbs. The shrimp (crayfish) and the crabs are good examples although there are so many species that the class crustacean is described as a super class.

5.0 Summary

As we continue to study the animal kingdom, you will not forget the unfolding gradual increase in both size and complexity. You will also bear in mind the adaptation, loss or acquisition of parts and function is dictated by way of life. You will recall that in the crustaceans, parasitic ones exist. These loose certain abilities which their free living counterparts use to advantage.

6.0 Tutor-Marked Question 18

What are the general characteristics of the crustaceans? How many pairs of appendages could a crab have? List the appendages and state their functions

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UNIT 19

Arthropoda
Class - Insecta

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1.0 Introduction

In the last unit we studied the super-class crustacean. We saw how the crustaceans modified their appendages for different use. We saw that they were aquatic. Even as aquatic animals they varied in their adaptation, some were walkers while others were swimmers and sessile. Their characteristic feature included the possession of a cephalothorac – a fusion of head and thoracic segments. The class insecta is different in this respect. They have distinct head, thorax and abdominal regions. In this unit you will learn more about insects and why they are described as the most successful of animals.

2.0 Objectives

As you go through this unit you should be able to:

1. Give the general characteristics of insects.
2. Draw and label the structure of an insect fully.
3. Describe the following as they relate to insects
   - water regulation
   - tracheal system.
   - possession of wings.
4. Describe the influence of chitin on insects.
5. Describe how insect societies came into being.
6. Analyse how structural modification in insects are an advantage.

3.1 General Characteristics

Insects are mainly terrestrial. They have well-defined head, thorax and abdomen. They have a pair of antennae and usually three pairs of mouth parts. They also have a pair of compound eyes and a pair of simple eyes.

There are three pairs of thoracic legs, one pair each in a segment. There are one or two pairs of wings; one on the second, when they are two, another on the third thoracic segment.

The life cycle involves complete or incomplete metamorphosis. There is usually larval stage.

There is usually no gill in the adult in which gaseous exchange is through the tracheae.

Typical and common examples of insects are cockroaches (Periplaneta), bees (Apis) white butterfly (Pierus). There are many others more like bugs, beetles, fleas, wasps, flies, dragonflies, termites and grasshoppers.

3.1.1 Structure of the Insect

Typically the body of the insect is divided into three parts, the head, the thorax and the abdomen.

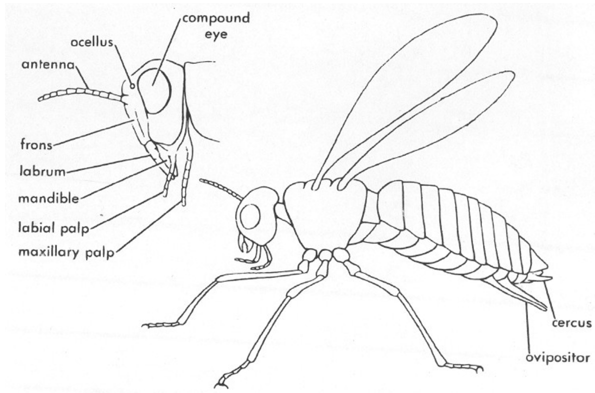


Fig. 19.1 External insect structure showing three-part body: six-segmented head with sensory and feeding structures; three-segmented thorax with three parts of legs and two pairs of wings; and eleven-segmented abdomen without appendages, other than reproductive structures.

The Head

The head is made up of six segments fused together. This head bears the following parts:
A pair of antennae
Mouth parts: a labium (lip-jaw)
Two sets of paired appendages
A pair of lateral compound eyes
One or more simple eyes.

Thorax

The thorax is not fused to the head as we saw in the crustaceans. It is usually connected by a narrow neck. It consist of three segments each with a pair of walking legs. The wings (when present) are not modified appendages but are new outgrowths from the dorsal side of the last two thoracic segments.

Abdomen

Usually there are eleven segments in the abdomen. It usually has no locomotive appendages in the adult form. The fundamental segmented nature is expressed even in the nervous system.

3.1.3 Self Assessment Exercise 19.1

Draw the external structure of insect showing the three-part body. Draw and label fully the head showing the feeding and sensory structures.

3.1.4 Internal Cavity

As in other arthropods, the internal cavity is the haemocoel. The heart is ostiate (lying in the dorsal portion of the abdomen.

The digestive tube consist of

- a chitin-lined fore gut. This is made up of the mouth to which the salivary gland discharge. There is also the muscular pharynx, an oesophagus with a dialated crop (serving as a food reservoir and a small gizzard.
- A mid gut which is lined by a folded epithelium. It is usually further extended by numerous tubular projections called the pyloric caecae. The cells of the mid gut do all the task of digesting and absorbing food substances.
- The chitinlined hind gut is supplied with tubes ending blindly at its anterior end. These are the malphighian tubules. They lie in the haemocoel. They are the excretory organs. There are the rectal glands at the end which reabsorb water from faeces before they are passed out.

3.1.5 Water Regulation

For these land animals, the general requirements of cells and tissues for water, salts and oxygen must also be met and maintained in a constant state. This is because the health and activity of the cells depends on the stability of the internal environment. In terrestrial animals, it is usually not easy to get water into them. It is instead easier to loose water if unchecked. To keep an internal state of the organism, constant water loss must be constantly checked. The followings are ways in which the insects regulate water:

1) The waxy outer surface prevent evaporation.
2) Malphighian tubules, lying in the blood-filled haemocoel, collect unwanted chemicals and send them to the hind gut for elimination. It at the same time reabsorb excess water.
3) Additional water is reabsorbed by the rectal gland, so that only solid matter is excreted.

Insects have developed such extensive excretory tubules to cope with the problem of water conservation. In the cockroach for example, there are sixty tubules with an absorptive surface area of upto fourteen square feet.

3.1.6 Tracheal System

This is the tubular system in animals which carries out the function of oxygen supply and carbondioxide removal. In insects the heart and the blood are not involved in tissue respiration. The heart serves mainly to maintain the blood in motion. The blood distributes nutrients absorbed from the digestive tube and enables the efficient working of the regulatory malpigian tubules.

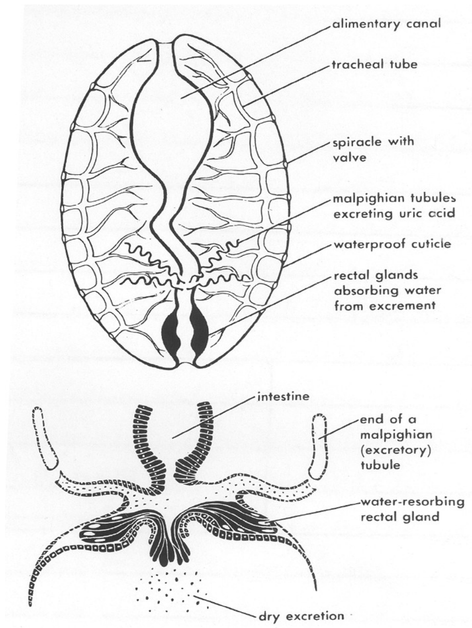


Fig. 19.2 In the course of evolution the insects have developed mechanisms for conserving water. Surface loss by evaporation is reduced by a thin layer of wax in the cuticle. Contact with outside air is through spiracles, with openings controlled by valves. The rectal glands remove any surplus water in the feces. The Malpiphian tubules convert waste nitrogen to uric acid, which is excreted as a solid.

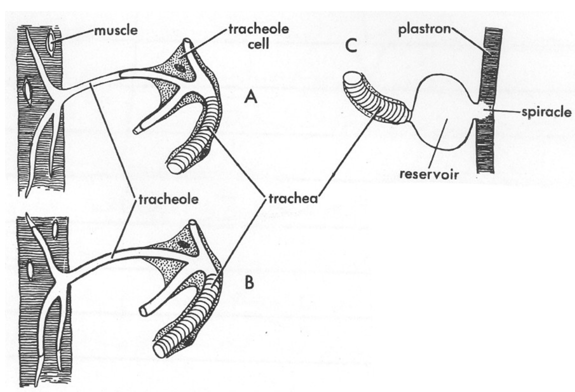


Fig. 19.3 Respiration by means of tracheal air tubes. A. and B. Tracheal tube, with annular reinforcement, branching to form several tracheoles supplying muscle tissue. In A the terminal part of the tracheole is filled with fluid; in B, under conditions of greater oxygen need, the fluid is resorbed and air extends into the tracheal branches within the muscle fiber. C. Air-intake unit of tracheal system, consisting of trachea, spiracle for controlling intake, reservoir, and the body surface, or plastron, which consists of a water-repellent coat of fine chitinous hairs.

The trachea is a system of tubes which penetrate the body from outside, forming a network, with every part communicating with every other part. The openings to the exterior, called the spiracle or stigmata, is usually made up of two pairs on the thorax and eight pairs on the abdomen. They lead to the main tracheal branches. These communicate laterally with one another and also subdivide to form five capillary tubes leading to the adjacent organs and tissues. The capillary tubes are called tracheoles and consist of intracellular tubes of special branching cells located at the ends of the tracheal tubes. The intercellular tubes lie near the surface or on the surface of cells and tissues to bring in oxygen and send out carbon dioxide. At their terminal ends they are about 0002mm i.e. about $^{1}/_{40}$ the diameter of the human red blood cell. The trachea are line with chitin to prevent their collapse. In the trachioles the chitin are so thin that they allow the diffusion of oxygen and carbon dioxide.

The circulation of air is brought about by the muscular respiratory movements of the body especially the abdomen and the corresponding opening and closing in the tracheal system. Respiratory movements in insects are controlled by respiratory centers in the nerve ganglia within each body segment.

But this style of respiration is limited by the fact that oxygen reaches the tissues by direct diffusion. Diffusion is only effective over short distances, beyond which the rate of diffusion continues to reduce. The surface area-volume ratio is another factor. With creater bulk this ratio is reduced. It is more so when the diffusion through narrow tubes. These are the issues that limit the size of insects. The best tracheal systems can effectively service tissues which are only are quarter inch from the surface. Small size means relatively large external body surface relative to body volume. This in turn, necessitate the waxy cover to guard against desiccation.

3.1.7 Self Assessment Exercise 19.2

Briefly describe the means by which insects respire?

3.1.8 Wings

Insects are typically winged with the exception of the very primitive ones. Some however like the lice, and fleas have secondarily lost their wings. Only adult forms have wings. Wings are a new creation in insects, unlike the wings of birds, where there are transformed limbs. They are usually two pairs but sometimes one may be transformed into a body cover or an organ of equilibrium. Wings are thin folds of skin of the upper sides of the thorax. They are flattened horizontally to allow the limbs to continue to function in their normal ways. This flat folds are covered by the usual chitinous layer of the body surface. Wings consist of two of such layers fused back to back except where tracheal tubes, blood vessels and nerves separate the two membranes. The wing veins are thick walled tracheal tubes which function as a strengthening framework for the wings. The muscles that move the wings extend from the upper to the lower sides of the thorax and from front to back on each side in each wing bearing segment flying is very oxygen consuming. A flying insect can consume as much as a hundred times that of a resting one. You will realize therefore that flying places a lot of stress on the ventilating tracheal system.

3.1.9 Chitin – a Limiting Agent

The chitinous covering of insect body has a great influence on growth. Once it has hardened, the body cannot expand. This hard chitinous coat must be cast off periodically to allow growth increase. After such casting off and growth increase, another chitinous cover must be formed. This process is called moulting. It must take place each time the body volume is increased. It involves the outer cover of the body as well as the lining of the fore-gut and the hind gut, and the tubular lining of the trachea system. Only the trachioles are not involved in moulting when moulting take place, the insect will have to wait till its new wings are formed before it can continue its usual ways of life. This is a dangerous situation for an insect. The body surface is at this time unprotected from desiccation, unable to fly away from enemies and to seek food. This kind of situation is avoided by postponing the formation of wings until all growth has ended. This is probably why only adult forms bear wings and only the young wingless ones grow and moult.

The process by which a change in form occurs in their life cycle is called metamorphosis. In more primitive forms, the larva resembles the adult forms during development. Each successive larval form is called the nymph or instar. This type of development is called incomplete metamorphosis. Examples are the locust and grasshoppers. Metamorphosis is complete when the final larval moult produces the adult tissues, using components from the degenerating larval tissues. Example is the dragon fly. The style of life of the young wingless ones is different from that of the adult. They adapt in many different ways to their different conditions. For example, the grasshopper typically lays its eggs on the ground. The young grasshoppers which emerge from them are air breathing and terrestrial like the adults except that they do not have wings. The eggs of the dragon fly hatch on the ground; and they quickly spring into nearby water and develop into water-breathing aquatic nymphs, much different from their winged adult forms.

The influence of chitin

The chitinous material of the insect exoskeleton has great impact on the life of the animal. It determines their size, and their success as a terrestrial type, it determines their great variety because of its adaptability for various forms and functions. It even determines the life cycle. For example, because their eggs are protected in chitin, they must be fertilized before this casing takes place because the fertilizing spermatozoon cannot penetrate the hardened chitin. So eggs must be fertilized as they are being laid (as in crustaceans) or before as occurs in insects. So there is copulation in insects involving the specialization of the first pair of abdominal appendages for this purpose as in crustaceans, and the specialization of the posterior abdominal appendages as in insects. It has also led to the evolution of complicated mating behaviour, special structures which can be modified for further use, as well as an overall control of reproductive procedures resulting in the formation of insect societies.

3.2 Self Assessment Exercise 19.3

List the ways in which the presence of chitin influence the life of insects.

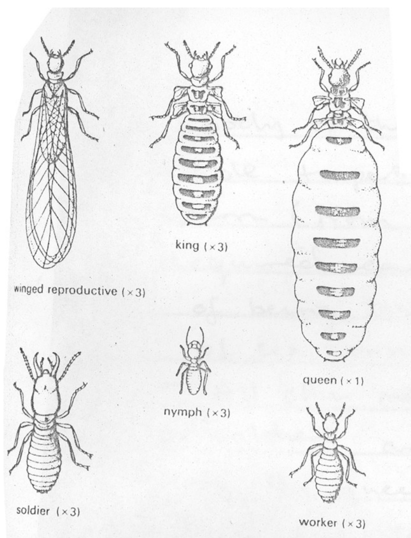
3.2.1 Insect Societies

Ants, termites, bees and wasps are insects that have developed distinctive societies. They are made possible by the fact that insect egg is not only yolky and enclosed in a protective case, but must be fertilized within the body of the female by sperm previously received in copulation with a male. Once she has received the sperm, the female becomes the independent reproductive mechanism. She might chose to behave in one of several ways: lay them in several ways and places and abandon them. She might lay them and remain until the eggs hatch and feed the larvae until they can fend for themselves. When the female and the young remain together for sometime as an interacting family group, an insect society has been initiated. In termite families the female sheds off her wings and specializes in egg production. Other members of the insect community take on other functions for the welfare of the community. An important feature is that the egg laying female member of the family has a relatively prolonged phase of egg-laying and a life span extending beyond those of her progency.

Even though the subject may not have been fully investigated the following facts are evident about the formation of insect societies:

- The males are haploid individuals which develop from unfertilized eggs.
- The body of the egg laying female (the queen) is able to permit or to prohibit the passage of sperm (from her store of spermatozoa acquired earlier) to the eggs in the process of being laid. This is highly refined way of sex control.

- All other members of the society – queen, workers and soldiers are genetically haploid but it is only the queen that becomes sexually mature, others are sterile.
- The nutritional control of development, involving the offering and withholding of royal jelly and its contained growth hormone is the main factor relating to the production of queens and workers in bees.
- In bees, population control is based mainly on combination of egg production (ovigenesis) and egg absorption (ovisorption). The two processes together constitute a primitive means of prolonging the life of the female in adverse conditions. She can only produce fertile eggs when offered the royal jelly by adult workers in the colony. The queen's physiological control of the rate of egg reabsorption gives her control over the population as a whole, without the wastage of living material, she withholds their production. (See Fig. 19.4)



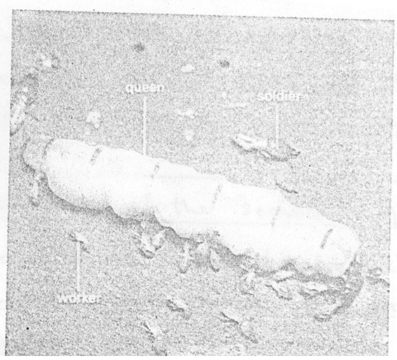
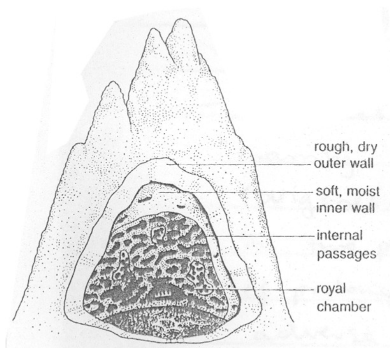


Fig. 19.4 Termite queen being fed by workers in royal chamber.



Termite mound partly opened

3.2.2 Structural Specialization

There are many more insect than all other forms of life put together. Their number is a reflection of their great diversity. The modification of the mouth parts is one of the important features of adaptation which make them a very successful group. In the primitive insect like the cockroach which is said to have survived up to 300 million years with little or no change there are the labrum (upper lip, a pair of mandibles, a hypopharynx connected with the salivary glands, a pair of maxillae, and a labium, or lower lip resulting from the fusion of a second pair of maxillae. In the cockroach the labium and the maxillae are used to manipulate the food which is mixed with saliva by the hypopharynx and chewed with the mandibles. The mandibles are reduced in the moths and butterfly. Instead the pair of maxillae are pressed close together and extended to form the proboscis which is flexible and coiled when not in use. It is the labium and an expanded sponge-like tip that form the proboscis in flies. Mosquitoes also have proboscis for piercing the skin. The labium forms a protective sheath around elongate, needlelike structures formed by the labium, mandibles, maxillae and hypoharynx (Fig. 19.5).

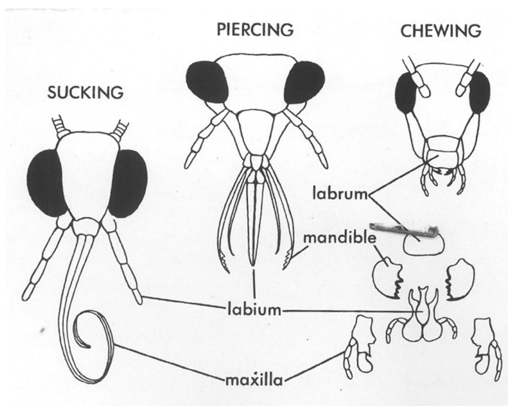


Fig. 19.5 Mouth parts of insects specialized to serve different forms of feeding. Chewing mouth parts are separately displayed at lower right.

4.0 Conclusion

You have learnt that insects are considered a very successful group of animals having more than the same number of all other animal species put together. You have learnt that their success is mainly due to various adaptations including their possession of chitin, their use of a tracheal system for respiration and their diverse structural adaptation of body parts. You have learnt that insects and crustaceans have developed from the basic annelid plan and have made very good success of the task of being basically terrestrial.

