FOREWORD

Since its establishment in 1976, Acharya Nagarjuna University has been forging ahead in the path of progress and dynamism, offering a variety of courses and research contributions. I am extremely happy that by gaining a B++ (80-85) grade from the NAAC in the year 2003, the University has achieved recognition as one of the front rank universities in the country. At present Acharya Nagarjuna University is offering educational opportunities at the UG, PG levels apart from research degrees to students from about 300 affiliated colleges spread over the three districts of Guntur, Krishna and Prakasam.

The University has also started the Centre for Distance Education with the aim to bring higher education within reach of all. The Centre will be a great help to those who cannot join in colleges, those who cannot afford the exorbitant fees as regular students, and even housewives desirous of pursuing higher studies. With the goal of bringing education to the doorstep of all such people, Acharya Nagarjuna University has started offering B.A., and B.Com courses at the Degree level and M.A., M.Com., M.Sc., M.B.A. and L.L.M. courses at the PG level from the academic year 2003-2004 onwards.

To facilitate easier understanding by students studying through the distance mode, these self-instruction materials have been prepared by eminent and experienced teachers. The lessons have been drafted with great care and expertise within the stipulated time by these teachers. Constructive ideas and scholarly suggestions are welcome from students and teachers involved respectively. Such ideas will be incorporated for the greater efficacy of this distance mode of education. For clarification of doubts and feedback, weekly classes and contact classes will be arranged at the UG and PG levels respectively.

It is my aim that students getting higher education through the Centre for Distance Education should improve their qualification, have better employment opportunities and in turn facilitate the country's progress. It is my fond desire that in the years to come, the Centre for Distance Education will grow from strength to strength in the form of new courses and by catering to larger number of people. My congratulations to all the Directors, Academic Co-ordinators, Editors and Lesson - writers of the Centre who have helped in these endeavours.

Prof. V. Balamohandas
Vice - Chancellor,
Acharya Nagarjuna University

DM - PAPER - 1
SYSTEMATICS AND ANATOMY OF INVERTEBRATES
Syllabus

UNIT - 1

General organization and classification of the Phylum Protozoa upto orders. Various types of reproductive processes in protozoa.

General organization and classification of the Phylum Porifera upto orders. Development in sponges.

UNIT - II

General Organization and classification of Phylum Coelentarata upto orders. Polymorphism in coelenteratas

General organization and classification of Phylum Platyhelmnthes upto orders. Parasitic adaptations in platyhelminthes

General organization and classification of Phylum Nemathelminthes upto orders.

UNIT - III

General organization and classification of Phylum Annelida upto orders.

General organizaton and classification of Phylum Arthropoda upto classes.

Trochophore larva and its evolutionary significance.

UNIT - IV

General organization and classification of Phylum Mollusca upto orders.

General organization and classification of Phylum Echinodermata upto orders. Larval forms in echinoderms.

UNIT - V

Minor Phyla - the general organization of Rotifera, Ectoprocta, Sipuncula, Chaetognatha.

LIST OF TEXT BOOKS :

1. T.J. Parker & W.A. Haswell, 1972. A Text book of Zoology, Vol.I, Invertebrates. (Eds.), A.J. Marshall & W. D. Williams ELBS. and Macmillan.
2. A. Kaestner, 1967. Invertebrate Zoology Vols. I to III, John Wiley & Sons Inc., New York.
3. V. Frrettar & A. Graham, 1976. A Functional Anatomy of Invertebrates. Academic Press Inc. (London) Ltd.
4. Hyman, L.H. 1953. The Invertebrates, Vols. I to VI. McGraw-Hill Book Company, New York, London
5. Borradaile, F., Potts, 1962. The Invertebrates. Asia Publishing House.
6. Robert, D. Barnes, 1980. Invertebrate Zoology. W.B.Saunder's Company, Japan.
7. A. Sedgwick, 1972. A text book of Zoology. Vol. I&II, Central Book Depo, Allahabad.
8. E.J.W. Barrington, 1971. Invertebrate structure and function. ELBS.

M.Sc., Degree Examination, December 2004

PAPER - I : SYSTEMATICS AND ANATOMY OF INVERTEBRATES

1st Year, Zoology

Time : Three hours Max. Marks : 100

All questions are compulsory
Each question carries 20 marks
Draw the diagrams wherever necessary

1. a) Classify the Phylum Porifera upto orders giving their general characters and suitable examples.

   or

   b) Write short notes on :

      i) Reproductive processes in protozoa

      ii) Development in sponges.

