PITHAPUR RAJAH'S GOVERNMENT COLLEGE

Autonomous and NAAC Re-accredited with 'A' Grade (3.17/4.00 CGPA)

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DEPARTMENT OF MICROBIOLOGY

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eukaryotic microorganisms

General characteristics

- Fungi are ***achlorophyllous, heterotrophic, eukaryotic thallophytes***.
- They are **non-green in color** with the capacity to live in all kinds of environments. They generally **feed on dead and decaying organic matter.**
- Fungi are eukaryotic organisms that include microorganisms such as **yeasts, moulds and mushrooms**. These organisms are classified under kingdom fungi.

FUNGI KINGDOM

Fungi can't make their own food.
They obtain **nutrients from the remains** of dead plants and animals.
Fungi can be **unicellular** or **multicelular**.

unicellular fungi

YEAST

Yeast is used to make bread.

*yeast

multicellular fungi

MOULD

Mould usually grows on food that is in bad conditions.

*mould

MUSHROOMS

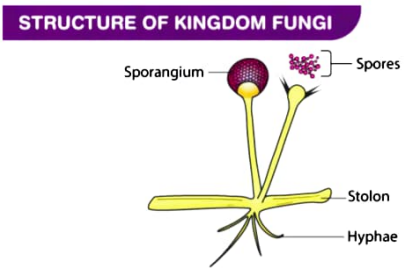
They grow from the underground. They can be edible or poisonous.

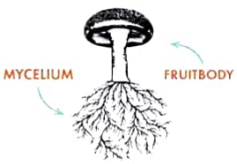
*mushrooms

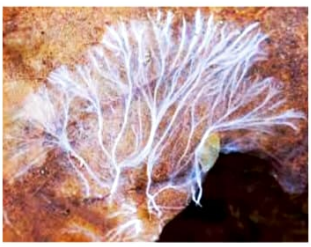
- **Habitat:** Fungi are very **abundant and widespread in nature**. They can virtually exploit any habitat on earth because of their **ability to utilise any substrate that contains traces of organic compounds**.
- **Fungal spores** are found in soil, water and air. They grow even in harsh environmental conditions such as in hot deserts, on cold mountains, on rocks and anywhere on living and dead organisms.
- Normally fungi grow between **0° to 30°C** with an optimum temperature range of **20°to 30°C.** Many fungi tolerate low temperature of **5° to 6°C** even below freezing.

Structure of Fungi

- Almost all the fungi have a **filamentous structure** except the **yeast cells.**
- They can be either **single-celled or multicellular organisms**.
- Fungi consist of long thread-like structures known as **hyphae**. These hyphae together form a **mesh-like structure** called **mycelium**. **Stolon**, stem like horizontal extensions that produce new individuals by budding
- Fungi possess a **cell wall** which is made up of **chitin and polysaccharides**.
- The cell wall comprises a protoplast, which is differentiated into other cell parts such as cell membrane, cytoplasm, cell organelles and nuclei.
- The nucleus is dense, clear, with chromatin threads. The nucleus is surrounded by a nuclear membrane.







Fungal mycelium

Yeast cells

Nutrition

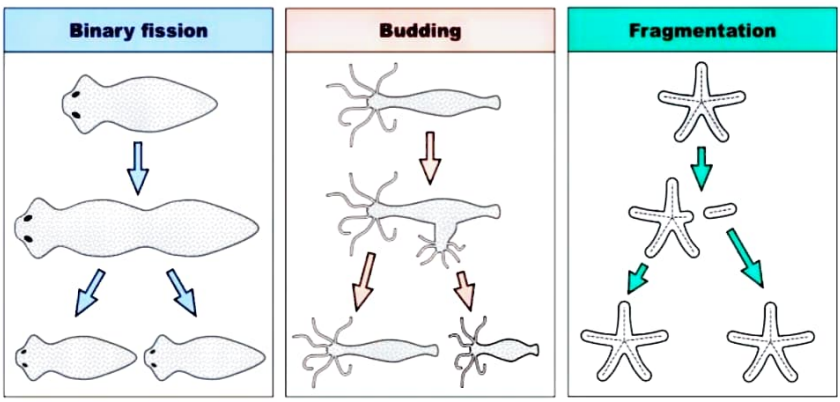
- On the basis of nutrition, kingdom fungi can be classified into 3 groups.
- **Saprophytic** – The fungi obtain their nutrition by feeding on **dead organic substances**. Examples: *Rhizopus, Penicillium* and *Aspergillus*.
- **Parasitic** – The fungi obtain their nutrition by **living on other living organisms** (plants or animals) and absorb nutrients from their host. Examples: *Taphrina* and *Puccinia*.
- **Symbiotic** – These fungi live by having an **interdependent relationship** with other species in which both are mutually benefited. Examples: **Lichens** and **mycorrhiza.** Lichens are the symbiotic association between algae and fungi. Here both algae and fungi are mutually benefited as fungi provide shelter for algae and in reverse algae synthesis carbohydrates for fungi.