5.0 Summary

In the next unit we will continue to study another class of animals in the phylum arthropoda which can be described as having successfully lived on land in way different from insects.

6.0 Tutor Marked Question

What major features account for the success of insects?

7.0 References

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UNIT 20

Arthropoda
Class – Chilopoda and Diplomoda

Table of Contents

1.0 Introduction

In the first part of this unit we shall be studying two classes of the arthropod phylum. These are the chilopoda (centipedes) and Diplopoda (millipedes). They are both terrestrial arthropods. They both have the same general features which you shall see soon. Their main differences are in their feeding habits. One is carnivorous (Chilopoda) while the other is herbivorous (the millipede). In the second, we shall study the class Arachmida like all others in this phylum, the Chilopoda, Diplopoda and the Arachida have several body segments and jointed appendages.

Let us set some objectives to guide the course of this unit.

2.0 Objectives

As you go through this unit, you should be able to:

1) Give the general characteristics of the classes chilopoda and diplopoda.
2) Distinguish between the chilopoda and diplopoda.

3) Give the general features of the arachnids.

3.1 General Characteristics

As you have been told in the introductory part of this unit, the chilopoda and the diplopoda have the same general characteristics. Let us simply name them here. You will remember that the features named here refer to the two classes – Chilopoda and Diplopoda.

- They are mainly terrestrial
- Have clearly defined head.
- Other body segments are all similar.
- Have one pair of antennae
- Have one pair of mouth parts or jaws.
- The eyes may be simple, compound or absent.
- There are numerous identical legs, a pair in each segment in the Chilopoda and two pairs in each segment in the Diplopoda.
- There are no larval forms.
- The gaseous exchange is by the trachea.
- The Chilopodans are mainly carnivorous while the Diplopodans are mainly herbivorous.

Examples are:
Chilopoda – Lulus (Millipede)
Diplopoda – Lithobuis (Centipede).

From the list of general characteristics, you must have noticed two main differences between the two classes.

The first is the fact that while centipedes have one pair of appendages per segment, the millipede has two. However both have several appendages. The second difference is that centipedes are carnivores while millipedes are herbivores.

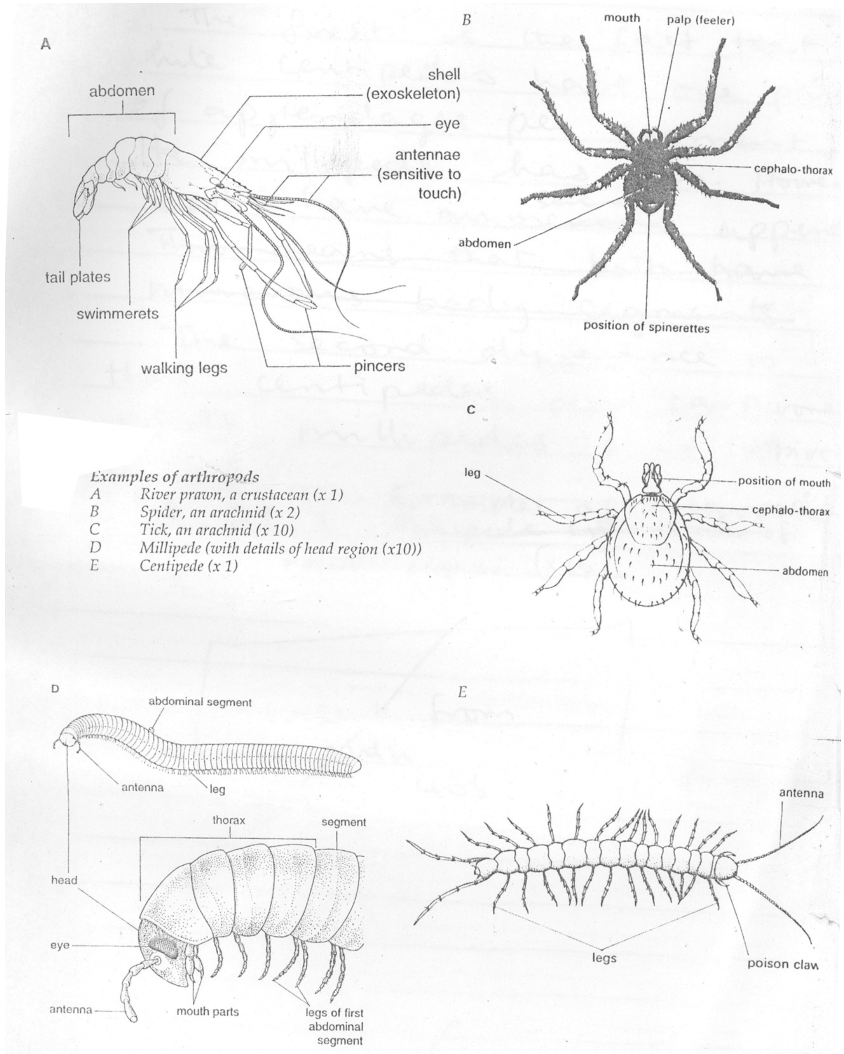

Fig. 20.1 Examples of arthropods

3.1.1 Practice Exercise 20.1

Practice drawing and labeling the millipede (especially the head region) and the centipede.

3.2 Millipede

The body of the millipede is more cylindrical. Millipedes live in the litters of leaves or just under the soil. They feed on dead leaves or dead plant material. They are useful because they help to break down dead plant material to humus.

3.3 Centipede

The bodies of centipedes are flat and usually have between fifteen to twenty segments. This number is fewer than that of the millipede. Centipedes move very fast. They hunt their food. They feed on insects, spiders, and worms which they paralyse with their bite and poisonous claw. Even to humans, their bite is painful.

3.3.1 Self Assessment Exercise 20.1

1. Which of the two, the millipede or the centipede is likely to be more useful to the farmer and why?

2. Draw and label the head end of the millipede.

3.4 The General Characteristics of the Arachnida

The arachnids are terrestrial. They have a cephalo thorax. The thorax is separated from the abdomen by a narrow waist-like constriction. They do not have antennae. They do not have true mouth parts. One pair of appendages is used for capturing the prey (chelicerae or pincers) while the other is used as a sensory palp. They only have simple eyes. There are no compound eyes. There are four pairs of working legs in segments 4-7. You remember insects have three pairs of legs? There are no larval forms gaseous exchange take place by “lungs” books (abdominal respiratory books made of many leaves) or trachea. Mites, ticks and scorpion belong to this group.

In the place of a terminal spine, the scorpion has at the end of its abdomen, a sting – its principal organ of offense.

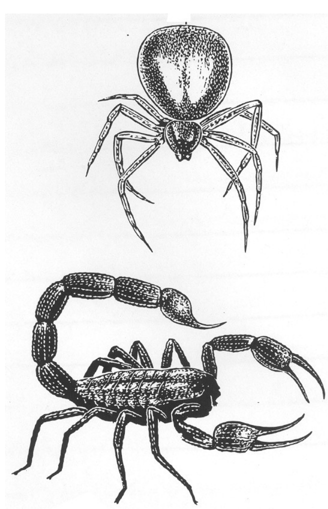

Fig. 20.2 Arachnida: Spider and Scorpion

3.5 Spiders and Scorpions

Spiders are in various ways more specialized than scorpions even though they have much in common. There are a set of eight simple eyes on carapace covering the cephalothorax. It has sharp chelicerae and contain poison gland. The chelicerae are for catching prey. Like in the scorpion, its first pair of working legs are modified as sensory pedipalps for holding and manipulating prey. The remaining four pairs of walking legs have clawed tips. There three pairs of spinnerets on the abdomen which does not show any sign of segmentation. The spinnerets are small appendages at the posterior end of the abdomen specialized for spinning silk. Several kinds of glands produce the silk as liquid which later hardens when it comes in contact with air. Each gland produces its own type of silk used for a particular purpose.

Spiders ingest digestive juice into the prey through the wound inflicted by the chelicerae. This predigest the food. Then with its sucking stomach its sucks up the liquefied food. It respires by lung book like the scorpion and by air tubes. There are usually of lung book and a pair of air tubes.

3.6 Answer the Self Assessment Exercise

If you said that the millipede is more useful to the farmer because of its way of feed, you are right. The millipede lives on decomposing vegetation. They are useful to the farmer because they help break the plant material to humus.

Drawing of the head end of the millipede

- Clear lives
- At least five segments shown
- Each segment with a pairs of jointed appendages.
- The head with jointed antennae, eye and mouth parts.

4.0 Conclusion

In this unit we have studied general characteristics of diplopoda, chilopoda and arachnida. We have learnt to notice the differences between the diplopoda and chilopoda even as they are very close.

5.0 Summary

With this unit we have come to the end of our study of the characteristic features of the arthropods. In the next we shall treat the mollusks.

6.0 References

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MODULE 5

UNIT 21

Phyla Mollusca + Echinodermata

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1.0 Introduction

The phylum mollusca is made up of many diverse group of animals. These include slow moving snails slugs and sedentary bivalves as well as the fast swimming squids. They also occupy a wide range of habitats because of the development of protective shells and gills. The mollusks are believed to have evolved from the basic annelid plan like the arthropods. You will recall that the basic annelid forms are bilateral symmetry metameric segmentation, triploblastic coelomate, definite cuticle, prostonium and segmentally arranged chaetae. From this basic forms arthropods evolved, developing jointed appendages, exoskeleton and reducing their coelom. In this unit you will learn how the mollusks in their different way evolved. You will also learn the general characteristics of echinoderms, a generally sessile group and how they gave rise to motile ones. The following objectives are set to guide you through this unit successfully.

2.0 Objectives

As you go through this unit, you should be able to:

1) Give the general characteristics of mollusks.
2) Distinguish the use of the shell to the mollusk and the chitin to the insect.
3) Describe the jet propulsion in the squid.
4) Give the general characteristics of echinoderms.
5) Describe how sessile echinoderms gave rise to motile ones.

3.1 General Features

The mollucs are unsegmented, triploblastic coelomates. They are usually bilaterally symmetrical. They are usually soft bodied, fleshy and divided into head, ventral muscular foot, and a dorsal visceral hump. The skin of the hump secretes a calcareous shell. The main body cavity is a haemocoel. There are no limbs.

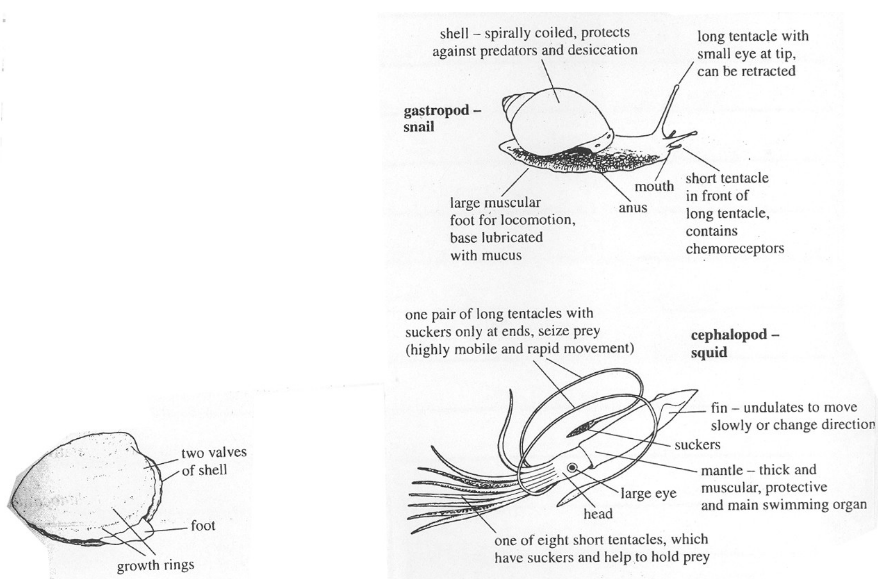

Fig. 21.1 A variety of mollusks.

Mollucs have highly developed digestive tube. They also have a heart and a blood circulatory system. Mollucs are generally sluggish except for the oceanic squids. The body maintaining operations are used to sustain large masses rather than high level of activity. The mollucs are believed to be derived from the basic annelid plan like the arthropods but in a different way.

3.2 Adaptations and Development

3.2.1 The Shell

While arthropods developed jointed appendages, mollucs developed shells for protection. This shell does not limit the mollucs like the chitin of the arthropods do. The body of the mollucs if free to grow continuously. It does not limit the growth of the animal.

The shell is laid down by the outermost layer of the epidermis of the mantle and dorsal surface of the body. They are manufactured in three layers.

The outer thin horny coat, the periostracum which is mainly made of protein and different chemically from chitin. It protects the underlying calcareous shell from being dissolved by carbonic acid.

The middle layer is the prismatic layer made up of calcium carbonate in form of calcite or aragonite crystals. This layer is secreted beneath the thickened edge of the mantle.

The third layer is the pearly or nacreous layer which is laid down by the whole of the outer surface of the mantle in form of thin sheets of calcium carbonate parallel to the surface of the shell. So the shell continues to increase both in thickness and in extent. When the mantle surface forms concentric layers of nacreous material around a foreign body like a parasite or grain of sand, a pearl is formed. You will remember the layers of chitin in exoskeleton of arthropods. Compare them.

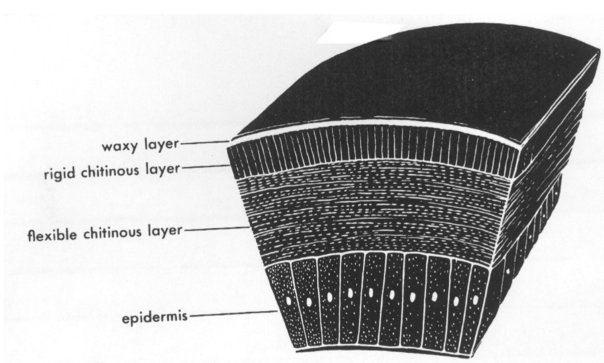

Fig. 21.2 Chitinous exoskeleton of arthropods, consisting of a flexible and a rigid layer of chitin external to the epidermis, with a waxy surface coat.

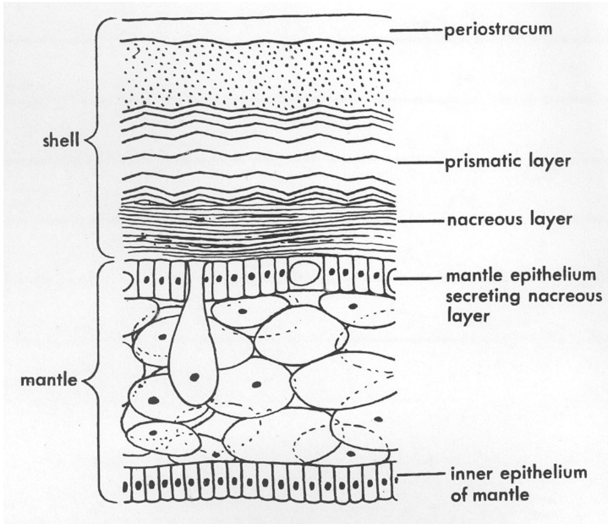

Fig. 21.3 Section through mantle and shell of a mollusk.

The shell is a form of calcium carbonate absorbed through the general body surface, the mantle and the gut. It passes through the mantle tissue mainly as calcium phosphate. It is then deposited as a fibrous organic matrix outside the mantle. Later it is converted into calcium carbonate. Molluscs also concentrate strontium – which could be radioactive – from nuclear – blast fallouts so radio active strontium could also accumulate in molluscan tissues used as food by men and fish.

3.2.2 Self Assessment Exercise 21.1

How are the molluscan shells different from the chitins in insects?

3.2.3 Locomotion and Loss of Segmentation

Molluscs move by peristaltic waves of muscle movement passing through the muscles at the foot. In this arrangement both segmentation and lateral appendages are irrelevant. In addition mollusks need space internally to accommodate the digestive and circulatory system which have been fore-shortened by its shortened and broad body. The internal septa and the body cavity divided by them have disappeared. A haemocoel like that found in the arthropod has taken its place. Within the haemocoel the digestive tube has become long, coiled bulky and more localized. The heart is relatively large. There are also within the haemocoel the excretory and reproductive organs. The body wall is not segmented externally

3.4 Digestive System

The alimentary canal is wiled at the hinder end. It occupies most of the haemocoel and is at points expanded and is at points expanded to form digestive glands and stomach. There is also a mouth equipped with the radula which is believed to have originated from the muscular producible anterior end of annelid worms. The radula consist of a ribbon of chitinous teeth arranged in transverse and longitudinal rows. As the animal crawls slowly along, the radula is protruded rhythmically, it rotates as well in the process scraping off any soft tissue on its path. The finely ground particles of food is passed back through the narrow gut to the stomach. Here the food particles are sorted out. The finer particles are sent into the digestive glands while the larger ones are passed on to the intestines. The finer ones are absorbed into the branched walls of the intestine where digestion takes place in tracellularly. The food particles are sorted out by the beating of the cilia by lubricants secreted from the front end of the digestive tube. The larger food particles unused in absorption are whirled up in the mucous secretion and ciliary actions along the intestines to the anus. The absorptive part proper is the digestive gland, with its enormous branching ends into the haemocoel. By this device, the necessary large surface required for digestion and absorption continues to grow as the animal increases in size.

3.5 Circulatory, Respiratory and Excretory Systems

There is an heart with openings which receives blood from the haemocoel on either side through a pair of lateral ostia. As the heart contracts, valves close the ostia, and blood is forced through arteries forward and backwards in the body.

Oxygen is obtained and carbon dioxide removed as blood passes through the gills which extend from both sides of the body within the mantle cavity of the body. The gills are protected by the mantle fold and suspended in flowing water. The gill is some feather-like extensions of the gall body wall, richly supplied with five blood vessels. The large surface area provided by the gills provide gaseous exchange between blood and water. The blood contain copper-base hemocyanin, as the oxygen carrying pigment. Some aquatic snails contain the pigment haemoglobin though.

The excretory material in the mollusk is removed by a single pair of excretory organ now that the segmentation has been removed. This organ filters fluid from the membranous sac, the pericardium which surrounds the heart and process the fluid as it passes to the exterior.

3.6 The Nervous System

The molluscan nervous system consists of a ring nerves surround the mouth. From this ring a long pair of nerves supply the muscles of the foot, the mantle, digestive tube, and other body structure. In the squid, the ring of nerves has become a genuine brain; compact, complex and the largest relative to the size of the body among invertebrates. The nerve centres are concentrated in the head region. Some are enlarged in keeping with the high development of motor and sensory activity of the whole body. The pair of optic lobes have become so enlarged in comparison to the enormous squid eyes. There is also a large central lobe for coordinating the activities of the whole brain and for storage of information in form of memory. The squid has a strikingly developed eyes with transparent lens, corner, a pigmented ivis diaphragm, a darkened eye chamber, a many-layered light sensitive retina and supportive tissues. There are also well developed organs of balance, touch and taste. This indicates that a more increase in bulk require a considerable elaboration of the basic distributive system for proper maintenance of the internal tissues even if the animal is inactive when it is active like the squid, the demands are more.