2. a) What are the salient features of Phylum Nemathelminthes? Classify upto orders.

   or

   b) Write shortnotes on :

      i) Polymorphism in coelenterates

      ii) Parasitic adaptations in platyhelmenthis.

3. a) Write in detail the general features of different classes in Phylum Arthropoda.

   or

   b) Write shortnotes on :

      i) Trochophore larva.

      ii) Excretion in earthworm.

4. a) Describe the general characteristics of Phylum Mollusca. Classify upto orders with examples.

   or

   b) Write shortnotes on :

      i) Bipinaria larva.

      ii) Echinopluteus larva.

5. a) Give an account of general organization of Rotifers.

   or

   b) Write shortnotes on :

      i) Reproduction in Ectoprocta.

      ii) Chaetognatha - Habit, Habitat and External features.

M.Sc., Degree Examination, December 2005

PAPER - I : SYSTEMATICS AND ANATOMY OF INVERTEBRATES

1st Year, Zoology

Time : Three hours Max. Marks : 100

All questions are compulsory
Each question carries 20 marks
Draw the diagrams wherever necessary

1. a) Describe the general characteristic features of phylum protozoa and classify it upto class level with examples.

or

b) Write short notes on :

i) General organization of phylum Porifera.
ii) Types of reproduction in phylum Protozoa.

2. a) What are the salient features of Phylum Coelenterata and explain in detail the polymorphism in it.

or

b) Write shortnotes on :

i) Parasitic adaptations in Platyhelminthes.
ii) Classification of Nematyhelminthes.

3. a) Mention the classes of phylum Arthropoda and describe their salient characteristic features with suitable examples.

or

b) Write shortnotes on :

i) Evolutionary significance of Trochophore larva.
ii) General organization of phylum Annelida.

4. a) Classify the phylum Mollusca and explain the general characteristic features of it.

or

b) Write shortnotes on :

i) Water Vascular system in Echinoderms
ii) Larval forms of Echinoderms.

5. a) Give an account on the general characters of Rotifera and add a note on its affinities.

or

b) Write shortnotes on :

i) Characters of Chaeognatha.
ii) Affinities of Ectoprocta and Sipunculoidea.

M.Sc. (ZOOLOGY) (Previous) DEGREE EXAMINATION :: MAY 2006

Paper - I : SYSTEMATICS AND ANATOMY OF INVERTEBRATES

Time: Three hours Maximum : 100 Marks

Answer ALL Questions
Each question carries 20 marks

1. (a) Write an essay on reproduction in protozoa.

Or

(b) Write notes on:
   (i) Parasitic protozoa
   (ii) General organization of Porifera.

2. (a) Discuss on the parasitic adaptations in Platyhelminthes.

Or

(b) Write notes on:
   (i) Polymorphism in coelenterate
   (ii) General organization of Nematyhelminthes.

3. (a) General organization of Arthropods.

Or

(b) Write notes on:
   (i) Reproduction in Annelida
   (ii) General features of Insects.

4. (a) Describe the general organization of Echinodermata.

Or

(b) Write notes on:
   (i) Bipinnaria larva
   (ii) Classify Mollusca upto orders.

5. (a) Write an essay on the general characters of Rotifera.

Or

(b) Write notes on:
   (i) Sipunculoidea
   (ii) Chaetognatha.

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CONTENTS

UNIT - 1

1.1 GENERAL ORGANIZATION OF PHYLUM PROTOZOA

1.1.1 OBJECTIVES

The purpose of this lesson is to:

- understand the general characters of protozoans
- exemplify the various groups of protozoans with the help of diagrams.
- study the general physiology of protozoans

1.1.2 INTRODUCTION

Protozoans are unicellular eukaryotic organisms. The Phylum Protozoa is a heterogeneous assemblage of some 80000 single-cell organisms. Protozoans possess typical membrane-bound cellular organelles. Hence, they are called as eukaryotes. Many of the protozoans are animal like, motile and heterotrophic.