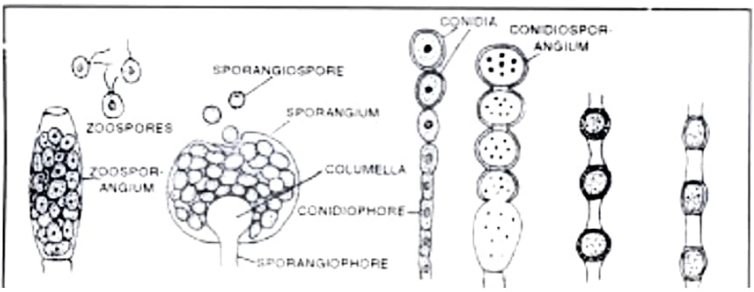
- Mycorrhiza is the symbiotic association present between **fungi and plants**. **Fungi improve nutrient uptake by plants**, whereas, plants provides organic molecules like sugar to the fungus.

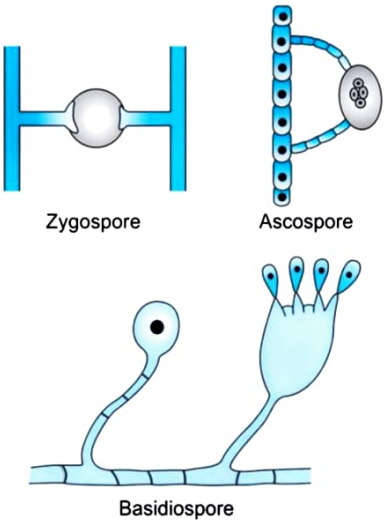
Lichens

Reproduction

- Reproduction in fungi is both by sexual and asexual means. The sexual mode of reproduction is referred to as Teleomorph and the asexual mode of reproduction is referred to as Anamorph.
- **Vegetative reproduction in fungi** –This takes place by **budding, fission and fragmentation.**
- **Asexual reproduction** – This takes place with the help of **spores** called **conidia or zoospores, or sporangiospores.**
- **Sexual reproduction** – This occurs by **ascospores, basidiospores, and oospores** or **zygospores**
- The conventional mode of **sexual reproduction** is not always observed in the kingdom Fungi. In some fungi, the fusion of two haploid hyphae does not result in the formation of a diploid cell. In such cases, there appears an intermediate stage called the Dikaryophase. This stage is followed by the formation of diploid cells.







Outline classification

The fungi can be classified according to the various parameters including

- **Classification based on taxonomy hierarchy**
- **Classification based on spore Production**
- **Classification of medically important fungi**
- **Classification based on route of acquisition**
- **Classification based on virulence**

Based on Spore Formation

Kingdom Fungi are classified into the following based on the formation of spores:

- **Zygomycetes**
- **Ascomycetes**
- **Basidiomycetes**
- **Deuteromycetes**

- **Zygomycetes** – These are formed by the **fusion of two different cells**. The sexual spores are known as **zygospores**, while the asexual spores are known as **sporangiospores**. The hyphae are without the septa. Example – ***Mucor.***
- **Ascomycetes** – They are also called **sac fungi**. They can be coprophilous, decomposers, parasitic or saprophytic. The sexual spores are called **ascospores**. Asexual reproduction occurs by **conidiospores**. Example – ***Saccharomyces.***
- **Basidiomycetes** – Mushrooms are the most commonly found basidiomycetes and mostly live as parasites. Sexual reproduction occurs by **basidiospores.** Asexual reproduction occurs by conidia, budding or fragmentation. Example- ***Agaricus***.
- **Deuteromycetes** – They are otherwise called **imperfect fungi** as they do not follow the regular reproduction cycle as the other fungi. They do not reproduce sexually. Asexual reproduction occurs by **conidia**. Example – ***Trichoderma.***

❑ REPRODUCTION

❖ In fungi reproduction may take place by three methods; vegetative, asexual and sexual.