There are a variety of mollucs, showing modification of the generalized plan to fit the possibilities that the environmental circumstances offer. So some browse and crawl like the snail, feeding on vegetation or anything they come across; others are sedentary filter-feeder like the clam or oyster which feed on particles suspended in water; whilst others like the fast swimming squid feed on fish and crustaceans.

3.7 Classification

There are three classes of mollucs.

3.7.1 The Gastropod

Has a genuine head equipped with brain or cerebral ganglia, a pair of eyes, organs for balance (statocysts) and tentacles on top and in front of the radula bearing mouth. The respiratory system is enlarged and simplified with only one or two gills in a spacious enclosed mantle cavity. Water is drawn into this mantle through a funnel-like fold of the mantle itself. In gastropods the large digestive gland and adjacent tissue grow in a spiral manner causing the hind end openings to be brought forward. They can be herbivores or carnivores. You have already seen how the herbivore feed in section 3.0. Carnivores however secrete extracellular digestive enzymes directly into the cavity of digestive tube itself. By peristaltic pumping action of the tube, food is swallowed and passed along. Some gastropod have lost their shell to become flexible slugs. They are primarily marine even though some fresh water ones which have retained their gills exist.

3.7.2 Bivalves

They are second group of mollucs. The shells are divided into left and right halves joined by a ligamentous hinge on the dorsal side of the animal. This two part shell only appears to be two. The hinge causing the two shell appearance is an uncalcified part of a whole. So the shell is in reality only one. The two haves have enlarged to enclose the whole animal. They are pulled together by strong adductor muscles inserted in the inner surface of the shell. When completely covered by the shell the bivalves are protected against most preys except starfish, carnivorous whells and snails which drill through their shells with their radula. Bivalves more about very little. They derive oxygen and food particles from water. They body is compressed from side to side to allow the left and right shells to meet each other on the ventral side when closed so also the underlying mantle which secretes the shell by which it is protected. The foot here has no broad base. It is compressed also into a slender foot almost always inside the mantle cavity to be occasionally used to raise the animal from one point to the other within the sand or mud in which it is often buried. Bivalves have no signs of head structures or radula.

Gills have cilia on their surfaces in the large mantle cavity. Gills in bivalves are extensive. They cover the median foot water enters and leaves the mantle through two holes (one for entry and one for leaving) on the line where the two mantle sides join.

The water circulates through following definite path carrying food particles which are also sorted by size by elaborate ciliary actions. They feed on large quantities of dilations, bacteria and detritus. Unlike the mucons-spinning style of gastropods, bivalves have evolved the crystalline style which is a proteinaceous starch-splitting enzyme in crystalline form. Food is absorbed intracellulary in microscopic particulate form. Bivalves main adaptations concern anchorage, safety and a steady supply of clear food containing water.

3.7.3 Self Assessment Exercise 21.2

Differentiate between the digestions in gastropods and bivalves.

3.7.4 Cephalopods

They are the fast-swimming mollucs. The squid captures its prey, fish in full motion and also avoids being eaten at the same time by moving with maximum speed, through water. To do this, the squid need power and least resistance to water. It also needs coordination and sensitivity to control direction when speeding. The squid has a streatined body and a well developed head with sense organs, large brain and ten prehensible tentacles.

It also has a powerful hydraulic jet propulsion locomotor system and fins. It also has an internal distributive system to meet these new demands.

Firstly, the squids had to decalcify and become light for their type of living. This completely decalcified and light. However to be driven in water at high speed there is need for some stiffening. The squid needs its shell like the fish needs its backbone. The shell in the squid is straight and entirely enclose within the body. The squid is streamlined like a dart or javelin. It is primarily designed to speed backwards. It is long, narrow and tapering. It has a pair of fins which serve as stabilizers for both backwards and forward swimming. You will need to know that the squid performs a striking jet propulsion motion using its typical respiratory apparatus. This is accomplished by taking in water in the usual manner for respiratory but gently as not to cause the animal to more forward. When the mantle wall contracts, the incurrent opening closes at one under pressure from within and is held tight. The enclosed water can escape only through the narrow siphon (which normally points forward. The muscle contract so strongly that the water leaving the siphon emerges as a powerful jet stream that causes the body to shoot rapidly backwards if the siphon is turned downwards and backwards, the jet steam can be used to drive the animal forwards. Try to imagine that the squid can be upto ten feet long and its tentacles thirty feet. For this size to be jet propelled, you want estimate the amount of energy and consume a lot of oxygen than all other mollucs. Oxygenated blood has to be pumped rapidly and the body through the three hearts (the systematic, median and dorsal) in the squid. The oxygenated blood from the lings is pumped by the systemic heart mainly forward to the mantle and the head under a pressure ten times more than that of other mullucs (snail and clams). The squids blood is rich with oxygen-carrying pigment – haemocyanmin. The two other hearts below the gills, one on either side of the body, serve to elevate the blood pressure to its maximum value, causing the blood to be driven rapidly through the many blood vessels in the gills. It returns from the gills to be systemic heart where the expansion of the animals such blood into the central chamber.

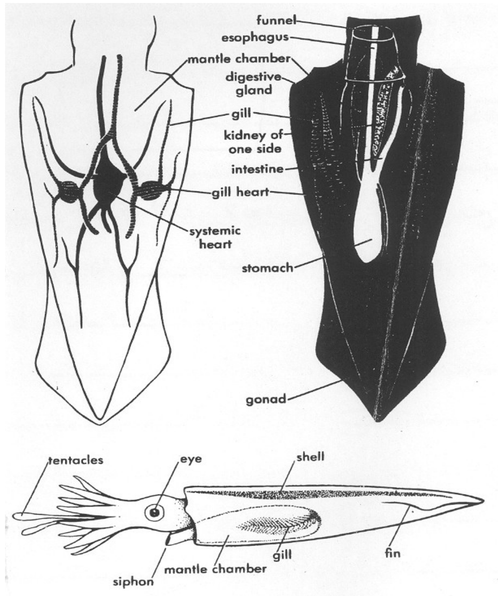

Fig. 21.4 Internal anatomy of squid showing digestive system and circulatory system. Side view diagram below shows location of mantle chamber, etc., and of axial supporting shell in relation to the body as a whole.

3.7.5 Self Assessment Exercise 21.3

Describe the jet propulsion in the squid.

3.8 General Features of Echinoderms

Echinoderms are generally triploblastic, coelomates. They are all marine types. The adults are pentamerously (i.e. show five-way) radially symmetrical. Their organ of locomotion are the tube feet. They also have calcareous endoskeleton. They have no head. The mouth is generally on the lower (oral) surface of the body while the anus is on the upper (aboral) surface of the body.

There are two classes of echinoderms, the stelleroidisa (starfish) and the echinodermata (sea urchins). The starfishes are star-shaped and flat. The arms of the star are not sharply separated from the disc. They have few calcareous plates in their body wall. Their spines are movable. The echinoderm on the other hand are of globular in shape. They do not possess arms. The numerous calcareous plates in the body wall are attached to each other to form a rigid movable structure. Fig. 21.5 shows examples of echinoderms.

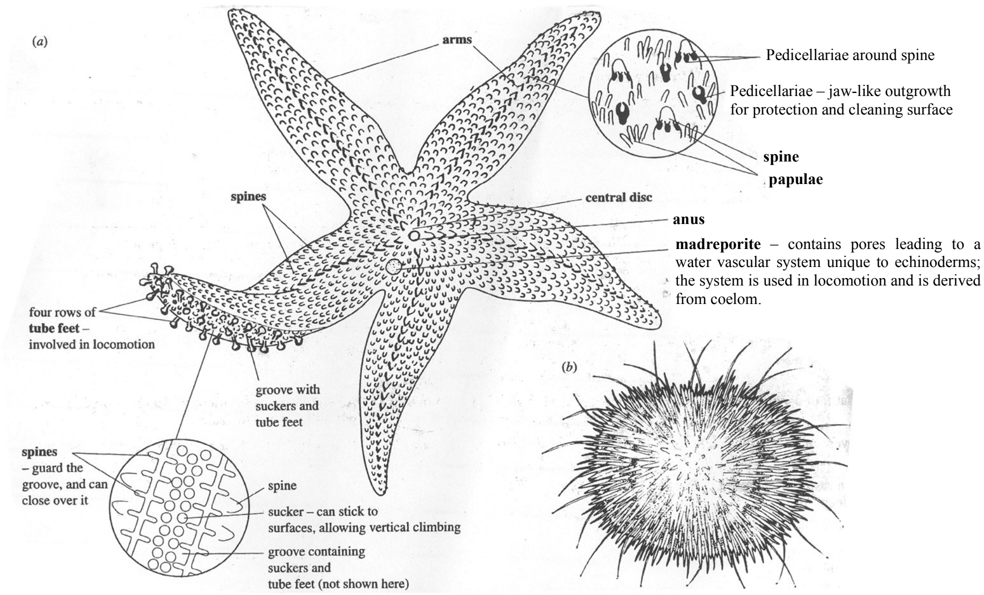

Fig. 21.5 (a) Asterias, the common starfish. One arm is turned to show the lower side. Circles contain magnified views. The mouth is in the centre of the lower surface, known as the oral surface. The top side is known as the aboral surface. (b) Echinocardium – sea urchin.

3.9 Adaptations

In the preceding units, you have seen how animals evolved from the basic annelid design to the very active anthropod forms. In other phyla, it would seem that mobility evolved from sessile echinoderms.

Symmetries

Bilateral symmetry is a characteristics of mobile animals. Correlated to this is the directed locomotion of the two sides of the body. This is also related with a mouth for food intake as well as a head with sensory organs located at their advancing end. On the other hand you will understand that those sessile animals or those that drift without direction are more effective on a radial symmetry plan. The echinoderm structure as exemplified has a three part plan which represents a biological device that functions as follows: there is a stalk (a root-like basal process) which anchors the organism to its substratum and elevates the rest of the body above the turbid bottom water. The second part is the five pairs of puriate tentacles radiate outward and upward around the mouth and serve to gather food particles and pas them to the mouth. The body (calyx) process the food and coordinate the activity of the tentacles. The tentacles are operated by both the neuromuscular system and the water vascular system which help manipulate food particles.

All echinoderms whether sessile or free exhibit this same fundamental pattern.

3.10 Conversion to Mobility

All free living echinoderms exhibit the radial symmetry and have the unique water vascular system. Using the starfish as an example let us see how this conversion to mobility was achieved.

The starfish has its mouth and the ambulacral side of its arms face down. The increased mobility is a response to the availability of food. Viewed from above, the five arms of the starfish radiate. The body and the arms are fairly rigid because of the calcareous plates embedded in the tissue of the calcareous wall. The mouth is in the centre of the undersurface. The anbulacral groves (i.e. the grove that passes from the tip of each pinnule down to its base on each side of the grove of the pinnule are the ginger-like projections called the podia) extend along the underside of each arm from mouth to hip. The podia in the starfish is called the tube feet. The tube feet extends in series along the ambulacral grove. The conversion mobility has to do with the change in the use of the podia and water-vascular system, operating in connection with the ambulacral groves to serve as locomotory mechanism instead of a feeding mechanism. The water-vascular system becomes a hydraulic power system. Water is drawn into the system by ciliary action through minute surface. This sieve plate on the upper surface. This passes down a tube (the store canal). This tube is stiffened by calcareous rings to the ring canal surrounding the mouth. From the ring canal, five radial canals lead off, one into each arm and each radial canal gives off a series of lateral branches to the tube feet of each side. Each tube foot has a sucker at its outer, free end and a closed sac, the ampulla at its innermost end. When the ampulla contracts, a valve prevents the water inside from flwoing back into the radial canal. The pressure that results forces the elastic tube foot to extend. This then attaches its sucker to the substrate outside. The longitudinal muscle of the tube foot then contracts, so that the tube shortens and the starfish is pulled forward. When the many tube feet operate in this way the animal glides along.

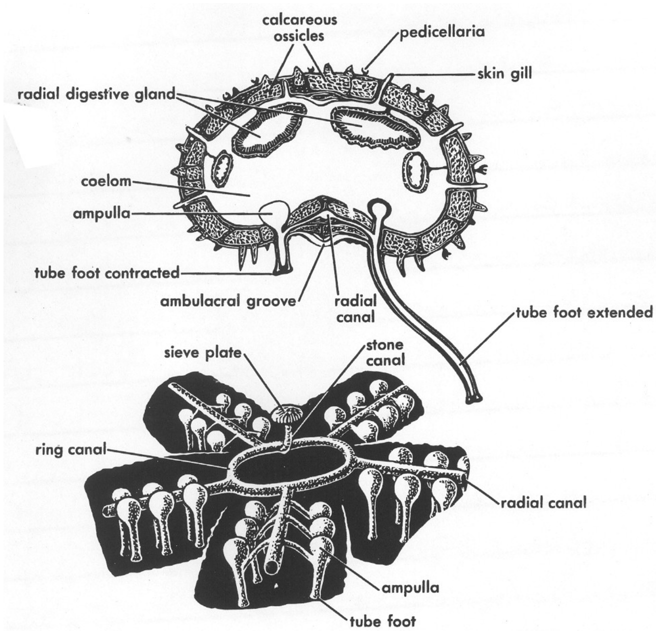

Fig. 21.6 Water-vascular system of starfish. Top: Cross section of arm showing radial canal with lateral branches to ampullae and tube feet; and also showing the coelom, skin gills extending through body wall from the coelom, etc. Bottom: Central part of system showing intake and distributive canals.

The water vascular locomotive mechanism is dependent on a continuous supply of water drawn through the sieve plate and forced under pressure into the ampullae of the tube feet. The whole operation is coordinated by a nervous system consisting of a ring of nerve tissue around the mouth, from which a radial nerve passes out into each arm with branches to the series of tube feet.

Feeding is also accomplished in a new way. The food is no more microscopic. The stomach lining is now everted over large prey to ingest them. By moving over a bivalve and attaching the tube feet of at least two arms to each shell, the extensor muscles of the body and arms are able to exert a prolonged pull over the two shells of as much as twelve pounds. The bivalve's muscle soon tires, the shell opens and the starfish has it meat.

So let us summarize like this:
The shift from sedentary to muscle is achieved in the following simple steps:

- The change in the position of the mouth from top to underneath the animal
- The change in the use of a feeding nerve – coordinated water vascular mechanism for locomotion.
- The change in the size of food all constitute a new way of life that made sedentary forms motile.

3.11 Answer to Self Assessment Exercises

Exercise 21.1

If the answers to your self assessment exercises are like the ones below, you are correct.

Molluscan shells are different from insect chitin in the following ways:

1. Chitins are made of lignin. Chemically chitin is a complex organic substance – a nitrogen – containing polysaccharide usually combined with protein. It is usually impregnated with mineral salts especially calcium carbonate. The molluscan shell is on the other hand laid by the mantle epidermis and edge in layers. The outer horny coat, the periostracum is mainly protein and chemically different from chitin. This overlays the calcareous shell made of calcium carbonate (in form of calcite or aragonite crystals). The third layer (inner most) is the pearly or ncreaous layer; is made also of calcium carbonate. Compare Fig. 21.2 and Fig. 21.3. Shells do not limit growth of mollucs. They grow as the animal grow. However the chitins of insects prevent growth chitins are also found lining the air trachea system and the end of the food and excretory canals. This is not so for shells.

Exercise 21.2

Table 21.1: Differences between Gastropods and Bivalves

Gastropods	Bivalves
Mainly herbivores using radula to browse on sea-weeds and cabbages	Food particles are sorted by size by ciliary action
The carnivores among them use their radula to drill through the shell of other mullucs	Feed on diatoms, dinoflagelates, bacteria and detritus
Carnivores secrete enzymes extracellularly into the digestive tube and swallow by peristaltic action of the muscular tube	Food absorption is intracellular
Herbivores sort their food by size by ciliary action aided by mucus	Amoeboid cells wander into gill surfaces to engulf food particles and take them to the digestive tube for digestion
Smaller ones are passed into digestive gland	
Digestion is intracellular	
Unused large particles are wound up with mucus and pass down out through the anus.	

Exercise 21.3

Jet propulsion in squids

- Water fill the mantle cavity – water flows in through the large shitlike opening.
- Mantle wall contracts – incurrent opening closes at once under pressure from within and is held tight. This enclosed water can only escape through the narrow siphon which usually points forward. The muscles of the mantle contract so strongly that water emerges in a very powerful jet stream which causes the body to shoot rapidly back, covering distances many times their size.

4.0 Conclusion

You have seen that mollucs, even though invertebrate have their peculiar developments. They have remained soft bodied to make development advances over the annelid basic structure. They have developed protective shells and gills or lungs for gaseous exchange. So they have been able to colonise both aquatic and terrestrial environments. However because a shell can be a handicap for locomotion more active mollucs slow a reduction or loss of shell.

5.0 Summary

In the last units you saw a pattern in the development of invertebrates. Unicellular organisms were followed by mutlcellular ones, more complex in structure and with increased bulk. In the present unit we have seen that increased bulk is an issue to reckon with whether or not the organism lives an active life. To maintain the life sustaining systems of a bulky organism, certain structures must be put in place. You must be asking what next. The mollucs do not seem to say much more than greater efficiency in servicing larger bulks.

6.0 References

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UNIT 22

Phylum – Chordata
Sub Phylum – Vertebrata, Protochordata & Fishes

Table of Contents

1.0 Introduction

The main distinguishing features of the chordates is the possession of a dorsal longitudinal running rod, the notochord. This lies between the dorsal nerve tube and the gut. The notochord is a flexible rod of tightly packed, vacuolated cells held together with a firm sheath.

It increases the internal support and locomotory power of the animal. It is suspected that the notochord evolved originally in the swimming larval forms of their chordate ancestors. The notochord is still found in the non-vertebrate chordates. However most chordate now have it replaced with the bony vertebral column or back bone during their embryonic development. Animals with a vertebral column are called vertebrates, those without are non-vertebrates. In the next few units we will be studying the vertebrates. In the next few units we will be studying the vertebrates. In the earlier part of this unit we will study the general features of chordates.

We will also study the general characteristics of vertebrates. You will learn to know that chordates that have a backbone or vertebral column as their axial supporting skeleton.

In order to help you succeed in going through this unit, let us set the following objectives:

2.0 Objectives

As you go through this unit, you should be able to:

1. Give the general characteristics of chordates
2. Describe the possible evolutionary link between protochordates and chordates.
3. Give the general characteristics of vertebrates.
4. Give the factors considered in classifying vertebrates.
5. Trace the evolutionary development in vertebrates.
6. Describe the basic chordate body plan
7. Distinguish bony and cartilaginous fish.
8. Analyze the general adaptation of fishes to life in water.

3.1 Classification and General Characteristics of Chordates

The characteristic features of the chordates are as follows:

- The notochord is present at some stage in the life history of chordate
- They are triploblastic coelomates
- Bilaterally symmetrical
- There are visceral (pharyngeal) clefts present.
- The dorsal hollow nerve chord is also present
- There are segmental muscle blocks (myotomes) on either side of the body
- There is a post anal tail
- Limbs are formed from more than one body segment.