1.1.3 HABIT AND HABITAT

Protozoans occur as solitary individuals and colonial forms. Some colonial forms, such as *Volvox* attain a degree of cellular interdependence, they approach a true multicellular level of structure. Both solitary and colonial species may be either free moving or sessile. Majority of protozoa are microscopic. *Anaplasma,* a blood parasite is so small that it occupies 1/6 to 1/10th of a RBC. A fresh

water ciliate, *Spirostomum* may reach a length of 3 mm and may be seen with the naked eye. Gas exchange occurs by diffusion across the cell membrane. Protozoa that live in the digestive tract of other animals can exist with little or no oxygen is present. Metabolic wastes diffuse to the outside of the organism. Ammonia is the principal nitrogenous waste material, and the amount eliminated varies directly with the amount of protein consumed.

The protozoa occur in the free-living state and as parasites. Free-living protozoa occur wherever moisture is present. They are found in both fresh and salt water, in the soil and decaying organic matter. It has been observed that they can tolerate excessive cold but easily killed by extreme heat.

Most of the protozoans live either in fresh or salt water, some groups live in both. Radiolarians are exclusively marine forms. Foraminiferans are mostly marine forms. Heliozoans are typically fresh water forms with few marine representation. Protozoans in the soil encyst during unfavorable conditions and they excyst under favorable conditions. Parasitic forms occur in all classes of protozoa-Mastigophora, Sarcodina, Sporozoa and Ciliata. The class Sporozoa contains exclusively parasitic forms.

1.1.4 STRUCTURE

The body of protozoans is usually bounded by cell membrane. The rigidity of the body and its shape are largely dependent on the nature of cytoskeleton. The cytoskeletons are not always located immediately below the cell membrane. The cytoskeleton together with the cell membrane and other organelles, forms the pellicle (a sort of protozoan cell wall). Protozoan skeletons can also b exoskeletons. They may be secreted onto the outer surface of the cells. Exoskeletons are usually called testa.

The majority of protozoa have a single nucleus. One nucleus is large and is called as macronucleus. The other is smaller and is called as micronucleus. The micronucleus lies close to the macronucleus. The macronucleus is associated with the vegetative function and the micronucleus with the reproductive function.

The protozoan locomotor organelles include flagella, cilia or flowing extrusions of the body called pseudopodia. These are the distinguishing characters of the protozoans.

1.1.5 NUTRITION

All types of nutrition occur in protozoa. The modes of nutrition are of four types: holozoic, holophytic, saprozoic and parasitic. In holozoic nutrition, small organisms like bacteria, algae, diatoms and other protozoa form the food. Many protozoans ingest food particles or prey and digest them intracellularly within food vacuoles. Food reaches the food vacuole often through a cell mouth or by engulfment. In flagellates, there is a definite mouth or cytostome at the base of the flagellum. The food particles are driven towards mouth by the lashing movements of the flagellum. In choanoflagellates, there is a funnel like structure surrounding the base of the flagellum. The flagellar movements waft the small organisms into the funnel. In sarcodines, mouth or digestive tract is absent. Small organisms are caught by the pseudopodia. Food is digested in the food vacuole.

In ciliates, there is a well-developed mouth or cytostome leading into a specialized part, the gullet or cytopharynx. Ingested food enters a vesicle or food vacuole. The food binds in the food vacuole and fuses with the primary lysozymes already present in the cell (Fig.1-1). Fusing results in the release of lysosomal and hydrolytic enzymes into the vacuole. Digestion occurs in the food vacuole and products of intracellular digestion diffuse into the cytoplasm. The undigested material is released from the cell to the exterior. The residual vesicle fuses with the cell membrane and are discharged to the exterior of the cell in a process called exocytosis.