❖ During asexual and sexual reproduction processes spores are the essential structures. The spores formed after meiosis are called meiospores (e.g., ascospores, basidiospores and sporangiospores) and those resulting from mitosis, called mitospores (e.g., mitospores, zoospores, aplanospores, conidia, uredospores).

❖ The diploid body produced as a result of sexual fusion is known as zygote which in lower fungi is termed as resting spore, oospore or zygospore.

❖ In higher fungi, the zygote is represented by a diploid nucleus produced in a cell (ascus or basidium). This diploid nucleus after undergoing meiosis results in the formation of haploid nuclei serving as centres for haploid sexual spores called ascospores and basidiospores.

➢ Vegetative reproduction: In this type of reproduction, a part of mycelium separate and forms a new individual. The various methods of vegetative reproduction are:

a. Fragmentation: The hyphae break into small fragments. Each piece upon getting suitable conditions, germinates to form a new mycelium.

b. Fission: This method involves the splitting of cells into two daughter cells by the formation of a constriction followed by a cell wall formation.

c. Budding: A small bud formed from the parent cell which gradually increases in size and receives a part of nucleus. A cell wall is formed which separates the daughter cell from the parent cell. Fragmentation

d. Sclerotia: These are perennating bodies formed by the compact masses of interwoven hyphae. Sclerotia under suitable conditions germinate to form new individuals e.g. Claviceps, Sclerotinia.

e. Rhizomorphs: These are root-like elongated mycelial strands. They remain dormant under unfavourable conditions and under favourable conditions develop into a new mycelium.

➢ Asexual reproduction: It commonly take place through spores, either motile or non-motile and form in a specialized part of mycelium. The various types of spores are:

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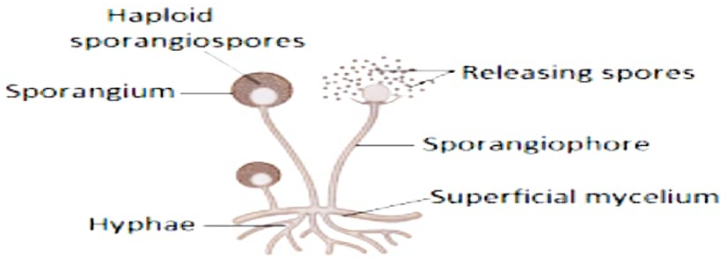
a. Zoospores: These are commonly found in lower fungi e.g., Saprolegnia, Pythium etc. They are naked spores, which after swarming, encyst, secrete a cell wall and germinate by germ tube into a thallus. They are equipped with one or two flagella

b. Sporangiospore: The sporangiospores or aplanospores are nonmotile and lack flagella and are formed inside the sporangium e.g. Mucor, Rhizopus. These spores may by uninucleate or multinucleate and possess two-layered cell wall. Sclerotia Rhizomorph Zoospores Sporangiospores



Spore-releasing *Mucor*

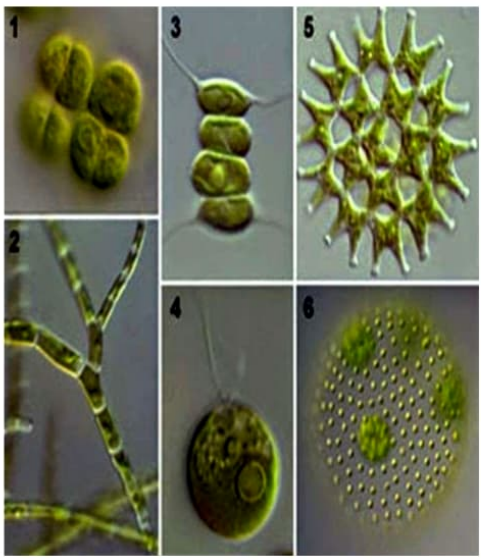
c. Conidia: They are produced externally on branched or unbranched hyphal tips termed as conidiophores. The conidia may be formed singly or in chains. The conidial chains may be basipetal or acropetal in succession. Conidia may be uninucleate or multinucleate. The latter type is more common in the members of the form class Deuteromycetes.

d. Oidia: They are produced by fragmentation of hyphae from apex to base. Each cell thus formed rounds off and separates as a spore which under favourable circumstances germinates and forms the mycelium.