3.2 Protochordata

The majority of chordate are vertebrates. The other subphylum of chordates that are not vertebrates are protochordates, which have some invertebrates features as well as the vertebrate features. This suggests that they are an evolutionary link between invertebrates and vertebrates. Amphioxus and the trinicates are said to be the only animals related with the vertebrates who lack the vertebral column. Amphioxus has a notochord, segmented musculature, and a dorsal nerve cord. It does not have a brain and sense organs. They live submerged in sand or mud. They do not have true jaws. They have suckerlike mouth. They take in water from the body surface and are able to move about.

The group of chordates that possess the vertebral column belong to the sub-phylum vertebratel are as follows:

3.3 General Characteristics of Vertebrates

- The notochord is replaced in the adult by a vertebral column.
- There is a well developed central nervous system including brain
- The skeleton is internal
- The pharyngeal clefts are few in number
- There are two pairs of fins or limbs.

3.3.1 Self Assessment Exercise 22.1

Why are the protochordata described as the evolutionary link between the vertebrates and invertebrate?

3.4 Factors of Classification of Vertebrates

The vertebrates are grouped into five classes:
Chondricnthyes
Osteichthyes
Amphibia
Reptilia
Aves
Mammalia

The factors of their classification are as follows:

- Whether the skin has scales and the type of scales
- The type of skeleton – whether cartilaginous or bony
- The type of limbs they posses and whether tails are symmetrical or assymetrical

- Whether or not the visceral clefts develop gills or not.
- Whether or not there are external ears.
- Whether or not eggs are produced
- Whether or not they are internally fertilized
- Whether animals are warm or cold blooded.

3.5 Evolutionary Developments in Vertebrates

In terms of individual size and power, vertebrates have become dominant or earth. They have adapted to land, sea, air and have evolved in very diverse ways. In the following sectors of this unit, we will make a general survey of the kingdom, and an analysis of adaptations of the fish as the fast swimming vertebrates as well as their progressive transformation as successful colonizers of the land, culminating in the birds and mammals, both which have become very remarkably independent of their environmental circumstances.

Apart from insects, vertebrates are the dominant creatures on earth. They include the primitive jawless fishes, the true fishes, the amphibians, the reptiles, the birds and the mammals.

In the phylum chordate also include two groups of animals that are not vertebrates. These are two marine groups the tunicates and the lancelets.

We can see a kind of progression in development from the primitive vertebrate structure – the fish, through amphibians and reptiles to the more advanced ones the birds and mammals. Even though any fish is compared to the amphibian, for example, because the amphibians represent a stage more adapted to life on land than the fish, the fish is some what specialized anyway. Similarly the reptile is more adapted to life on land than the amphibian and so on till we meet the mammals. So we will now, as we study the various group of chordates see how they have developed from the basic chordate body plan.

3.5.1 Self Assessment Exercise 22.2

What are the features by which vertebrates are classified into six different classes?

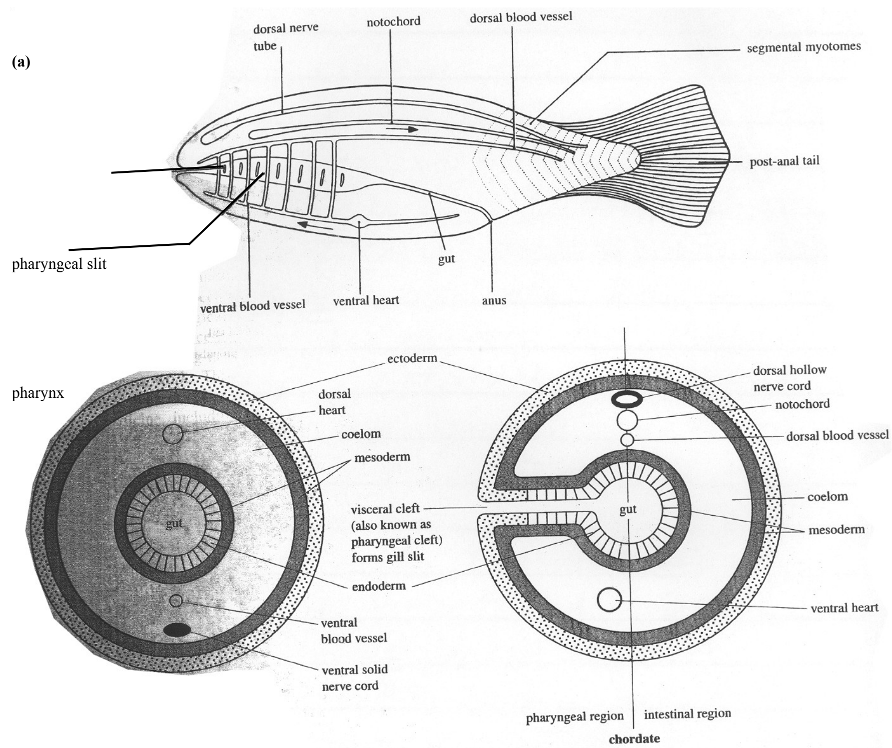


Fig. 22.1 (a) Diagram showing basic chordate body plan.
(b) Transverse sections of a non-chordate coelomate and a chordate for comparison.

3.6 The Basic Chordate Body Plan

This body plan comprises of the notochord, above which is the tubular nerve cord. There are pared gills slits which open from the throat to the exterior of the body. There is a heart located on the more ventral part of the body. It is only in the vertebrates that a series of bony or cartilaginous vertebrae develop round the notochord. These strengthen the notochord but retains its flexibility. Also associated with these are a series of blocks of muscle tissue on either side of the body used in swimming. This reflects segmentation which is also evident in the arrangement of vertebrae, spinal nerves and arteries, and even some excretory organs.

The gills were seen as primarily apertures by which excess water let in through the mouth of the feeding or swimming animal are passed out. The involvement of gills with respiration seems a secondary development.

In aquatic vertebrates locomotion is effected by muscle contraction initiated in the muscle segments beginning from the head, and transmitted as a wave passing through the rest of the body. In primitive jawless fish only single longitudinal dorsal and ventral fin serve as stabilizer in forward movements. In the true fishes there are two sets of pairs fins, each pair attached to an internal supporting skeletal girdle. These serve as additional stabilizers and control. Complete movable jaws are also present in the true fishes.

So in general we can say that vertebrates have an extremely remote marine ancestry and have become highly structured swimmers, progressively left water for life on land and so developed outstanding ability to manage changing environmental conditions.

We will now study the classes chondrichthyes and osteichthyes.

3.7 General Characteristics

Class – Chondricthyes (cartilaginous fishes)

These are the cartilaginous fishes. They have skins with tooth-like (placoid) scales. There skeletons are made of cartilage. They have paired pelvic and pectoral fins. They have no air bladder. Asymmetric tail fin helps to prevent animal from sinking. Five pairs of visceral clefts exist as separate gill openings. There are no external ears. Eggs are produced and fertilization is internal. They are cold blooded. Examples are the dog-fish, shark, skates and rays.

3.8 Class – Osteichthyes

These are the bony fishes. Their skins are covered with thin, round by scales. These scales are described as cycloid. Their skeleton is made of bones, unlike the cartilaginous fishes. The paired pectoral and pelvic fin are here supported by bony rays. This makes it easier to maneuver. Unlike in the cartilaginous fish, the fish tail of the bony fishes are symmetrical. The four visceral clefts are present as four separate gill openings on either side of the head. They are however covered by a bony flap called the operculum. There are no external ears. You notice the cartilaginous fishes do not have external ears too. Unlike in the cartilaginous fishes, the eggs produced by bony fishes are fertilized externally. They are also cold-blooded. The common Tilapia and the African mud fish are bony fishes.

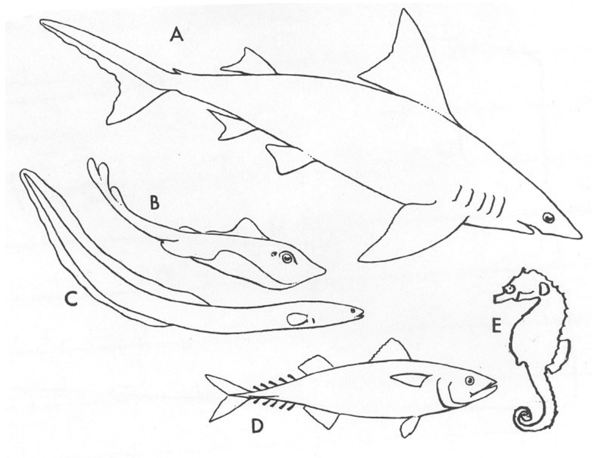


Fig. 22.2 Forms of fish (not to same scale): A. shark; B. ray or skate; C. eel; D. mackerel; E. sea horse. The shark and ray are cartilaginous fishes (elasmobranches); the others are bony fishes (teleosts).

Practice Exercise 24.1

The general characteristics of the two classes of fishes you have just read are important. You can go back to sections 3.7 and 3.8 and read them again. Then practice listing these features in tabular form for the two groups side by side so that you can see their similarities and differences.

3.9 Adaptations of Fish

Fishes are typically streamlined and have somewhat rounded head end. The streamline body is designed for moving through the dense water medium with minimum friction and turbulence. The head contains most of the sensory and feeding structures. The rest of the body contains the locomotive muscles that propel the fish through water. Lateral and vertical fins act as stabilizers. Because they are predators (carnivores) they have jaws.

The body of the fish is comparatively large, compact and energetic. These three features demand an efficient maintenance organization. The upper body is typically segmented while the lower part is not segmented and encloses a large body cavity which is a true coelom. The segmented muscle organization gives a locomotive advantage as well as room for growth and elaborate digestive system. By this arrangement, fishes have room to expand to meet the demands of a compact, active and bulky body. The capacity of this body to move through water at high speed cal for direction and action directing nervous system.

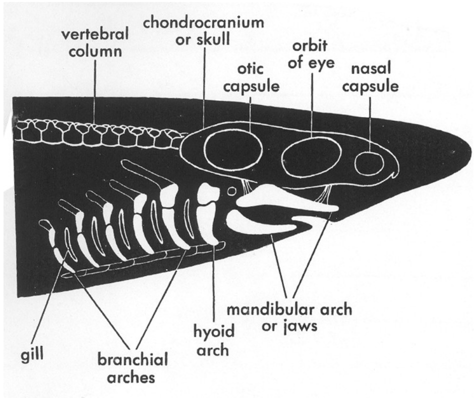


Fig. 23.3 Head of shark showing skull and vertebral column, and series of mandibular, hyoid, and branchial skeletal arches.

The sharks are the earliest group of cartilaginous fishes.

3.10 Evolution of the Vertebrate Jaws

The placoderms are the earliest true fishes with true jaws. The jaws consisted of an enlarged pair of hinged gill supports with two skeletal bars on each side of the throat, hinged together on the side at the junction of the two bars. It is also hinged below with the lower bar of the opposite side. Each bard is titled forward and enlarged. This tilt causes the formation of an angle for the jaws. The lower junction now becomes the front end where the lower jaws meet. The upper bar becomes the upper jaw on each side and are attached to the skull by muscles that operate them. This development into jaws of a gill supporting skeletal system is seen in the development of all embryos of all vertebrates – from fish to man (except in the jawless cyclostomes).

3.11 The Maintenance Systems

Food Intake

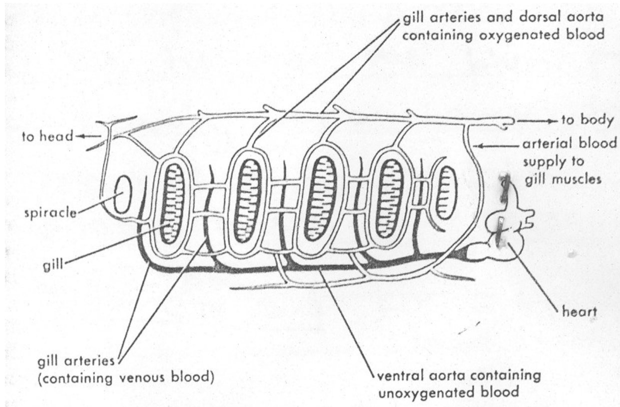
The food and water is taken in through the large mouth of the fish and is swallowed. On reaching the throat water escapes through the series of gill slits. The walls of the slits are much folded to form enormous respiratory surfaces. The slits in bony fishes are fewer 9four in number) while in the cartilaginous fishes they could be up to seven. Fish have gill rakers which form rigid cross grid for preventing food particles from escaping with water. As it moves through water with its mouth open, it automatically drive water through the gill slits by muscular action of the throat wall of each side, which alternately expands and contracts the throat. In cartilaginous fishes each gill slit opens independently to the exterior, whereas in bony fishes the operculum covers the gill openings on each side, forming a gill chamber.

The jaws serve to open and close the mouth; to seize and hold food, the jaws resemble the gill arch except that the jaws are bigger and have attachment to the base of the skull. The upper and lower jaws are known as the first (mandibular) and the second (hyoid) arch respectively.

The Digestive System consists of the moult with its jaws, teeth, tongue and oesophagues, a large stomach designed to accommodate a large quickly ingested meal in which enzymes secreted by the infolding walls break down protein physically and chemically. The narrow long small intestine leading from the small intestine and separate from it by a ring of muscle is also part of the alimentary canal. The ring of muscle serve as sphincter under nervous control. Here the chemical breakdown of all classes of food is completed. Their absorption also is done here through the epithelial lining. Finally in the large intestine, the food residues are stored until they are eliminated. The small intestine is considerably coiled and has a narrow passage and a greatly folded inner lining. And is responsible for most of the digestive and absorptive processes. Most of the digestive enzymes come from the pancrease. Bile is also supplied by the liver. The digestive system is therefore adapted to manage food enough to sustain the activities and tissues of a swimming vertebrate.

Circulatory System

The vertebrate blood is rich in concentration of haemoglobin. Oxygen and nutrients are absorbed from the small intestine are distributed round the body by a well-developed circulatory system. The fish's circulatory system is made up of heart, blood and blood vessels. The heart is located at the mid ventral region of the body. You will remember that in the crustaceans the heart is in the mid dorsal region. The fish heart is two-chambered, fore and aft pump which draws blood from behind and propels it forward. The posterior chamber is called the atrium (auncle) and the anterior chamber (the ventricle). The venus sinosus receives venons blood and pumps it forward to gills by the ventral aorta. The major arteries pass from the ventral aorta to the gills on each side and are numbered according to the gill arch they supply. The blood pressure drops by nearly one third as it passes through the gills where respiratory exchanges occur. The arteries from either side join at the mid dorsal vessel – the dorsal aorta that runs the whole length of the animal beneath the vertebral column. It divides to carry blood to the head and backwards to all the other organs. After passing through the capillary of the tissues the blood pressure drops to nearly zero. Large view from the front end of the fish carry blood back to the heart.



Gill respiratory blood circulation of cartilaginous fish.

Excretion

The kidneys are the excretory organs. They lie in the upper part of the body cavity attached one on either side of the dorsal aorta. Arterial blood from the dorsal aorta enter it under fairly high pressure. A percentage of the blood nutrients are filtered at the glomerulus. The blood leaves the kidney by the renal vein and from there to the heart. The liquid filtered collect in long five kidney tubules which eventually unite to form the excretory or nephric duct of each kidney. Reabsorbtion takes place as the substances pass through the tubules and stored in the blood system.

The excretory ducts run along the upper part of the body cavity and come to the open rear the arms at the cloaca. The body cell and tissues are of a greater concentration than the fresh water in the environment. This means there will be continual water intake which the kidney must remove from the body. Because the filter pumps of kidney tubules are not selective, they also reabsorb certain substances as the filtrates pass down the tubes.

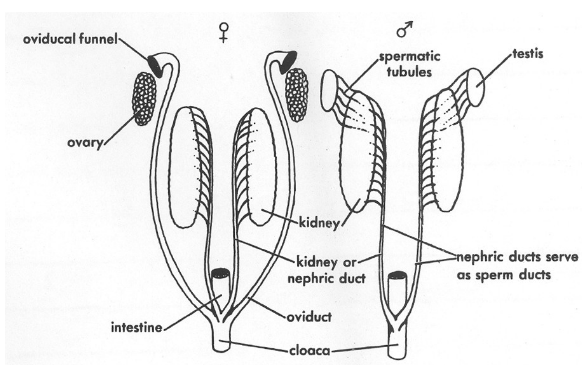


Fig. 22.4 Excretory and reproductive systems of cartilaginous fishes and amphibians; left, female, right, male. In the male, sperm pass from testis to kidney through fine tubules, and thence to the cloaca and the exterior by way of the kidney, or nephric, duct. In the female, ripe ova liberated from the ovary must reach the wide oviducal funnel of the oviduct and pass to the cloaca without utilizing kidney structures.

Locomotion

For the fish to move rapidly through a highly resistant medium like water, it must have the essential features of shape, leverage, stabilizing fins and automatic regulators. You will now take note of the adaptations of the fist to locomotion in water.

1. The streamlined body-tapering at both ends, move to the tail then at the head. This gives the least resistance to water and so lesser energy is expended in trying to pas through water.

2. It presses down against the resisting water with its tail fin. This creates a leverage which propels the animal forward.

3. The tail also moves from side to side, thus causing the body to move under the pressure of water that the tail is always in a slant up position relative to the body axis. As the blade pushes the water away in any direction, the reward is a forward movement.

4. The effectiveness of this forward movement depends on the size, relative size of the tail fins, the slant of the blade and the speed at which it is moved.

5. Much of the forward thrust of the fist comes form the side to side movements caused by the muscles rather than that of the tail fin.

6. The muscles run parallel to the side of the body, from the head to the tail. When those on one side contrast, the others on the opposite side relax, causing the body to bend towards the side of the contracting muscles.

7. Muscle contraction is controlled by the segmented nervous system along the long nerve fibres that run the length of the body from the head to the tail.

8. In each segment a cross section of the spinal cord shows a pair of ventral or motor nerves and a pair of dorsal sensory ones.

Each segment therefore has its own spinal nerve control so that the stimulus arising from either the skin or the muscle can produce a response from the same segment. There is also the nervous communication up down the animal in successive segments supplied by the cord.

The fish also has vertical fins which serve as keels preventing it from loosing balance when it makes quick turns.

The two pairs of horizontal fins extending sideways from the body, the pectoral and the pelvic fins (articulate with the internal skeletal support) function as control for the up and down pitching movement of the head and the body, keeping the whole animal on a level course.

The Senses

The ultimate source of external stimuli are the senses which include the eye, the stretch receptors, the organs of balance (labyrinth or vestibular apparatus) and the lateral like. Here we will briefly mention their functions.

1. The eyes relate the animal's direction of movement to some external objects.

2. The stretch receptors or muscle spindles are located in muscle tissue throughout the body. They respond to contractile changes in the muscles. The brain and the spinal cord mediate both the incoming and outgoing impulses to effect a dynamic self regulation.