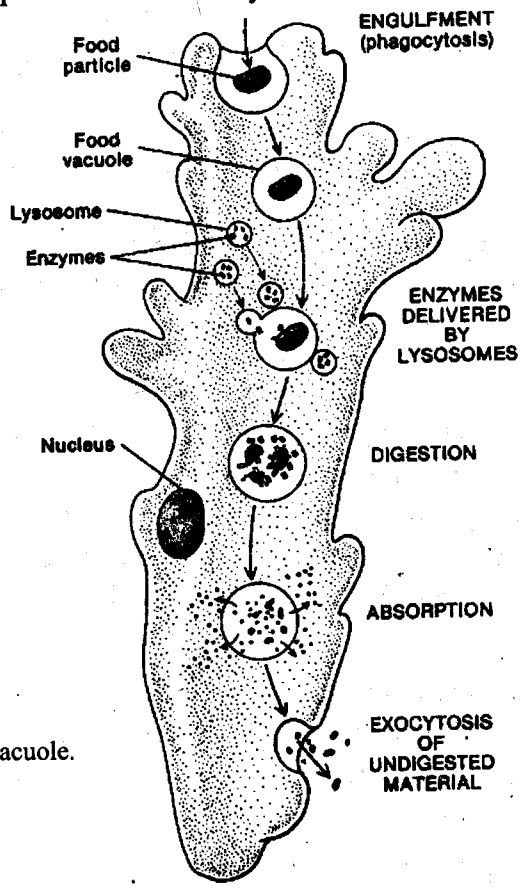

Fig. 1-1.
Digestion within a food vacuole.

In holophytic nutrition, the nutrition process is effected with the help of chlorophyll. This process is similar to that of photosynthesis in plants. This type of nutrition is characteristic of phytomonadin flagellates. Pyrenoids are associated with this nutrition. They help in the formation of reserve food.

In saprozoic nutrition, the food, which is not solid, is absorbed by diffusion through body surface. Saprozoic animals live in media containing decaying organic matter. Mouth is absent in them. The nutritive substances enter protozoan cells in a variety of ways. The extra cellular materials enter the cell in minute pits on the cell membrane. Later these pits pinch off internally, a process called endocytosis. The nonspecific form of endocytosis (in which the rate of uptake is in proportion to the external concentration of the material being absorbed) is called pinocytosis. Water, ions and smaller molecules may be taken in through pinocytosis. The engulfment of bacteria and other small protozoa is known as phagocytosis.

1.1.6 LOCOMOTION

Several types of locomotor organelles occur in the Phylum Protozoa. In most of the protozoa, the locomotor organelles also serve for food capture. Flagella and cilia are the locomotor organelles in the flagellates and ciliates. The flagellum is an whip like extension of the cytoplasm. It contains an axial filament, axoneme surrounded by a contractile protoplasmic sheath. The number of flagella may vary from 1 to 8 or more in various groups. When there is a single flagellum, it arises from the anterior end or from near the posterior end (*Trypanosoma*). Numerous flagella are present in hypermastigotes (*Trichonympha*). In parasitic flagellates (*Trypanosoma*), an undulating membrane extends between the flagellum and to the extreme anterior end (in addition to flagellum). In some dinc flagellates (*Ceratium*), there is a longitudinal flagellum and a transverse flagellum. Both flagella and pseudopodia occur in some mastigophorans (*Mastigamoeba*). Few of these possess pseudopodia in one phase of life cycle and flagellum in another phase.

Pseudopodia occur in the sarcodines. Pseudopodia are the temporary extensions of the cytoplasm. Basing on the difference in form and structure, pseudopodia are classified into 4 types:

Lobopodia, lobe like pseudopodia with broad, round ends having both the ectoplasm and the endoplasm (as in *Amoeba*)

Filopodia, more or less filamentous and composed of ectoplasm only (as in *Allogramia*)

Reticulopodia, also filamentous and thread like (as in *Globigerina*). They branch and anastomose to form network. This type occurs in foraminiferans.

Auxopodia, more or less straight and radiating pseudopodia and composed of ectoplasm. The fine and needle like pseudopodia are called auxopodia. (as in *Actinophrys* and *Actinospherium*). These are characteristic of heliozoans.

In the ciliates, the locomotor organelles are the cilia. These are like flagella. These a , the protoplasmic projections. These are shorter and many arising from basal granules lying in the cor x. In Holotricha, cilia are usually arranged in longitudinal, oblique or spiral rows and cover the whole body. In Hypotricha and Peritricha, cilia are restricted to certain regions. Also, in Hypotrichia, cilia are fused to form cirri. They are restricted to ventral region. In Suctoria (sessile forms), cilia are present in the young stage and absent in the adult. The locomotor organelles in various groups serve the active locomotion and food catching function.

1.1.7 REPRODUCTION

In Protozoa reproduction takes place by asexual and sexual methods. Asexual reproduction takes place by a process of binary fission, budding and multiple fission.

Binary fission – in this process the parent divides into two nearly equal daughter cells. This occurs in *Amoeba, Arcella, Difflugia* etc.

In flagellates the division is longitudinal. This occurs in *Paramecium.* The division is transverse in few forms (*Polystoma* etc. and certain dinoflagellates).