- Algae possess diverse characters in their pigments, nature of reserve food, nature of cilia etc. According to these morphological and physiological differences they are classified by many people.
- Fritsch (1935) classified the whole of the algae into eleven classes on the basis of type of pigments, nature of reserve food material, mode of reproduction etc.
- They are Chlorophyceae, Xanthophyceae, Chrysophyceae, Bacillariophyceae, Cryptophyceae, Dinophyceae, Chloromonodineae, Euglinineae, Phaeophyceae, Rhodophyceae and Myxophyceae (Cyanophyceae).
- The classification is published in his book titled "The Structure and Reproduction of Algae".

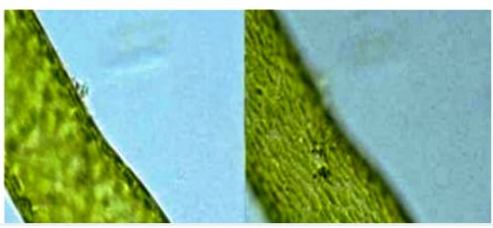
1. Class: Chlorophyceae (Green Algae)

- Occurrence: Most forms are fresh water and a few are marine.
- Pigments: Chief pigments are chlorophyll a an b and carotenoids (yellow pigments)
- Reserve food: Starch
- Structure: Unicellular motile to heterotrichous filaments. Cell wall consists of Cellulose. Pyrenoids are commonly surrounded by starch sheath. Motile cells have equal flagella(24).
- Reproduction: Sexual reproduction ranges from isogamous to advanced oogamous type.
- Example: *Chlamydomonas, Volvox, Chlorella, Scenedesmus ,Pediastrum*



2. Class: Xanthophyceae (Yellow green algae)

- Occurrence: Most forms are fresh water but a few are marine.
- Pigments: Yellow xanthophyll is found abundantly.
- Reserve food: oil
- Structure: Unicellular motile to simple filamentous. Cell wall rich

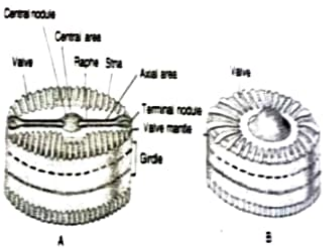


3. Class: Chrysophyceae

- Occurrence: Most forms occur in cold fresh water but a few are marine.
- Pigments: Chromatophores are brown or orange colored. Phycochrysin serves as chief accessory pigments.
- Reserve food: Fat and leucosin.
- Structure: Plants are unicellular motile to branched filamentous. Flagella are unequal attached at front end. Cells commonly contain one or two parietal chrmoatophores.
- Reproduction: Sexual reproduction seldom occurs but is of isogamous type.
- Example: *Chrysodendron, Phaeothamnion*

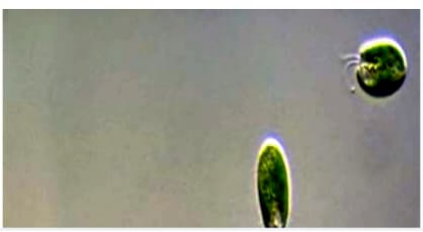
4. Class: Bacillariophyceae (Diatoms)

- Occurrence: In all kind of fresh water, sea, soil and terrestrial habitats.
- Pigments: Chromatophores are yellow or golden brown. Nature of accessory pigments is not very definite.
- Reserve food: Fat and volutin.
- Structure: All the members are unicellular or colonial. Cell wall is partly composed of silica and partly of pectic substances. It consists of two halves and each has two or more pieces. Cell wall is richly ornamental
- Reproduction: Forms are diploid.Sexual reproduction is special type, occurs by fusion of protoplasts of the ordinary individuals.
- Example: Pinnularia



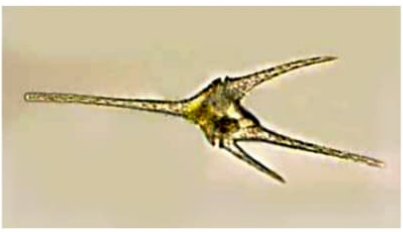
5. Class: Cryptophyceae

- Occurrence: Both in marine and fresh water
- Pigments: Chromatophores show diverse pigmentation. It may be some shades of brown. Chromatophores are usually parietal.