3. The labyrinth is located on either side of the head immediately behind the eyes. They maintain equilibrium during movement. They contain the three semi-circular canals (all filled with fluid) arranged at right angles to one another so that where ever a fist turns it can have a sense of balance. This is done through nerve impulse connected to the brain.

4. The lateral line is an additional device for the fish to perceive water pressure at the body surface. All fist have this line as an organized system of sensory canals in the skin which open at intervals to the surface. This system extend the whole lengths of the body.

The Head

The head has several functions. Because of its shape, rigidity and the fact that it bears the sense organs associated with movement through water, and orientation. It also has the parts which are responsible for food and water intake.

The skull which houses the brain is cartilaginous, tough and flexible. It is reinforced from outside by the scales, bones or mineral deposits. The head consist of several segments fused form compact and rigid structure better able to work as a unit. In some part fusion is complete, in others it is not.

The Brain

Is the front part of the spinal cord. It is expanded to contain the cranial nerves, sense organs and the activity of the jaws. The brain parts are arranged in the same sequence as the parts of the body they control. You can see the details of structure in Fig. 22.5, brain and cranial nerves of dog fish. You will understand this better from your practical lessons especially when you dissect the fish.

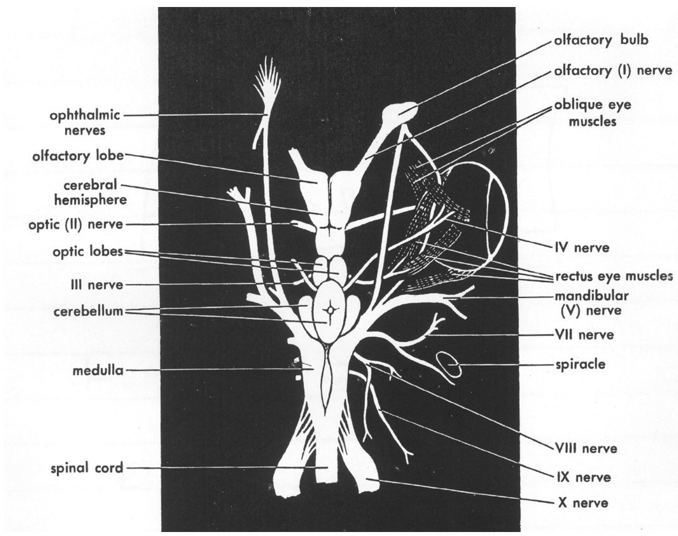


Fig. 25.5 Brain and cranial nerves of dogfish. (No. VI is hidden beneath the rectus eye muscles.) Dorsal view.

4.0 Conclusion

You have learnt a lot in this unit. Remember to go back and study the objectives to ensure that you achieve the goals set for this lesson. You started by going through the general characteristics of chordates. The vertebrates being the predominant subphylum of this group take the main part of the discussions in this unit. The non-vertebrate phyla of the chordates has been briefly mentioned. They serve as an evolutionary link between the vertebrate and invertebrate world. A close study of the general structures and the maintenance systems of the fish in general. You have also learnt how to distinguish between the bony and cartilaginous fish. These are the major groups of fish that exist.

5.0 Summary

As we continue to study the vertebrates in the next few units, you will continue to see the progressive increase in adaptations to life on land. In the next unit we shall study the Amphibians.

5.1 Answer to Self Assessment and Study Exercises

1. The protochordata (invertebrate chordates) are described as the evolutionary link between the vertebrates and invertebrate world because they posses both features of vertebrates and invertebrates. Amphioxus their most popular representative lack the vertebral column. It however has the notochord, a segmented musculature and a dorsal nerve cord. It has no brain nor sense organs, nor jaws, but is able to move about.

2. Vertebrates are classified by the following features:
    - The presence or absence of what type of scales.
    - Whether skeleton is bony or cartilaginous
    - Whether or not there are visceral clefts which later develop into gills
    - Type of limbs and whether tail funs are symmetrical or asymmetrical
    - Presence or absence of external ears
    - Production or non of eggs.
    - Internally or externally fertilized eggs
    - Warm or cold blooded.

Practice Exercise 22.1

Differences between cartilaginous fish and bony fish

Chondreicthyes (cartilaginous fish)	Osteichthyes (bony fish)
Skin with placoid scales	Skin with cycloid scales
Cartilaginous skeleton	Bony skeleton
Paired pectoral and pelvic fins	Paired pectoral and pelvic fins supported by bony rays.
Asymmetric tail fins	Symmetrical tail fins
Five visceral clefts present as separate gills	Visceral clefts present as separate gill opening but covered by bony operculum
No external ear	No external ear
Cold-blooded	Cold blooded

6.0 Tutor-Marked Question 22

How are fishes adapted to life in water? Distinguish between bony and cartilaginous fish.

7.0 References

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UNIT 23

Chordata
Class Amphibia, Class Reptilia

Table of Contents

1.0 Introduction

In the last unit we studied fishes that are aquatic. There are however some fishes that are preadapted to survive out of water. As we saw that arthropods are preadapted to terrestrial life by nature of their exoskeleton which helps them conserve water, and gives them bodily support. We can similarly say that some primitive bony fish that stay permanently in fresh waters. These have a thick muscular section at the base of its fins which makes it possible for the fins to be used as paddles as well. These fishes also have functional lungs sacs leading off from oesophagus into which from the atmosphere is swallowed. Even though the air is taken in through the mouth, the air passes through the wall of the oesophagus to the internal nasal opening. This is addition to the usual external nasal opening (or olfactory sac) possed by all fishes. These lung fishes need this additional source of oxygen supply swallowed from the air.

Their water conserving scales, fleshy fins, and air breathing lungs, all features of fish, pave way for life on land.

You would already expect that amphibian would have some of these features enabling to live on land and water.

2.0 Objectives

As you go through this unit, you would be able to:

1. Give the characteristics of amphibians.
2. Explain the adaptation of amphibians to their habitat.
3. Give the characteristics of reptiles.
4. Explain how reptiles are adapted to life on land.
5. Analyse the evolutionary position of amphibians and reptiles in the history of animal life.

3.1 Class Amphibia

3.1.1 General Characteristics

Amphibians have moist skin which help them in gaseous exchange in supplement to the lungs. They have no scales Their skeleton is bony. There are two pairs of limbs which end in five fingers. These are called pendactyle limbs. Visceral clefts are present in the aquatic larvae (tadpole) only. The adults are terrestrial and have lungs. There is metamorphosis from larvae to adult in the life cycle. They have no external ear. They produce eggs which are fertilized externally. Adults return to water for reproduction. They are cold blooded. Toads, frogs and salamanders belong to this group.

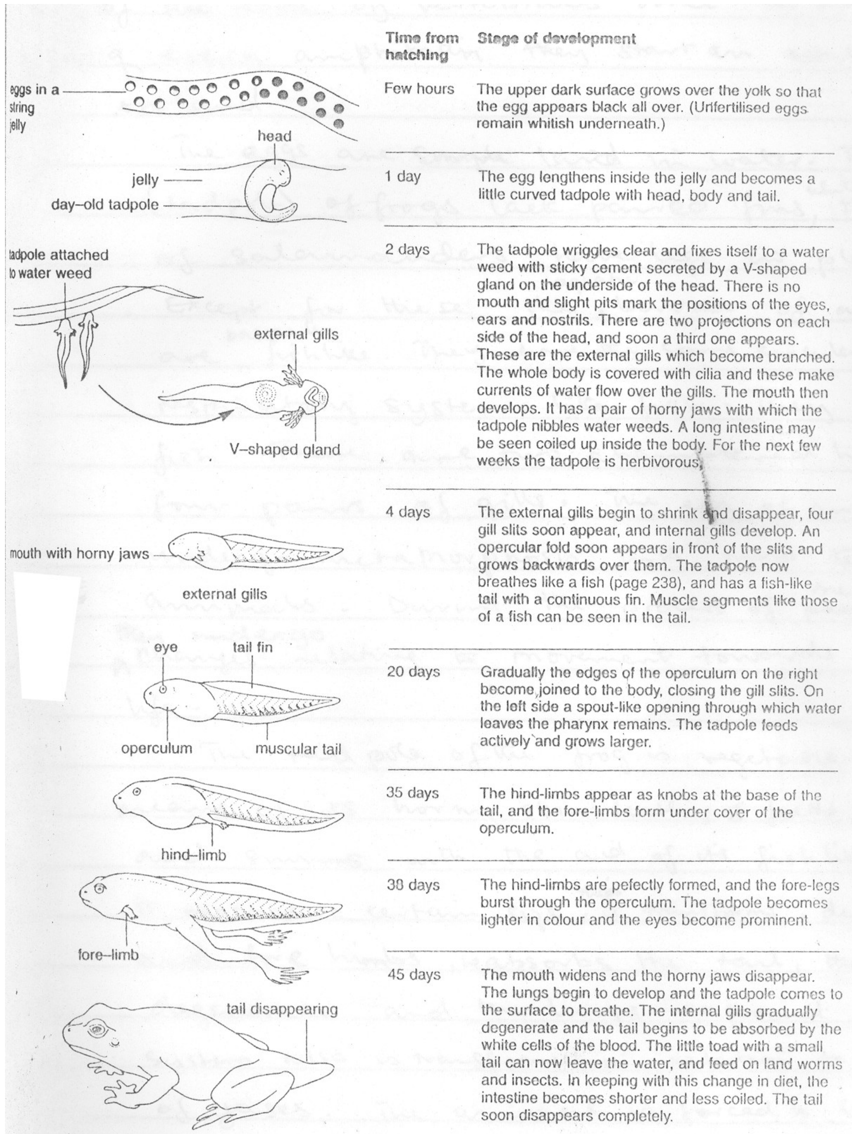
3.1.2 Adaptations

For animals that are primarily aquatic to inhabit the land, there must structural and physiological changes. Amphibians are vertebrates that live part of their life in water and part on land. They pass through a fish-like phase during their early life. Reptiles are the first group of vertebrates that are fully land animals. They mature to adulthood from the time the egg is laid on land. Birds and mammals are further adaptations or transformations of the reptiles.

Amphibian absorb oxygen through the skin and poorly developed lungs. They are of interest in respect of colonization of the land by vertebrates since in the life cycle of every amphibian they start in water and end on land.

The eggs are laid in water. The larvae (tadpole) of frogs lack paired fins, while the larvae of salamanders have legs in place of fins. Except for these, the aquatic larvae of amphibians are basically fishlike. They have the same circulatory and respiratory systems like fish. They swim like fish. There are two chambered heart and four pairs of gills. The egg of amphibians undergo metamorphosis into more terrestrial animals. During the process of metamorphosis they undergo changes relating to movement towards terrestrial life.

The tadpole of the frog is vegetarian. By means of its horny skin teeth, it feeds on vegetation, and swims with the aid of its fish like tail. When it reaches a certain size, it transforms, develops hind and fore limbs, reabsorbs the tail, the guts degenerate and the lungs expand. The circulatory system also is transformed in relation to exchange of gases. The animal is force to leave water if it is not to drown. The tail will interfere with its leaping if not reabsorbed. The diet also had to change from a vegetarian diet to insects. This called for a change in the digestive tube. True teeth replaced horny skin teeth of the tadpole.



Time from hatching	Stage of development
Few hours	The upper dark surface grows over the yolk so that the egg appears black all over. (Unfertilised eggs remain whitish underneath.)
1 day	The egg lengthens inside the jelly and becomes a little curved tadpole with head, body and tail.
2 days	The tadpole wriggles clear and fixes itself to a water weed with sticky cement secreted by a V-shaped gland on the underside of the head. There is no mouth and slight pits mark the positions of the eyes, ears and nostrils. There are two projections on each side of the head, and soon a third one appears. These are the external gills which become branched. The whole body is covered with cilia and these make currents of water flow over the gills. The mouth then develops. It has a pair of horny jaws with which the tadpole nibbles water weeds. A long intestine may be seen coiled up inside the body. For the next few weeks the tadpole is herbivorous.
4 days	The external gills begin to shrink and disappear, four gill slits soon appear, and internal gills develop. An opercular fold soon appears in front of the slits and grows backwards over them. The tadpole now breathes like a fish (page 238), and has a fish-like tail with a continuous fin. Muscle segments like those of a fish can be seen in the tail.
20 days	Gradually the edges of the operculum on the right become joined to the body, closing the gill slits. On the left side a spout-like opening through which water leaves the pharynx remains. The tadpole feeds actively and grows larger.
35 days	The hind-limbs appear as knobs at the base of the tail, and the fore-limbs form under cover of the operculum.
38 days	The hind-limbs are pefectly formed, and the fore-legs burst through the operculum. The tadpole becomes lighter in colour and the eyes become prominent.
45 days	The mouth widens and the horny jaws disappear. The lungs begin to develop and the tadpole comes to the surface to breathe. The internal gills gradually degenerate and the tail begins to be absorbed by the white cells of the blood. The little toad with a small tail can now leave the water, and feed on land worms and insects. In keeping with this change in diet, the intestine becomes shorter and less coiled. The tail soon disappears completely.

Fig. 23.1 Life history of the toad

3.1.3 Practice Exercise 23.1

Label fully the drawing of the life cycle of the frog provided below.

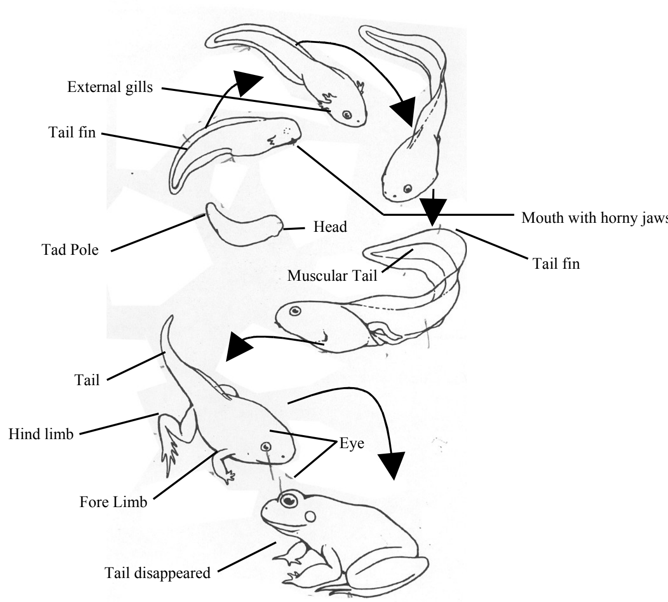


Fig. 23.2 Life cycle of frog, from hatching stage to adult form.

3.2 Class Reptilia

3.2.1 General Characteristics

Reptiles have dry scaly skins. The scales are horny. They have bony skeleton. There are two pairs of pentadactye limbs. Their visceral clefts never develop gills. They have no external ears. Their fertilized yolky eggs are retained by the reptile until hatching. The fertilization is internal. Eggs have a leathery skin. They have beak developed in place of teeth. T hey are cold blooded. Examples include lizards, alligators, turtles and tortoises.

3.2.2 Adaptations

Reptiles are an example of vertebrates of the four legged (tetrapod) type. The lizard has been described as being perfectly adapted to life on land from the beginning of its life cycle to adulthood.

Reptiles have retained the streamline shape. Its body is covered with horny scales which does not allow water to penetrate through it. The body is therefore resistant to water loss in dry water. The four legs are very strong and connected beneath the body so that it gives support to the body and propels the animal forwards as it moves. The lungs and circulation are adapted for aerial life. The eggs are types that are laid on land and can develop without passing an aquatic larval stage. The adaptive features generally concern at the maintenance of constant internal body conditions and managing the body in a terrestrial environment.

Now we will study in details the adaptive features and evolutionary development

3.3 Adaptive Features and Evolutionary Development

3.3.1 Body and Locomotion

The body of the lizard consists of head, trunk and tail. The head is clearly raised from the ground on a well developed neck. The body remains streamlined, tapering towards the laid. The head slightly blunt at the anterior end, and the body widening onto the middle. The two limbs are attached to the pectoral and pelvic girdles and are placed beneath the body. The girdles are shaped like bracers. With the limbs they offer effective support to the weight of the animal. The tails seem to serve mainly for balancing the animal and preventing it from toppling over its nose. The body is not adapted for locomotion. The body is simply a mass that moved forward. The limbs have to be stronger and tougher to bear the weight of the animal which is now transmitted to them, body having been raised off the ground. The limbs themselves must be joined to firm frames which in turn articulate with the vertebral column which must be stronger, bonier and more closely articulated and less flexible.

In preparation for locomotion the body is raised by limb and girdle muscles which form the lever along with the skeleton of the limbs. The limb arrangement are closely related to the fish patters. The part of the limb nearer the body are fewer than those farther away. The gradual increase in their parts give the fan-like arrangement. So the upper limb is made up of one bone, which articulates with the girdle the proximal and two other distal bones at its distal end. Further distal are many bones of the wrist and ankle. Then there are five rows of slender bones in hand or foot which end with five fingers or toes. This is the ancestral pentadactye limb from which those of the vertebrate ones have evolved. Muscles also become arranged round the girdles to serve for moving the body and balancing it. The muscles are either extensions which push the limbs backwards or flexors which draw them forward.

3.3.2 Respiration and Blood Circulation

Respiration is a process that is seriously affected by movement out of water. Reptiles rely entirely on land. Unlike the amphibian which still rely on the moist skin and the air taken in through the mouth. It does not employ the fish throat mechanism for breathing. The ribs and rib muscles pull in air by expanding the chest or thorax. The arteries now lead to the lungs, the head and the dorsal aorta. In amphibians and reptiles blood flows in three arterial paths; one divides to left and right to supply the lungs; another to left and right part of the head (carotid arteries) and the third divides left and right then reunite above the digestive tube to form the dorsal aorta. This last one is the systematic arch. It corresponds to a pair of gill arteries without the gill capillary system. This is like the arrangement in the fish gill arteries which is in parts suppressed and in some places enlarged. It is like a system – readjusted to another. Example of this is what happens in the development of the frogs. Here the fisklike tadpole changes to a four footed land animal. This tadpole swims like fish and has complete gills with typical gill arteries. During metamorphosis the pattern of arteries changes, through a process of local shrinkage and enlargement into the amphibian – reptile arrangement just described.

Further, as a consequence of change from gill to lungs, the heart is affected, in fish and the tadpole (or juvenile aquatic stage of amphibians) the heart has two chambers. It pumps blood which get oxygenated through the gill capillary vessels. This blood then move under pressure to the body tissues. The two chambered heart here handles only venous blood (this is deoxygenated blood). This is oxygenated as it passes through the gills.

In the reptile, the blood going through the carotid arteries to the head and through the systematic arch to the dorsal aorta reaches the issues under full pressure because the resistance of a gill capillary system is no longer present on its way. This is a great improvement. Useful blood needs be oxygenated before it leaves the heart. In this way it gains vigour of pumping and vitality of the oxygen. This is accomplished by the device which virtually separates the heart into two (although separation is not complete) chambers. The right half, the auricular chamber and the right half of the ventricle. It pumps blood forward to the lungs. Here blood gets oxygenated and returns directly to the other half of the heart. This other half (also consisting of another auricular chamber and the left half of the ventricle), pumps the oxygenated blood forward to the head and body. The ventricle however allows some mixed material and venous blood to pass on to the tissues, in both frog and lizard, because the partition is not complete.