In ciliates the division is usually transverse. In *Opalina* and *Actinosphaerium,* the body divides into two without any relation to the number of nuclei. This kind of division is known as plasmotony.

Budding may be exogenous (as in *Noctiluca* etc) or endogenous (*Tokophyra* and in certain suctorians).

Multiple fission (or spore formation or schizogony) occurs typically amongst sporozoans. In this process the parent nucleus divides into a number of daughter nuclei. Then, the cytoplasm aggregates around the bits of nuclei, resulting in a number of daughter cells. Thus, the parent gives rise to a number of daughter individuals by multiple fission. Many protozoa reproduce by sexual mode in a manner, which is comparable to the reproduction of higher animals. Two individuals or gametes unite and their nuclei may fuse into one. This fusion is known as syngamy and the cell resulting from such union is called a zygote. Its nucleus is called synkaryon. If the uniting gametes are similar in size and form, they are called isogametes and if they are dissimilar, they are called anisogametes. The union of isogametes is termed isogamy and the union of anisogametes is anisogamy. The larger anisogamete is known as macrogamete and the smaller is the microgamete. The temporary union of two individuals for the nuclear exchange is known as conjugation. This is found in ciliates. The uniting individuals known as conjugants, may be unequal as in *Vorticella* and equal as in *Paramecium*. The occurrence of nuclear reorganization in an individual (without nuclear contribution from another individual) is known as endomixis.

1.1.8 MASTIGOPHORANS (FLAGELLATES)

The flagella of some species of phytoflagellates, such as *Ochromonas*, bear stiff lateral fibrils, called mastigonemes, which cannot be seen with ordinary light microscope. Mastigonemes probably function to reverse water propulsion.

Mastigophorans that have thin, flexible pellicles are often capable of amoeboid movement. Some forms, such as Chrysomonads, may cast off their flagella and assume an amoeboid type of locomotion entirely. Many flagellates cannot be classified as strict autotrophs or heterotrophs, because intermediate condition exists in some forms.

For instance, some species such as *Euglena* are strictly photoautotrophic and can synt[illegible] organic compounds from inorganic sources. It can also become saprophytic in the absence of light and even loses its pigments. *Haematococcus* is holophytic in the light and also saprophytic in the dark.

A number of chrysomonads and some dinoflagellates are both autotrophic and heterotrophic. Strict heterotrophic nutrition occurs in zooflagellates.

Biology of flagellata groups:

Flagellates vary so greatly in structure and have distinct anterior and posterior ends. Most are free swimming but there are some sessile forms. There are also many species that are colonial.

Euglenophyceae:

Marine and fresh water for[illegible]. Contain chlorophyll and are classified with the green algae in the chlorophyta. The genera *Pera[illegible]a* and *Euglena* (Fig. 1-2) contain perhaps the familiar flagellates. Body is elongated with an evagination (reservoir) at the anterior end, two flagella arise

from its wall. One flagellum is very small and it terminates at the base of the long flagellum. In the colorless *Peranema*, both flagella are long but one trails backwards. Nutrition in *Peranema* is holozoic and it can ingest living organisms including *Euglena.*

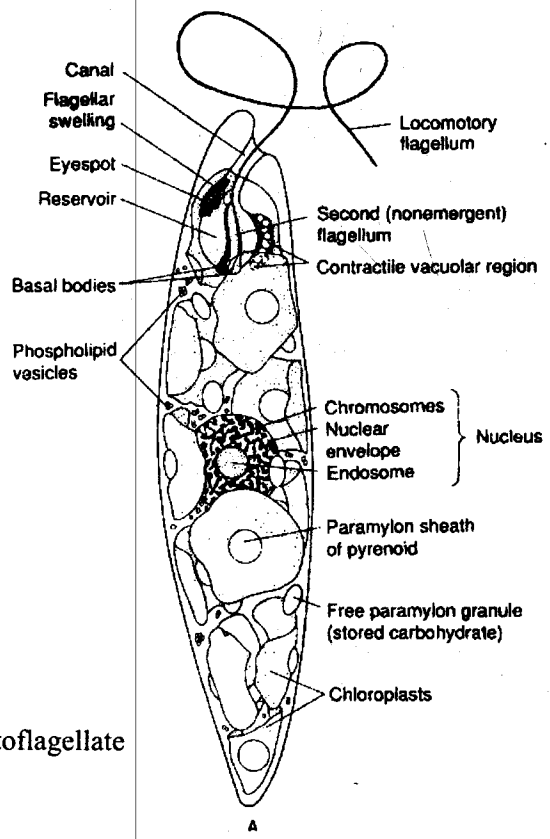

Fig. 1-2.
Structure of the phytoflagellate *Euglena gracilis.*

Chlorophyceae:

The large group of marine and fresh water green algae. It includes non-motile filamentous and thalloid forms, as well as some flagellates. The cells are bounded by a cellulose wall and are similar in organization to those of multicellular green plants. Among the flagellate groups, some are solitary, such as *Chlamydomonas,* and others are colonial. In colonial forms such as *Gonium, Pandorina* and *Eudorina*, the cells composing the colony varies from 4 to 64 and are held together by mucoid material.

Dinoflagellates:

Marine and fresh water dinoflagellates. These are allied with the brown algae and diatoms by the presence of xanthophyll pigment (that gives them a brown or golden brown color) and by the absence of chlorophyll b (chlorophylls a and c are present). They are roughly ovoid and typically possess two flagella. *Gymnodinium,* is said to be unarmored and naked. Armored dinoflagellates have well developed theca. The armor is like projections in *Ceratium*. *Noctiluca* is large and aberrant.

Choanoflagellida:

Marine and fresh water zooflagellates that contain a number of colonial forms. These are peculiar in having a cylindrical collar around the base of the single flagellum (Fig. 1-3A). The collar

is composed of rod like pseudopodia and filter fine particles from the water current produced by the beating of the flagellum. The particles are then engulfed. Many of these colonies are sessile and attached to the substratum directly or by a stalk. In *Proterospongia* (Fig. 1-3B), however, the colony consists of a gelatinous mass into which the flagellated collar cells are embedded. These are of particular interest as being the possible ancestors of sponges, which also possess collar cells.

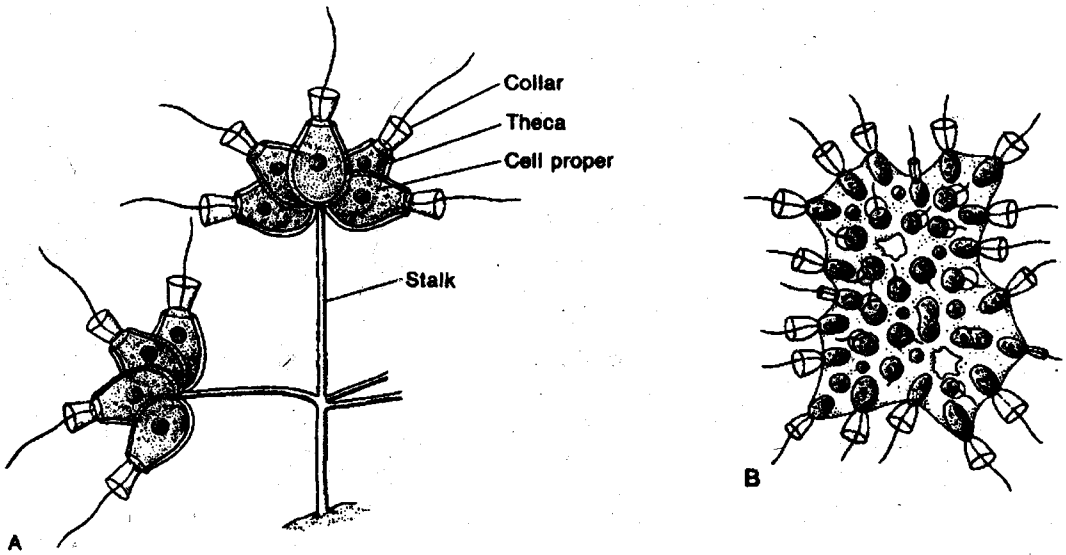

Fig. 1-3. Choanoflegellates, in which the flagellum is surrounded by a collar of microvilli. **A,** A stalked species. The stalk is an extension of a vaselike theca that surrounds the cell proper. ***B,*** *Proterospongia,* a colonial species, in which the individuals are connected by a jelly-like matrix.

Kinetoplastida:

Free living species as well as important parasites. All possess an organelle called a kinetoplast. Trypanosomids are gut parasites of insects and blood parasites of vertebrates. Only the anterior flagellum is present, the second flagellum being represented by a basal body. Commonly the flagellum trails and is connected along the sides of the body by an undulating membrane.