6. Class: Dinophyceae

- Occurrence: Plants occur widely as sea water planktons. A few may be fresh water forms.
- Pigments: Chromaophores are dark yellow, brown , etc., and contain a number of special pigments.
- Reserve food: Starch and oil
- Structure: plants are unicellular motile to branched filamentous.
- Reproduction: Sexual reproduction is of isogamous type. it is rare and not very definite.
- Example: Dinoflagellate , Ceratium



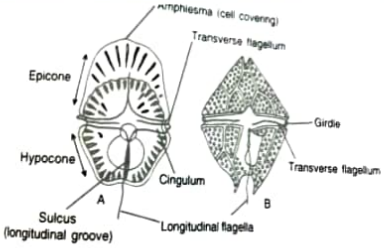
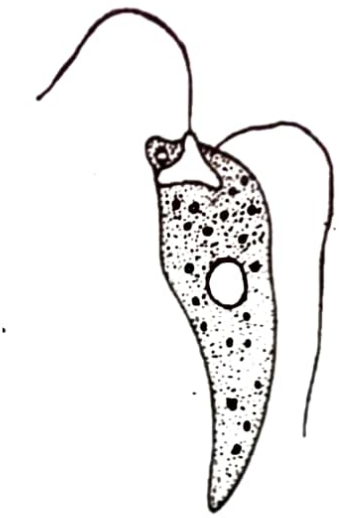


Fig. 54.1. Dinoflagellates. A—*Gymnodinium* and B—*Peridinium*.

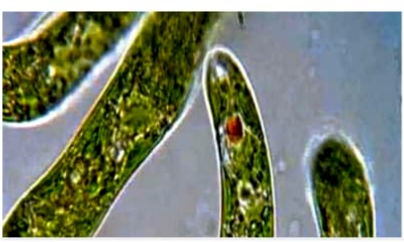
7. Class: Chloromonadineae

- Occurrence: All plants are fresh water forms.
- Pigments: Chromatophores are bright green in colour and contain an excess of xanthophyll.
- Reserve food: Oil
- Structure: The plants are motile, flagellate with two almost equal flagella.
- Reproduction: Sexual reproduction absent, cells divide by longitudinal division.
- Example: Trentonia



8. Class: Euglenineae

- Occurrence: Only fresh water forms are known
- Pigments: Chromatophores are pure green. Each cell has several chromatophores.
- Reserve food: Polysaccharide and Paramylon



Reproduction

- Reproduction is the biological process by which new individual organisms "offspring" are produced from their "parents".
- Reproduction is a fundamental feature of all known life; each individual organism exists as the result of reproduction.
- There are three forms of reproduction.

Types of Reproduction

➢ **There are three common methods of reproduction found in algae.**

1. Vegetative reproduction
2. Asexual reproduction
3. Sexual reproduction

1. Vegetative reproduction

- The vegetative reproduction in algae includes those methods of propagation in which portion of the plant body become separated off to give rise to individuals.
- Vegetative reproduction take place by different methods.

❖ (i) **By cell division**:

- The mother cells divide and the daughter cells are produced, which become new plants.
- It is sometime known as Binary Fission.
- This type of reproduction is found in Diatoms , Euglena .

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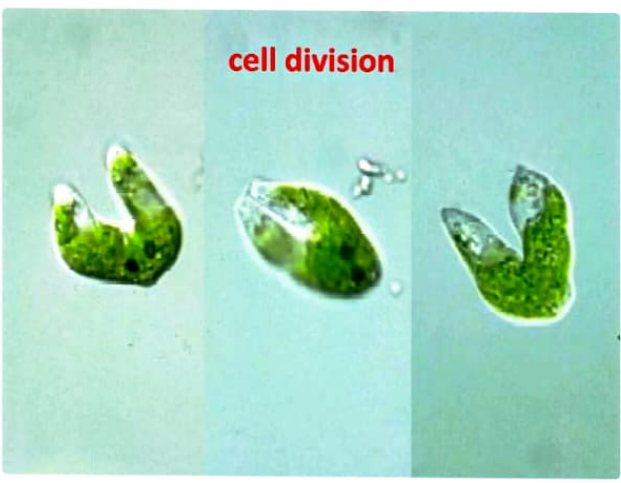

❖ (ii) **Fragmentation**:

- The plant body breaks into several parts or fragments and each such fragment develops into an individual.
- This type of vegetative reproduction is commonly met within filamentous forms, e.g., Ulothrix, Spirogyra, etc.
- The fragmentation of colonies also takes place in several blue green algae, e.g.Aphanothece, Nostoc, etc.