3.3.3 Self Assessment Exercise 23.1

Describe the changes in the blood and respiratory systems as the tadpole changes to the adult.

3.3.4 Water Conservation

The main success of land animals arise from their capacity to conserve water. The ancient lung fishes which are seen as the earliest groups transiting from water to land and from which land vertebrate arose, had hard scales. The horny protein material of the skin of terrestrial vertebrates, is made of keratin. Keratin is used to form the over lapping scales of reptiles. Keratin is hard, dry and impervious to water. It is a light weight protective layer which prevents water loss over the body surface. The only source of water loss is through the lungs in respiration. So the animal is enclosed in its body juices.

The excretory organs also help in water conservation. Fish kidneys are efficient water eliminators as they must continue to send out water that continuously enters the animal. This kind of kidney will not help the reptile. So in the reptile, most of the water that carry wastes excretion are reabsorbed from the drainage tubules. For example water is reabsorbed from dilute nitrogenous wastes in form of ammonia to form uric acid which is passed out nearly in solid form. By the two processes, the body surface control of water loss and the activity of the kidneys, the body tissues maintain their constant liquid medium. This is a great accomplishment for the reptile and other land animals.

The greater fluctuations of temperature is another variable the land animal faces. Fish and invertebrate assume the temperature of their aquatic environment which are often more stable than the land has to offer. Because of the evaporation from their moist body surfaces, amphibians may even be cooler to touch. Reptiles however manage to control their body temperature to some extent by changing their colour. By contraction and relaxation of pigment cells (melanophores or chromatophores) beneath the skin, under the control of hormones of hormones or nerves cause colour changes from dark to light. Reptiles also control their temperature by moving between shade and sun and maintain them between 30^0 and 43^{0C}. Much below this range, they become sluggish and higher, they could even die.

3.3.5 Self Assessment Exercise 23.2

1. How are land animals protected against water loss?

2. What is the role of kidneys in water conservation in land animals?

3.3.6 Senses and Brains

The water pressure and vibration sensing organs including the head sense organs and lateral line disappear in time of metamorphosis in amphibian. So also is the sensory structures related to the gills as air is now drawn into the nose through the olfactory organs, as well as into the throat by the internal nasal openings. The tetrapod characteristics had to develop to bring the chemicals in air in contact with the living of the organs of smell. The eyes also had to be adjusted to function out of water. Because of the difference in the refractive index of air, the cornea had to become curved and responsible for projecting the mirage out the retina. Because it is no more in water the eyes had to be kept moist and protected with eyelids, the inchitating membrane, and the glands. The organ of hearing on land consists of the organ itself and a means of transmitting air borne waves to it. The sensory structure is an outgrowth from the base of the organ of balance on either side of the head. In amphibians it is short and simple. It however becomes long and tapering and finally coiled in reptiles birds and mammals.

In terrestrial animals, the auditions organs is situated within the head, behind the eye and incorporated in the skill so that as the sound waves tough on the body, they cannot affect the organ deep in the head. The apparatus conveying the waves to the delicate organs is a device associated with the hyoid gill slit. This slit is the one immediately behind the jaw angle. In the dog fish for example, the gill slit opens to the exterior behind the eye, and on its inside into the fore-part of the throat. This space persists in all terrestrial vertebrates and brings the air closer to the organs in the land vertebrates. It is this space that is used for transmission of sound waves touching on the surface of the body. In amphibians the outer end is closed by a membrane (the eardrum) which is free to vibrate. Fig. 23.3 shows the ear of the reptile.

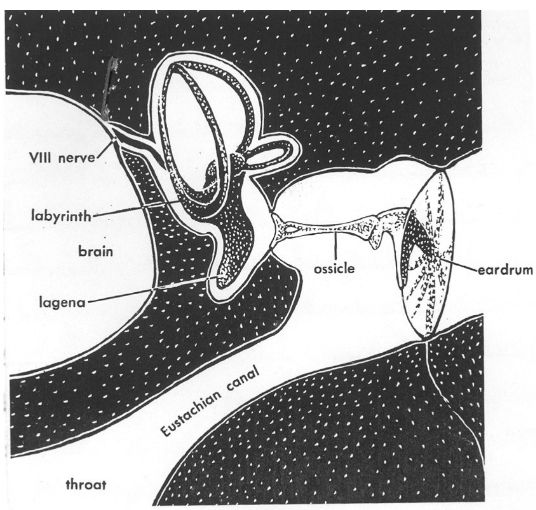


Fig. 23.3 Ear of reptile, showing labytinth of inner ear with lagena (forerunner of cochlea); and the middle ear, consisting of eardrum, middle ear cavity. Eustachian tube leading to the throat, and the ear bone, or ossicle, connecting the eardrum with the membrane of the opening to the inner ear.

In amphibians, reptiles and birds, a bony rod (columella, derived from the part of the hyoid gill skeleton which had been associated with supporting the jaw. It connects the centre of the inner side of the ear drum with the wall of an outgrowth of the organ of balance. The nod transmits sound vibrations from the eardrum to the sensory structures. The brain of the amphibians and the reptiles show enlargement of the hemispheres compared to of the fish.

3.3.7 The Amniotic Eggs

The amphibians which continue to lay their eggs in water are not true land animals. Reptiles have evolved a type of egg which can laid on land. It is this type that the birds and mammal lay too. No aquatic stage is needed in the development of this egg which is known as the amniotic egg (See Fig. 23.4)

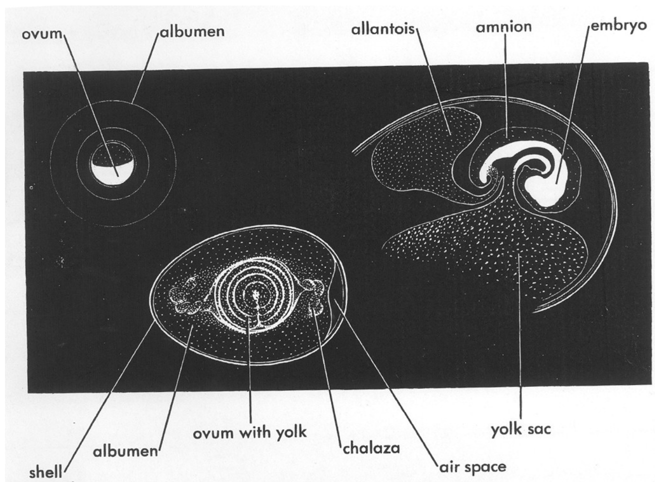


Fig. 23.4 The amniote egg, with amphibian egg shown at top left for comparison, but on a larger scale.

The emergence of the amniotic egg represent a significant invention in history of life. To be able to develop out of water, the egg needs the followings:

1. a shell for protection against desiccation and to support the semi-liquid egg cell against the pull of gravity.
2. yolk within the cell, sufficient to allow the embryo to grow large enough to omit the larval stages and proceed directly to become small forms of adult types
3. water for growing tissues within
4. a store for toxic materials produced.

All of these conditions are met in the amniotic eggs of all true (and vertebrates with this type of egg) the only need for water by terrestrial animals is for drinking.

It however has its constrains on development and fertilization. With a shell, it means that the egg must be fertilized before it is enclosed in the shell. This means the sperm must be transferred into the female before the egg is laid. The development of the egg in the shell is also significant.

1. The yolk provides food for the growing embryo. It is not involved in cell division. It is enclosed in a yolk sac.

2. The liquid waste material produced by the growing embryo is stored in the allantoic sac. Both yolk and the allantoic sac are surrounded by a blood circulation which connects them to activity dividing embryo. They supply food (yolk) and serve as a means for excretion (allantoic fluid).

3. The amnion forms a pair of folds which cover the embryo and enclose the amniotic fluid so that even when laid on dry land, it develops within an aquatic environment. It is from this layer the egg got its name.

4. The chorion, is the outermost layer of cells. It surrounds the embryo and the embryonic membranes. The amnion, chonon yolk sac and allantois are all composite structures consisting of two layers of tissue, either ectoderm and mesoderm, as in chonon and amnion, or endoderm, and mesoderm, as in the yolk sac and allantous.

The Embryo only breaks through the shell when all food and water have been used up, to take its first breath of air.

In the Mesozoic era (a period of about 70 million years) the reptiles were very many and of different varieties; huge vegetarians, savage flesh eaters, flying creatures etc. Only lizards, turtles and crocodiles till exist.

3.3.8 Self Assessment Exercise 23.3

1. Draw and label an amniotic egg.

2. What are the functions of its parts?

3.3.9 Answer to Self Assessment and Practice Exercises

If your responses are like these you are right.

Practice Exercise 23.1

Life cycle of frog or toad

SAE 15.1

Changes in the respiratory system as the tadpole changes to adult form:

The gills are replaced with lungs. The ribs and rib muscles pull in air by expanding the chest or thorax. The arteries now lead to the head, the lungs and the dorsal aorta. The part of arteries in the tadpole changes through strintages of vessels and enlargement in parts. A two chambered heart emerges which pumps oxygenated (in the lungs) blood under pressure to other parts of the body. This is unlike in the fish where only deoxygenated blood enters the heart. However, because the partition between the ventricles is not complete oxygenated and deoxygenated blood mix up in the reptiles and amphibia.

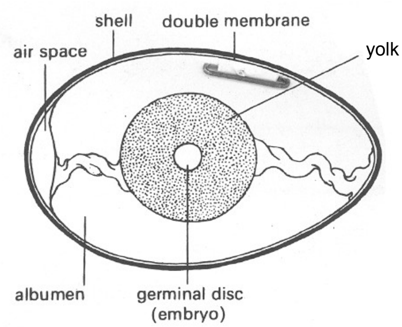


Fig. 23.5 Diagrammatic transverse section of bird's egg before germination.

The eggs of the reptile, and the bird are amniotic eggs.

The functions of the amniotic egg:

Shell	-	is porous and allows the passage of gasses
Albumen	-	encloses the yolk. Nourishes the growing embryo
Yolk	-	suspended by the chalazas. It nourishes the growing Embryo
Amniotic Water jacket	-	stores liquid wastes
Germinal disc (embryo)	-	responds to warmth and develops into young animal

SAE 15.2:

Land animals are protected from water loss in two ways:

1. Horny protein chitin covers the surfaces of the body. It prevents water evaporation from body surface. This chitin is made of protein called keratin. The keratin is used to form light overlapping scales in

reptiles with the scales on, the only source of water loss is through the lungs in respiration.

2. The excretory organs of land animals are very effective for filtering waste materials from blood for excretion. They in this process further prevent excessive loss from these excretory materials by reabsorption of water from them. In reptiles the excretory material is a solid uric acid instead of ammonia.

4.0 Conclusion

In this unit, you have learnt about two groups of chordate, the amphibian and the class reptilia. You have seen how both moved onto the land. The amphibian as the transistory class lives part of its life on land and part in water. You saw how amphibian eggs which must be laid in water evolved terrestrial adults which must go into water breed. You saw how the reptiles developed a greater independence of water and evolved an effective means of inhabiting the land. This is in the development of the amniotic egg. This is an egg which even though laid on land, develops within an aquatic environment. Within this egg, the animal is protected and nourished until the young animal, similar in every way to the adult except for size emerges.

5.0 Summary

We have therefore in this unit emerged onto land life. In subsequent units you will follow the trend in the development of land animals.

6.0 Tutor Marked Questions 23

Explain the importance of amphibians and reptiles in the animal evolutionary history.

7.0 References

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UNIT 24

Phylum Chordata
Class Aves - Birds

Table of Contents

1.0 Introduction

You shall learn about the birds in this unit. Birds can be described as those vertebrates adapted to flying. Reptiles you will remember are vertebrates that walk on four legs. They have some characteristics in common with birds because they are all vertebrates. In this unit we will see the similarities and differences between birds and reptiles.

The following objectives are therefore set to help you go through this unit successfully.

2.0 Objectives

As you go through this unit, you should be able to:

1. Itemize the distinguishing characters of the birds
2. Describe the basic structure of feathers
3. Describe the structure of the wings
4. Describe the adaptations of birds to flight
5. Describe the modifications of beaks of birds to their diet
6. State how reproduction in birds differ from those of the reptiles.

3.0 General Characteristics and Adaptations

The skin of birds bear feathers and their legs have scales. Their skeletons are bony. There are two pairs of pentadactyl limbs, the front pair of which form wings. Their visceral clefts never develop gills. They have no external ear. Their fertilized yolky eggs are laid on land, and covered with calcareous shells. Fertilization is internal. They are worm blooded. Some examples are Columba (the pigeon) and Aquila (the eagle).

Just as reptile can be described as fish-like vertebrates adapted to life on land, so can birds be described as reptile-like adapted to flight. Flying implies activeness and freedom of movement. Apart from flight there are two other things that of equal importance to birds in their adaptations to environmental changes are a constant temperature and a large brain.

To be physiologically constant is a major biological requirement to be a successful organism. It must continually keep itself moist, warm, supplied with oxygen, salts, sugar, protein and other essentials within the limits tolerable to the animals. The birds ability to fly enables it to maintain its internal stability by flying to suitable environment and food, and it demands the use of a lot of energy. Those which remain as birds on land, are structurally like a reptile, running on two legs, with head erect, and fore limbs set free for other uses. It is assumed that they evolved from walking reptiles; that their wings which must have evolved before the ability to fly was necessitated by the need to keep a constant body temperature. You will remember that reptiles moved from place to place depending on the external environmental conditions. To have a constant body temperature means not to be too cold or too warm. This is achieved by insulation from the external environment. To a small degree the scaly skin of reptiles serve this purpose. These scaly skin have been replaced in birds by feathers except on the legs and feet. Here the feathers serve primarily to insulate by trapping warm air spaces between them.

3.1.1 Self Assessment Exercise 24.1

Itemize the characteristics of birds.

3.1.2 Feather

The feathers are of three basic types:

1. **The down feathers**
   These are simple in structure. They like all feathers are made of keratin which is produced by the skin and are localized in patterns on the skin like the scales of reptiles are. Many young birds and some adults have this body cover. They have short shaft and barbs which do not interlock.

2. **The Quill Feathers**
   These consist of a central rod (shaft) which bears a flat expanded part called the vane. The lower part of the central rod is hollow, and forms the quill. At the base of the shaft is a hole at the base of which a tuft of papilla or tissue fits into a pit-like follicle. The vane is made up of many processes called barbs arranged on either side of the rachis like the teeth of a comb. Each barb bears two rows of small branches called barbules which are also arranged obliquely so that adjacent barb overlap. The barbules hold the barbs together. There are small hooks on those barbules on the lower surface of the feather, while those upper barbules have ridges. These can only be seen under the microscope. The barbule hooks of on lower barb fits into the ridge of the upper one. These binds the whole vane together to provide a surface capable of beating the air.

3. **The Covert Feathers**
   They are similar structurally to the quill feathers except that they are smaller. They cover the body. There are filoplumes all over the body between the covert feathers. They consist of a slender thread-like shaft with a tuft of barbs at the end.

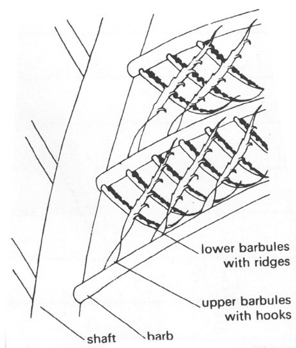


Fig. 24.1a Diagram of part of feather to show interlocking of barbules

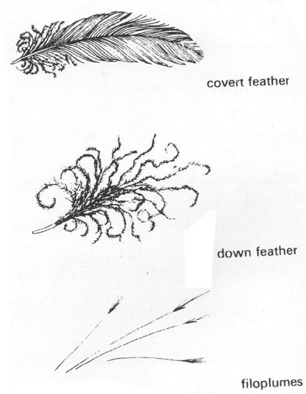


Fig. 24.1b Body-covering feathers

3.1.3 Self Assessment Exercise 24.2

Practice drawing and labeling the various types of feathers in a bird.

What are the functions of the various types?

3.1.4 Wings

The forelimbs of birds serve as wings. They function like wings and propeller at the same time. There are three parts, which correspond with upper arm, forearm and hand of the mammal. When not in flight the whole arm is folded in a Z shape. This way they are folded neatly to the body so that they do not interfere with the other movements like walking or hopping. The three parts of the arm are held by two fold of skin, one from the upper arm to the wrist and the other across the armpit. The wings are covered with feathers in most parts. This provide a large surface area for the bird to bit the wind. The whole structure is light because of the nature of the feathers.

They are made of keratin. The muscles and the bones of the forearm provide the base to which the feathers are attached. There are only three digits, the thumb which remains separate, while the second and third are firmly fixed together by a web of skin. The tuft has a tuft of feathers. The feathers fixed to the upper part of the hand are called primaries, while those of the forearm are secondaries. See Fig. 24.2.

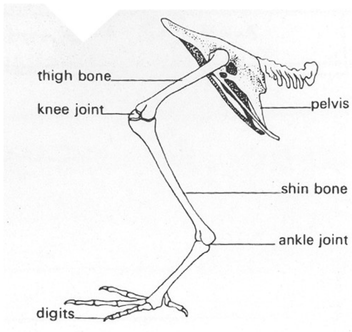


Fig. 24.2 Skeleton of bird's leg

Uses of Feather

Feathers are provided with muscles at the base. When these contract or relax, they bring about a control of body temperature, flight, or displays of feather in connection to see and so on. They are also supplied with nerve fibres so that they are sensitive to touch. They give shape to the body.

3.1.5 Flight

Birds are able to fly because they have evolved feathers. It however can also run and walk on two legs, and keep itself balanced. They are able to fly also because the feathers have been formed into wings, there are hollow bones, they are warm blooded and have extraordinary efficient respiratory system and powerful breast muscles. All these make for high power and little weight. The bird skeleton is light and strong because the bones are hollow and thin and some parts have been fused together. The lower vertebra are made tip of hip, the sacrum are fused into a tube like structure. The hollow finger bones are also fused together. The tail is reduced to a small plate at the end of the vertebral column. The ribs are flat and thin and with their overlapping joints form a strong flexible basket.

The skeleton of the bird helps it to fly as well as walk on two legs when necessary. It is comprised of the breast bone for attachment of the huge muscles that move the wings. It is an adaptation of the sternum which has become a big keel, which has extended for below the ribs. The wing is lifted or lowered by another muscle which is also attached to the sternum but passed over the shoulder to the other side of the humerus. They also rotate the humerus. The other muscles within the wing serve to fold and extend it. Much of the bulk of the body has been pushed back. This include the keel and its muscles. This brings the centre of gravity over the legs and facilitates walking. The leg bones are therefore strong. The femur is directed forward to bring about balancing. The leg muscle fix the leg to the body as well as cause their movement. They make perching and even standing on one leg possible. Spread out, the wing are curved like that of an aeroplane; with a concave under-part and a convex upper-part. The wings are raised above the back of the body of the bird during flight.