Man is the primary host for *Leishmania.* It is transmitted by sand flies and causes the disease leishmaniasis, or kala-azar, characterized by loss of hair, enlargement of the spleen and liver and other symptoms. Species of *Trypanosoma* (Fig. 1-4) cause African sleeping sickness and tropical American

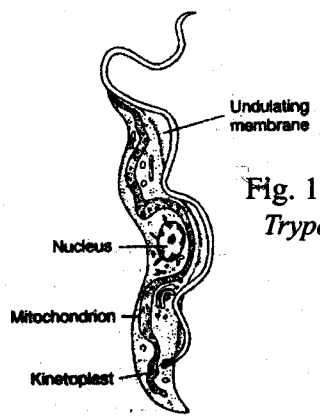

Fig. 1-4. Kinetoplastid-*Trypanosoma brucei.*

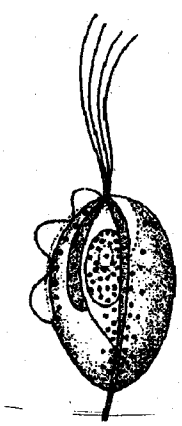

Fig. 1-5. *Trichomonas vaginalis,* a trichomonad, parasitic in the human vagina and male reproductive tract. In addition to the four anterior flagella, there is a trailing flagellum bordering an undulating membrane.

Chagas' disease. The infected person is afflicted with fever and brain symptoms, such as lethargy. Transmission is by blood-sucking bugs (Chagas' disease) and tsetse flies (Afrcian sleeping sickness).

Metamonad flagellates:

Few free living species (*Hexamita*) and some are parasitic in the gut or genital tract of vertebrates (*Trichomonas*) (Fig. 1-5).

1.1.9 SARCODINES

Adults possess flowing extensions of the body called pseudopodia. Pseudopodia are used in capturing prey in all Sarcodina, and in benthic groups, pseudopodia are also used as locomotor organelles. It includes the familiar amoebas as well as many other marine, fresh water and terrestrial forms. However, the skeletal structures, which are found in the majority of species, reach a complexity and beauty that is surpassed by few other animals.

There is an evidence of a close phylogenetic relationship between the Sarcodina and the Mastigophora. As already mentioned, many mastigophorans undergo amoeboid phases in which the flagellum is lost and movement is achieved by pseudopodia. The presence of flagellated gametes among many sarcodines and the tendency of loosing flagella during their life cycle in flagellates would seem to indicate that the Mastigophora is the ancestral group.

Amoebae are naked or enclosed in a shell. The naked amoebas, which include the genera *Amoeba* (Fig. 1-6), *Pelomyxa* live in sea, fresh water and soil. Asymmetrical and constantly change their body shape. Some giant species reach several mm in length. Cytoplasm is divided into stiff ectoplasm and fluid endoplasm. Pseudopodia are off 2 types:

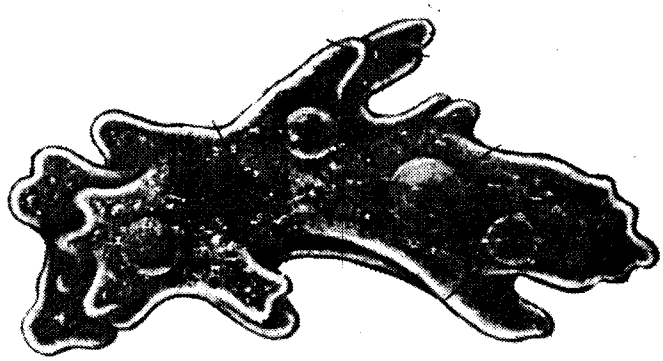

Fig. 1-6. *Amoeba*

Lobopodia – typical of most amoebas, wide with rounded or blunt tips or tubular composed of both ectoplasm and endoplasm.

Filopodia – present in small amoebas. Tend to have pointed ends. Consist of ectoplasm only.

In shelled amoebas, which are inhabitants of fresh water, damp soil, the shell is secreted by the cytoplasm, it is either chitinoid or siliceous or is composed of foreign materials embedded in a cementing matrix. The amoeba is attached to the inner wall of the shell by protoplasmic strands and there is a large opening through which the pseudopodia or body can be protruded. In *Arcella* (Fig. 1-7A and B),