2.Asexual Reproduction

- Asexual reproduction is a mode of reproduction by which offspring arise from a single organism, and inherit the genes of that parent only.
- it is reproduction which almost never involves ploidy or reduction.
- The offspring will be exact genetic copies of the parent, except in the specific case of automixis .

- A more stringent definition is agamogenesis which is reproduction without the fusion of gametes.
- Usually the protoplast of a cell divides into several protoplasts and there after they escape from the mother and develop into new plants.
- Asexual reproduction is the primary form of reproduction for single-celled organisms such as the archaebacteria , eubacteria, and protists .

- Many plants and fungi reproduce asexually as well.
- Asexual reproduction take place by a variety of spore formed in different Algae. they include.....

3. Sexual reproduction

- **why sexual reproduction developed and why it is maintained ?**

- The first fossilized evidence of sexual reproduction in eukaryotes is from the Stenian period, about 1 to 1.2 billion years ago.
- These reasons include fighting the accumulation of deleterious mutations, increasing rate of adaptation to changing environments, dealing with competition or as an adaptation for repairing DNA damage and masking deleterious mutations.

- While these ideas about why sexual reproduction has been maintained are generally supported, the ultimate size of the population determines if sexual reproduction is entirely beneficial.
- Larger populations appear to respond more quickly to benefits obtained through sexual reproduction than smaller population sizes.

AD

•a basic advantage for sexual reproduction in slowly reproducing complex organisms, exhibiting characteristics that depend on the specific environment that the given species inhabit, and the particular survival strategies that they employ .

•It is greatly advanced method of reproduction

- Conditions for sexual reproduction:
- (a) The sexual reproduction takes place after considerable accumulation of food material and the climax of vegetative activity is over.
- (b) The bright light is the major factor for the production of the gametes.
- (c) A suitable pH value is required.
- (d) The optimum temperature is necessary.

USEFUL ASPECTS OF ALGAE

1) Algae as human food:

- **Chlorella**, a unicellular green alga, possesses a high quality of food value.It has about 50 % proteins and 20% lipids and carbohydrates. Besides, it contains vitamins A, B, C, K and essential amino acids.
- **Porphyra tenera** (a red alga) is known as Amanori in Japan and the preparation is known as Asakusa Nori.
- **Laminaria (**a brown alga) yields a food product known as kombu or konbu. Young stipes of Laminaria are eaten directly in certain parts of Europe and America.
- **Nostoc** (blue green alga) balls of terrestrial species are collected, boiled and consumed as food by the Chinese.
- **Alaria (**a brown alga) yields a product known as Sarumen in Japan.
- **Monostroma** (a green alga) yields food product Aonori in Japan.
- **Ulva lactuca**(a green alga) used in salad and soups.
- **Rhodymenia palmate** (a red alga) used as food and also as confectionary named dulse.

Phylum Protozoa: General characters and Classification

Introduction

The animals included in phylum Protozoa can be defined as microscopic and a cellular animalcules without tissues and organs. They have one or more nuclei. Protozoa exist either singly or in colonies. Almost about 50,000 species are known till date.

Anton Van Leeuwenhoek was the first to observe protozoa (Vorticella convellaria) under a microscope. He called them animalcules. Gold fuss coined the term Protozoa which in Greek means first animals (Proto= first; zoans=animals). Hyman and other zoologists preferred to call them as acellular animals.

The body of protozoans is unicellular. They are generally referred to as acellular rather than unicellular as the so called single cell performs all the life activities. Though it is structurally equivalent to a single cell of the metazoan body, it is functionally equivalent to the whole metazoan animals.

General Characters of Phylum Protozoa

- Protozoan animals exhibit protoplasmic grade of organization. There is division of labor among various organelles of the cell.
- These are solitary (*Euglena*), or colonial (*Proteospongia*)
- They may be free living (*Amoeba*) or symbiotic (Parasitic, mutualistic or commensalistic)
- Body symmetry is symmetrical (Actinopodeans) or radial (sessile forms) or bilateral (*Giardia*) or absent (*Amoeba*)
- Locomotion is brought about by pseudopodia or flagella or cilia or myonemes.