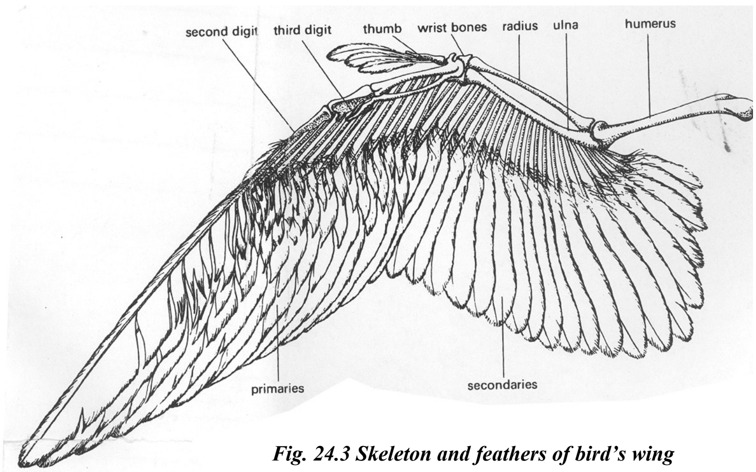
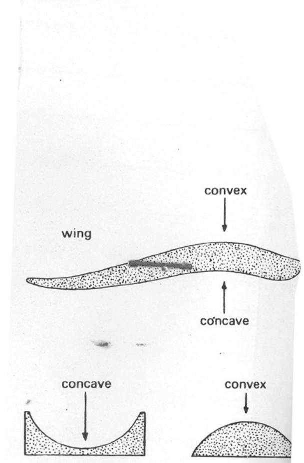


Fig. 24.3 Skeleton and feathers of bird's wing



The edge of each wing bends upward in down stroke because of its flexibility. So each stroke causes the bird to move upwards and forwards. When the bird is to land or take off, the wing beats cause the quill feathers at the tip to spread out to form a wing slot which stops the bird from stalling. The legs are folded in under the body in flight but stretched out for landing.

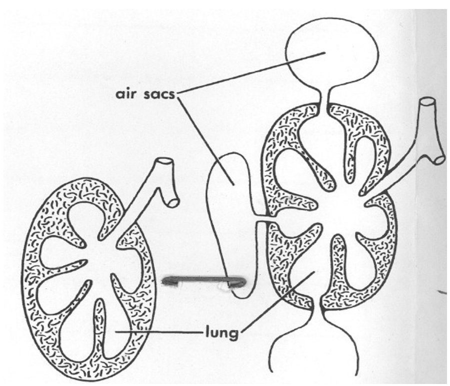
Their alternate forward and downward arrangement of their parts make for shock absorption as they land.

3.1.6 Oxygen Supply and Energy

With such an apparatus for flying, there is need for an effective machinery for energy supply. This is evident in the completely divided heart. The right part pumps blood exclusively to the lungs whilst the left pumps to the oxygenated blood from the lungs to the body. Big arteries supply the muscles. Oxygen is delivered to the tissues at high artenal pressure and the red blood cells carry very large amount of oxygen which they can give up suddenly at relatively high oxygen tension. The body is high $42^{0C} – 45^{0C}$ (the bird maintain a high body metabolism). To maintain this, the birds need an efficient respiratory system.

Air is drawn in through the long trachea air tube in the neck to the lungs and finally to the air sacs (Fig. 24.4).

Fig. 24.4 Diagram of a bird lung showing air sacs leading off from lung cavity, so that air passes completely through the lung in both inhalation and exhalation; the sacs improve respiration and lighten the body. Left, a diagram of a reptilian lung is shown for comparison.

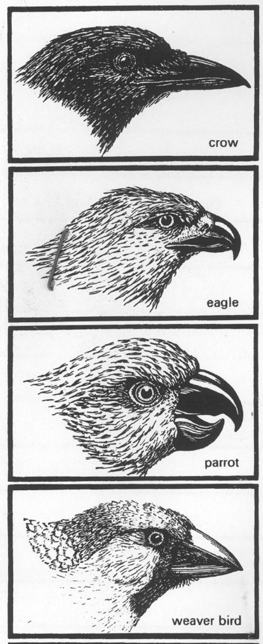


The air sacs help make the bird light. They extent into all parts of the bird, including the hollow bones and toe bones. These air sacs are filled when the bird inspires with oxygen to flush out the used air from tissues and this increasing respiratory efficiency. The air also helps to cool the overheat body of the bird.

For flight a great amount of food that can be quickly digested is required. For this reason, birds eat only high calorie food like, insects, seeds, worms, fish, rodents and fruits. The daily food intake can reach 30% of the body weight, compare to the 10% of that of mammals.

The Beak is the structure with which the bird takes in food. It is a horny structure covering the small toothless jaws. It is used for obtaining all sorts of food. Its special shape and adaptations depend on the type of food the particular species requires. (See Fig. 24.5) for the description of beaks and the special food of the birds concerned.

FIG. 97 Different types of birds' beaks



Type of food	Type of bird	Type of beak	Special uses
Anything (omnivorous)	Crow	Strong, pointed	—
Flesh	Eagle, Hawk, Owl	Hooked	For killing prey and tearing off strips of flesh
Hard seeds	Parrot	Hooked	For cracking seeds, also used in climbing
Small seeds	Finches, Rice birds, Weaver birds	Short, strong, conical	—
Insects	Woodpecker	Short, narrow	For picking insects from cracks in bark
Insects	Swallow, Swift	Short with wide gape	For catching insects in flight
Nectar	Sunbird	Slender, slightly curved	—
Fish	Heron	Long, strong	For spearing fish
Worms, aquatic creatures	Ibis, Curlew, Snipe	Long, narrow, curved	For probing earth and mud
Frogs and anything edible in water	Duck	Flat, grooved and ridged on inside	For gripping slippery animal e.g. frog. Also takes in beakful of muddy water, and squeezes it out through side of beak using ridges as a sieve to retain anything edible

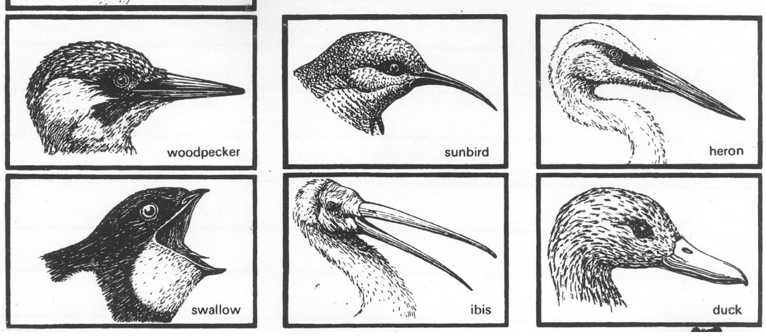


Fig. 24.5 Different types of birds' beaks

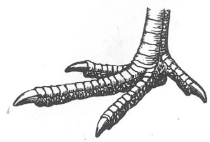
3.1.7 Self Assessment Exercise 24.3

In at most four words each describe the shape of the beaks of animals adapted to, cracking , probing, killing, gripping and catching insects.

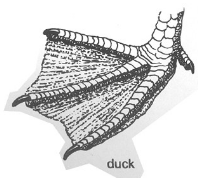
In some birds the feet are also adapted for special functions like catching prey, scratching and swimming (see Fig. 24.6).

Fig. 24.6 Different types of birds' feet

owl



domestic fowl



duck

In some birds also the feet are adapted to help in feeding, and the following table gives some examples.

Type of food	Type of bird	Type of feet	Special uses
Flesh	Eagle, Hawk, Owl	Long, sharp claws	For catching and holding prey
Seeds and worms	Domestic fowl Game birds	Strong feet, blunt nails	For scratching in the earth
Any food in water	Duck	Webs between toes	For swimming (see note below)

3.2 Reproduction

Birds go through a period of courtship which is usually long and complicated. The colours of the male bird becomes very bright and he displays himself to the female. Sometimes displays are carried out to scare away other males from identified mate. After mating, the nest is prepared.

The well developed eggs are fertilized in the ovary of the bird. It is only after fertilization that the shell glands secretion is received as the egg moves down the oviduct. An average of an egg is laid a day. It is only when all eggs are laid i.e. the clutch is complete that the bird begins to sit on them and use its body heat to hatch them. The eggs are similar in structure with the reptilian egg. You will remember that we described in details how the egg hatches. Unlike the reptiles the birds incubate their eggs. Sometimes both the male and female share the incubation in other cases it is only the hen. When they hatch, the young are looked after and fed by the parents until they are able to fend for themselves. When newly hatched, most birds are blind and naked.

Migration

A good number of birds migrate yearly along routes that become very customary for them. In this migration, they can cover very vast lands across continents e.g. the Swallow leaves Europe for Africa in September only to return to Europe in April the following year.

Let us now summarize the basic differences we have seen between birds and reptiles as follows:

Table 24.1: Differences between Reptiles and Birds

Feature	Reptiles	Birds
Temperature control	Cold-blooded	Warm-blooded
Feathers	No feathers	Feathers present
Teeth	Teeth present	No teeth (except in extinct forms found only as fossils)
Type of heart	Single ventricle or only partly divided (except crocodile, where ventricle is completely divided into two)	Ventricle of heart completely divided into two, a right and a left ventricle.

3.2.1 Self Assessment Question 24.4

Can you also on your own remember two basic similarities between reptiles and birds?

3.2.2 Self Assessment Question 24.5

Name the differences between birds and reptiles.

3.2.3 Answer to Self Assessment Exercises

The general characteristics of birds are as follows:

1. Feathers
   Bony skeleton
   Pentadaclyl limbs – front pair form wings
   Visceral clefts never developed gills
   No external ears
   Fertilized yolky eggs laid
   Calcareous egg shell
   Internal fertilization
   Warm-blooded

2. There are four kinds of feathers
   - The quill feather – is the flying feather, it forms the wings in birds.
   - The covert feather – form a cover for the body of the bird.

- Down feather – are found between the covert feathers. They form the main cover of young birds.
- Filoplumes form part of the cover of birds.

Drawing Practice

Draw feathers with sharp pencils as always. The vane of feathers are drawn with single lines which can touch each other to indicate where barbules interlock. The rachis are drawn with two lines which gradually meet at the either end as it tapers to the tip and the quill end. The down feathers have tiny projections representing the short shaft and barbs (see Fig. 24.1b) again.

3. Adaptation of bird beaks to:

Cracking	-	hooked beak e.g. Parrot.
Probing	-	long, narrow, curved
Killing	-	hooked e.g. Eagle, Hawk, snipe
Gripping	-	flat, grooved and ridged at the sides e.g. Duck
Catching	-	short with wide gape e.g. Swallow.

4. Similarities between birds and reptiles

- Both birds and reptiles have chalky shells.
- Both have epidermal scales, even though they are confined to the legs in the birds.

5.. Differences between birds and reptiles

Reptiles	Birds
Cold blooded	Warm blooded
No feathers	Feathers present
Teeth present	No teeth
Ventricle only	Ventricle completely divide into two

If your answers are like these presented above, you are correct.

4.0 Conclusion

We have discussed the general features of birds in this unit. We have also learnt of the special adaptations peculiar to birds as vertebrates. You have learnt of the similarities and differences between reptiles and birds.

5.0 Summary

In our study of animals our next group of study is the mammals. You will see in the next unit why mammals are considered more advanced than birds. Do not forget that even though birds can fly, they cannot swim. This is to say that inspite of the fact that animals living on land are considered more independent, there is no doubt that the ability to survive in water is also special. We may say that birds are vertebrates specially adapted for flight.

6.0 Tutor-Marked Question 24

Describe the special adaptations of birds in details.

7.0 References

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UNIT 25

Mammalia

Table of Contents

1.0 Introduction

In this unit, you are going to study the general characteristics of mammals. You will learn about the details of adaptations in the various mammals. I the last three units we have been studying chordates. Mammals are the last of the chordates we are learning about in this course. You have now got used to the general pattern of studies in this course. You will remember that in this course you are helped to understand the basic reasons why certain organizations belong to a group and why others do not. The fact that mammals are diverse in their adaptations – some to life in water, others to land and others even are flying means that they could be further divided. Their adaptations call for modifications in structure and functions of the body parts. Some eat vegetation; others are carnivores while even others are herbivores. For these reasons structures like limbs and teeth have to be modified. In this unit you will learn about all of these.

2.0 Objectives

As you go through this unit you should be able to:

1. Give the general characteristics of mammals.
2. Describe how mammals are adapted to their very active life.
3. Describe how mammals are adapted for food intake.
4. Describe how mammals are adapted for running.
5. Describe the adaptations of mammals to care for their young.
6. Describe at least three varieties of mammals.

3.1 General Characteristics and Adaptations

Mammalian skins bear hair with two types of glands. These are sebaceous and sweat glands. Their skeletons are bony. There are two pairs of pentadactyl limbs. They never develop gills from their visceral clefts. They have external ear in addition to middle and inner ears. Only two of the genera lay eggs. The embryo develops within the mother. The mother has mammary glands which produce milk for the new born. Fertilization is internal. There are different types of teeth performing different functions. There is a muscular diaphragm between the thorax and abdomen. They are warm blooded. Examples are man and dog.

Mammals are more profoundly transformed from the original terrestrial vertebrate type than the birds; although the birds are particularly specialized for flying. Mammals are more independent of the conditions in their external environment and maintain a stable internal environment irrespective of environmental changes. Mammals can be defined as advanced vertebrates. They are called mammals because they posses mammary glands with which their young, born alive, are fed. Their developing embryo is nourished from the placenta. All of these indicate a high level of specialization and organization in the mammalian body.

3.1.1 Practice Exercise 25.1

List in short clauses or sentences the major characteristics of mammals.

3.1.2 Hair, Heat and Action Adaptations – Skin, Lungs and Heart

Mammals are warm blooded. This means they keep a constant body temperature which could even be higher than that of their environment except when in hibernation, mammals are ready for action at all times.

The following briefs describe the structure and function of the skin:

The skin is made of several layers:

1) The **horny layer** made of flat, dead cells resembling scales for protection
2) **Malpighian layer** – of more rounded cells massed together to form tongues which project into the third layer. These cells contain pigment for skin colour. These two layers form the epidermis which contain no blood vessels or nerves. Its thickness vary from part to part in the body.
3) **The dermis** – is the true skin. Its cells are heaped into small projections (papillae) which fit in between the tongues of cells sticking down from the epidermis. It contains blood vessels and nerves.
4) **Subcutaneous tissue** – these are connective tissues. It contains fat. The hair grows out of the hair follicle and is oiled by the sebum secreted by the sebaceous gland. When the muscles attached at the base of the hair follicle contract, they pull the otherwise slanting hair to a right-angled position to the skin. This traps a body of hair which forms a warm blanket that helps to keep the body warm.

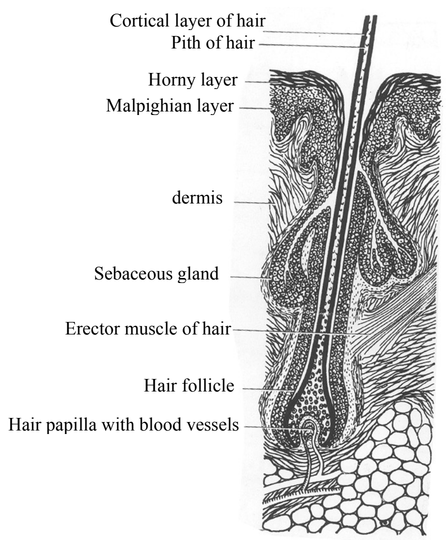

Fig. 25.1 Section through hair and hair follicle

The high body temperature is the result of the activity of the muscle tissue which produces heat continually. The coat of hair on the skin act as insulators preventing heat loss, the same way as feathers do in birds. The sweat glands in the skin, secrete water into the skin surface, which when evaporated causes the cooling of high body temperatures. In this way the mammal regulates its body temperatures. With a constant body temperature and blood component, the body can carry out activities at all times irrespective of the conditions in the environment.

3.1.3 Practice Exercise 2

Learn to draw and label the transverse section of the human skin. Learn to know the function of its parts.

The essence of mammals seem to be energy, stability and sensitivity. They exist with a constant internal environment throughout life. This gives them the best pre-requisite for a free life. Their blood must be kept in the normal state for the animal to function well. Ill-heath results otherwise. A particular mammal is unique by the constancy of blood supply and the activity of its brain. The brain is enormously enlarged compared with that of other vertebrates.

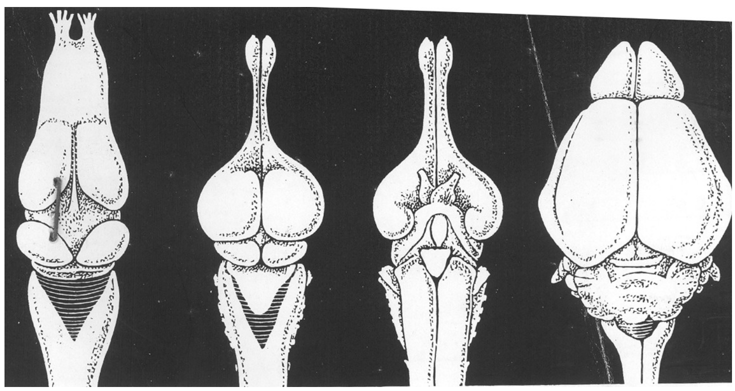

Fig. 25.2 Left, brain of amphibian, in dorsal view. Center, brain of reptile, in dorsal and ventral views. Right, brain of bird, in dorsal view. In the amphibian the cerebral hemispheres and the optic lobes are of much the same size. In the reptile the cerebral hemispheres are relatively much enlarged and the olfactory lobes reduced. In bird and mammal the cerebral hemispheres and the cerebellum are both relatively greatly increased compared with the reptile.

3.1.4 Practice Exercise 3

Learn to draw the structure of the hearts of the fish, amphibian, reptile and mammal. Note their differences.

Curiosity and explorations are therefore peculiar only to mammals. The high activity of the muscle and the brain can only be sustained by an efficient blood supply. The mammalian blood system is driven by a heart with four chambers – two in one half of the heart. One half carries deoxygenated blood to the lungs (to be oxygenated) while the other receives oxygenated blood under high aetrial pressure.

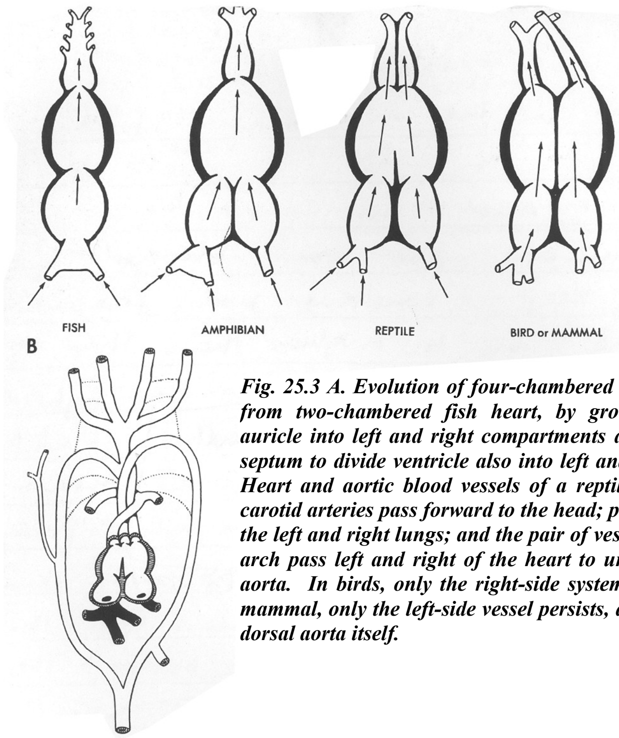

Fig. 25.3 A. Evolution of four-chambered heart of bird or mammal from two-chambered fish heart, by growth of septum dividing auricle into left and right compartments and later by extension of septum to divide ventricle also into left and right compartments. B. Heart and aortic blood vessels of a reptile; external and internal carotid arteries pass forward to the head; pulmonary arteries pass to the left and right lungs; and the pair of vessels forming the systemic arch pass left and right of the heart to unite behind as the dorsal aorta. In birds, only the right-side systemic vessel persists; in the mammal, only the left-side vessel persists, as the forward part of the dorsal aorta itself.

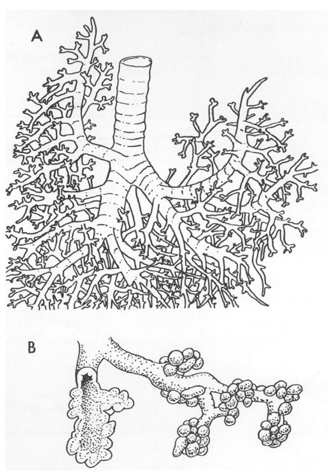

Fig. 25.4 Detail of mammalian lung. A. Part of the branching system of bronchial tubes and bronchioles, ending in alveolar chambers where gaseous exchange between air and blood occurs. B. Enlarged bronchiole and alveolar chambers.

The highly efficient blood system works in conjunction with equally highly developed respiratory system. Air drawn in through the nasal passages where it is warmed and cleaned, passes through the pharynx, larynx, and trachea on its way to the lungs where it receives oxygen. The tracheal tubes are guarded from collapse by rings of cartilage. The trachea further branch into bronchi and bronchioles to reach the round sac like alveoli where gaseous exchange occurs with the blood cells. The aleoli are very small air chamber of which there are said to be as mainly as 700 million in man providing total surface area for gaseous exchange of more than 50 square meters. The influx of air is effect by the activities of the intercostals and diaphragm muscle. The muscles between the ribs (intercostals) contact to raise the ribs. The diaphragm contract to flatten its dome-shaped structure. The chest cavity is enlarged and air rushes in under pressure. When however they relax, the cavity decreases and air is pushed out.

3.2 Food Intake Adaptations - Skull, Jaws, Ears

Mammals need nutrition to produce energy in presence of oxygen. The nature of the skull and jaws ensure that food can be taken in and processed for digestion. The skull bones have been reduce in number but enlarged in their individual sizes. The original front side now has hole to accommodate the powerful jaw muscles. A bony portion separates the nasal and food passages to as far as the throat. Since the mammal is always active, it must have a constant supply of oxygen. The skull is largely swollen to accommodate the brain. The jaw bones are also reduced in number but increased in size (probably from fussion of parts) to ensure increase in strength. All these adaptations of the skull and jaw bones is to ensure that the powerful muscles will not break them under the stress of chewing. They also support the teeth which have been differentiated into different types for chewing (premolars and molars), for cutting the canines and the sharp pointed incisors for tearing. There are two sets of teeth in the mammal – the milk teeth and the permanent teeth. The original primitive mammalian set of teeth (totaling 44) is adapted in many various ways. Each half jaw (primitive) in the adult has three shard-edged incisors in front, a single large pointed canine, four premolars and three grinding molars. The number of teeth vary from mammal to mammal. The type of dentition is determined by feeding. The number and type of each set of teeth is called dentition. Table 25.1 shows the relationship between the type of food eaten and the type of teeth.

Fig. 25.5 The teeth of humans

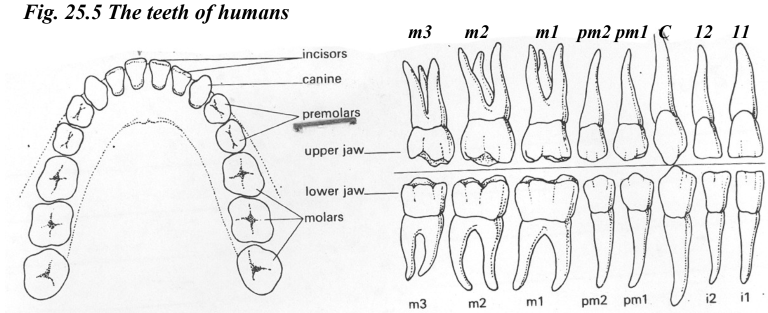

Table 25.1: Relationship between the type of food eaten and the type of teeth.

Animal	Type of food	Dental formula i c p m	Jaw movements	Special features
Dog	Meat	$\frac{3}{3}\ \frac{1}{1}\ \frac{4}{4}\ \frac{2}{3}$	Up and down only	Carnassials which have scissor-like action and canines for tearing
Rabbit		$\frac{2}{1}\ \frac{0}{0}\ \frac{3}{2}\ \frac{3}{3}$	Up and down and backwards and forwards	Long curved constantly growing incisors for gnawing. Flat ridged premolars and molars for grinding
Black rat	Vegetables and grass	$\frac{1}{1}\ \frac{0}{0}\ \frac{0}{0}\ \frac{3}{3}$		
Horse	Grass	$\frac{3}{3}\ \frac{1}{1}\ \frac{4}{4}\ \frac{3}{3}$	Side to side	Incisors for tearing grass and broad flat back teeth for grinding.
Sheep, Cow	Grass	$\frac{0}{3}\ \frac{0}{1}\ \frac{3}{3}\ \frac{3}{3}$	Side to side	Hard pad instead of upper canines and incisors
Man	Meat and vegetables	$\frac{2}{2}\ \frac{1}{1}\ \frac{2}{2}\ \frac{3}{3}$	Up and down side to side backwards and forwards	

Irrespective of their type and shape, all the teeth have the same basic structures: the part of the tooth above the gum called crown; the neck, is the slightly narrowed portion at the level of the gum. It also has the portion imbedded in the jaw bone called the root. The tooth is made up of a hard substance called dentine which surrounds a central pulp cavity. The pulp cavity contains blood vessels and nerves with which the tooth is nourished and sensitized

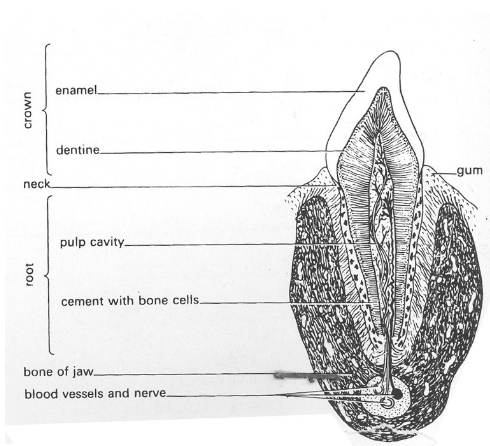

Fig. 25.6 Section through tooth

In some mammals, the tooth stops growing when it reaches a certain size it stops growing. The hole at the tip of the root through which it gets its blood and nerve supply becomes very small. Such a tooth is a closed tooth. In herbivores like the rabbit, sheep and horse the hole is very large. The teeth grow as fast as they are worn off.

3.2.1 Self Assessment Exercise 25.1

List the general trend in the adaptation of mammals for taking in their food.

3.2.2 The Ear

Another advance in the mammal is the presence of three pieces of bone in the ear which form a chain in articulation. These are called the stapes (or stirrup) which corresponds to the columella of the amphibians (you remember amphibian reptiles and birds only have one bone the columella) which transmit vibrations from the center to the inner ear. The outer two, the anvil and the hammer are said to be derived from displaced jaw angle bones of the reptile.

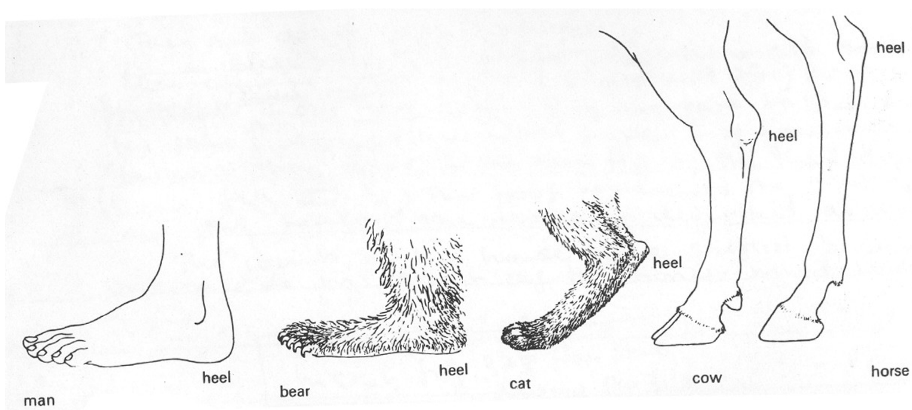

Fig. 25.7 Hind-limb of some animals.

The organ of hearing is highly developed in mammals. Accompanying this is the development of the voice. In mammals it produced by the air column passing between the vocal cords in the larynx at the upper end of the trachea.

3.2.3 Adaptation for Running – Bones and Joints

Generally speaking, mammals are the only vertebrates constructed for running. It must run to find food or to escape from being eaten. The four legged ones swing their legs to and fro with elbows pointing back and knees pointing forward. This is accompanies with many changes in the basic structure of bones, muscles and joints. One of the first features indicating adaptation for fast movement is the posture of the foot. You notice that when you are walking, your feet are flat on the ground. When however, you have to run, your heels are raised, and you move on your toes. By doing this you increase your speed by lengthening your legs. Animals which move on their whole feet are not fast movers. These, which move on the flat of their feet are described as plantigrade. They are different from the subplantigrades which rest with the sole of their feet on the ground and move on the end joints of the fingers and toes, like the hare. Cats and dogs stand and walk on the end joints of their toes and fingers. They have their heels and toes permanently lifted from the ground. They are digitigrade animals.

Basically, the limbs of mammals end in five digits (you can re-read section 3.3.1 of unit 25). However horses today have only one digit. They are said to have evolved from the five digit ancestral type. They gradually had to loose because they walk on the very tip of the third digit (see Fig. 25.6). The hoof represents the nail of the digit, for this reason the horse is described as unguligrade.

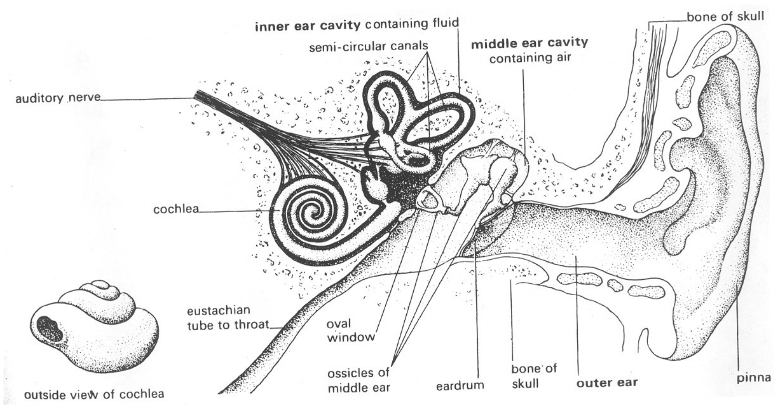

Fig. 25.8 Diagrammatic section of human ear.

The joints in the horse have shifted because of the increase in length of the bones. What looks like the elbow is really the wrist because of the increased length of the bones of what should be the palm. The elbow is inside the body of the animal (see the diagram 25.6 again).

Sheep and cow are unguligrades but they have two digits (3^{rd} and 4^{th}) still functional. The nails of these two digit form the cloven hoof. The vestiges of the second and the fifth are tiny projections behind the hoof now. They do not touch the ground. In bats (the only mammals which can actively fly) the fore limb is modified to form a wing. It differs from the wing of birds because the hind limb is also part of the wing in the bat. The wing is a fold of skin supported by the forearm and forefingers – spread out and elongated.

The short thumb has a hooked claw and projects forwards from the edge of the wing. The membrane of the wing is joined to the ankle of the foot and extent between the legs. It can only manage awkward ground movement because of the adaptation for flight. This locomotion is related to flesh eating. This is in turn related to increase in size of brain for increased alertness, balance, and welfare.

3.2.4 Self Assessment Exercise 25.2

List in short sentences the pattern in the adaptation of mammals for running.

3.2.5 Maternity – Adaptations for care of young

Mammals demonstrate a high degree of care for their young. You remember the amniotic egg of the birds and reptiles, how though laid on land, live in a fluid environment in the shell. Only the primitive mammals lay egg. In all other mammals, the egg remains in the body for much longer time. This retention helps to protect the developing embryo and saves the female the trouble of having to guard the eggs. It also increases their chances of survival for the embryo. Some retiles (snakes) also give birth to their young alive like mammals. Birds however are known not to have such members who give birth to their young ones alive. This is probably related to their flying habit in which they cannot afford to bear such burden in flight.

Mammals retain the fertilized egg and nourish it with the maternal tissues. The mammalian egg is much smaller than those of the birds and reptiles. It is just visible to the naked eye. The egg and the maternal system carrying the egg has been considerably transformed. The developing egg becomes attached to the wall of uterus or womb. It is housed in the placenta and attached to the uterus by the umbilical cord. It is through the placenta that the embryo receives oxygen and nutrients from, as well as sends out wastes matter into the maternal blood stream of the components of the amniotic egg, only the amnion persist in its original state and serves as a protective water jacket around the developing embryo. It forms the foetal membranes which rupture during the birth of the young mammal.

3.2.6 Mammary Gland

Mammals suckle their young after they are born from the mammary gland until they (the young) are able to fend for themselves. So you see that the whole process of reproduction from the time of attaining sexual maturity, to mating, birth and weaning of the young become a complex issue involving physical, physiological and behavioural controls. The climax of this complexity is found in man.

The two main groups of mammals are the pouched mammals and the true placenta mammals. The pouched mammals (the marsupials) have been relatively unsuccessful in attaching the placenta to the wall of the uterus. The young are born premature and are suckled with the protective pouch called marsupium. The microscopic shell and virtually yolk less eggs are retained in the uterus to develop for about two weeks. Then they are born small and premature to suckle in the marsupium for a long time. All other mammals have true placenta.

3.2.7 Self Assessment Exercise 25.3

In short listed sentences describe how mammals care for their young.

3.3 Diversity

Mammals are so diverse in size. They range from the small quarter-ounce shrew to the eighty-foot, hundred-ton whale. Mammals have become adapted to every mode of life – walking, running, burrowing, swimming, climbing and flying and feed in all possible ways. Some chew grass, some tear flesh, some sieve plankton, while others catch insects on the wing. Each feeding habit is reflected in the nature of their teeth.

The original mammalian diet seem to have been small forms of animals like grubs, worms, winged and wingless insects inspite of their variety they have retained some fundamental similarities. There are seven cervival vertebrae in all (elephant, mice, man, giraffe etc). The class insectivore are equipped with long pointed nose and long tapering tongue to lick up multitude of minute insects. All hoofed forms feed on vegetation. Most ungulates have to be fast runners to escape being eaten by flesh eaters. This has necessitated changes in the skeleton of the limb. They have developed hooves for gaining traction on the ground as they run. Mammals include; horses, zebras, deer and cattle. Rodents are vegetation. They are also called knawing animals and described as the most successful of all mammals. All rodents have efficient grinding teeth. Most herbivorous mammals are a source of protein for man. Flesh eating mammals include the cats family great and small, the weasels, bears, rancoons, dog and seal families. These all have retained their incisors for tearing and biting. Cetaceans (whales) and porpoises are air breathing warn-blooded mammals that bear and suckle their young in the typical mammalian fashion. They have however completely readapted to life in water. Their bodies have adopted fish like forms with fish-like tail, hydroplane flippers and dorsal fin. The neck bones are squashed to enforce a streamline shape. The hind limbs have been eliminated. Examples are dolphins and whales.

Primates, like monkeys are arboreal. Their feet are used for grasping and climbing. Their diet omnivorous and their vision stereoscopic.

3.4 Tutor-Marked Question 25

Why is the skin important to the mammal?

4.0 Conclusion

In this unit you have learnt about the general characteristics of mammals. You have also learnt of their wide range of adaptive features which make them one of the most successful groups of animals on land. You have learnt of how they are more developed than the rest of other vertebrates.

5.0 Summary

You can well say that even through mammals can be described as the most advanced of all chordates, the reptiles are most adapted for walking chordates, whilst birds are the most adapted for flying.

6.0 Answer to Self Assessment and Practice Exercises

Practice Exercise 1
Your answers are correct if they are like these:

- Skin bears hairs with two types of glands – sebaceous and sweat.
- Bony
- Two pairs of pentadactyl limbs
- Visceral cleft never develop gills
- External ear in addition to middle inner ear
- Only two general lay eggs
- Embryo develops in mother
- Mothers mammary glands feed new born
- Fertilization internal
- Different types of teeth for different functions
- Muscular diaphragm between thorax and abdomen
- Homeothermic.

Practice Exercise 2

Look at Fig. 25.1 this the answer to the exercise learn it over again

Practice Exercise 3

Fig. 25.3 is the answer to this practice exercise. Learn it over again.

Self Assessment Exercise 25.1

The nature of the jaws and skull need to ensure that food can be taken in. So the following are the trend:

- Skull bones reduced in number but enlarged in size.
- Original front of skull now has a hole to accommodate powerful jaw muscles.
- Bony separation between nasal and food paths.
- Jaw bones reduced in number but increased in size.
- Reduction in number may mean fusion of parts for greater strength
- Jaw bones house differentiated teeth
- Teeth differentiated by food type – for tearing, cutting and grinding.
- Number of type of teeth vary with feeding habit.
- Tooth structure basically same
- Large skull house enlarged brain
- Better developed brain ensure alertness
- Three ear ossicles for sensing vibrations
- Emergence of a voice box

Self Assessment Exercise 25.2

Runners are adapted by:

- Decrease in the number of digits to one or two
- Raising of heels
- Standing on end joints of toes and fingers
- Lengthening of bones
- Nails become hooves

Self Assessment Exercise 25.3

Mammals care for their young by:

- Only primitive mammals lay eggs
- Premature young of egg-layers snokled for a long time in the massupium
- Other mammals have placenta
- Retain fertilized egg
- Nourish embryo from maternal tissues
- Pass out excretory material through maternal tissues.
- Amniotic fluid protects embryo against shock
- Mammary gland suckle young

7.0 References

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