- Nutrition is holozoic or holophytic or osmotrophic (Saprophytic or parasitic). Digestion is intracellular. Some forms like Euglena are mixotrophic (perform more than one type of nutrition)
- Exchange of respiratory gases takes place by diffusion through the general body surface. Respiration is anaerobic in some parasitic forms.
- Excretion occurs by diffusion across general body surface or by contractile vacuoles. Contractile vacuoles serve mainly for Osmoregulation and are common in freshwater forms.
- Asexual reproduction takes place by binary fission or multiple fission or plasmotomy or budding.
- Sexual reproduction takes place by syngamy or conjugation
- Many forms undergo encyctment to tide over unfavorable conditions
- Somotoplasm and germplasm are not differentiated. Hence they are

further divided into 5 classes.

Most accepted classification of protozoa is given by BM Honigberg and others based on the scheme given by the committee on Taxonomy and Taxonomic problems of the society of Protozoologists divides this phyla into 4 subphyla.

SUBPHYLUM I: SARCOMASTIGOPHORA (Gr. Sarcodes=fleshy; mastix=whip; phoros=bearing)

The locomotion in this subphylum is brought about by flagella or pseudopodia or both. Other important feature of this subphylum is the presence of monomorphic nuclei. This subphylum is further divided in to 3 super classes:

Superclass 1: Mastigophora (Gr. Mastix=whip; phoros=bearing)

The body of the animals belonging to this super class is covered by pellicle. The locomotory organelles are flagella. In this super class the asexual reproduction occurs by longitudinal binary fission. This super class includes 2 classes:

Class 1: Phytomastigophora (Gr. Phyton=plant; Mastix=whip; phoros=bearing)

They have chromatophores with chlorophyll. The nutrition in these organisms is mainly holophytic which takes place by phototrophy. These are free living organisms. The reserve food in these organisms is starch or paramylon. These organisms may have 1 or 2 flagella.

Ex: *Euglena, Ceratium, Noctiluca*

Class 2: Zoomastigophora (Gr. Zoon=animal; Mastix=whip; phoros=bearing)

These organisms do not have chlorophyll bearing chromatophores. These are mostly parasitic. The nutrition in these organisms is holozoic or saprozoic. The reserved food is glycogen. They may have one to many flagella.

Ex: *Leishmania, Trypanosoma, Trichomonas, Trichonympha*

Superclass 2: Opalinata

The organisms belonging to this super class live as commensals or parasites in the gut of anurans. Their body is covered by oblique rows of cilia-like flagella. These organisms may have 2 or many nuclei also the nuclei are monomorphic. They undergo asexual reproduction by binary fission or by syngamy. Sexual reproduction takes place by anisogamy.

Ex: *Opalina, Zelleriella*

Superclass 3: Sarcodina (Gr. Sarcode=fleshy)

The locomotion in the organism belonging to this superclass is brought about by pseudopodia. Their body is amoeboid without definite pellicle. The

ECONOMIC IMPORTANCE OF PROTOZOA

Protozoa are unicellular, eukaryotic, and animal-like protists. They are found everywhere, in water, soil, and even on the bodies of organisms. They are of considerable economic value to mankind. Based on their activities, they can be divided by the following two heads:

1. Beneficial Protozoa 2. Harmful Protozoa

BENEFICIAL PROTOZOA

Protozoa are useful to us in many ways, some of them are as follows:

1. **FOOD:** Protozoa provide food for insect larvae, crustaceans, and worms, which are taken by large animals like fishes, lobsters, clams, and crabs, which are eaten by man. Thus they form sources of food supply to man both directly and indirectly.

2. **INSECT CONTROL:** Several protozoa control harmful insects by persisting in their bodies, they can be used in biological control of insects, i.e. *Nosema locustae*.

3. **HELPFUL IN SANITATION:** A large number of protozoa living in polluted water feed upon waste organic matters and thus purify it. Many protozoa feed upon bacteria and play an important role in the sanitary betterment and keeping water safe for drinking.

4. **BUILDING MATERIAL:** The skeletal deposits of protozoa (mostly foraminifera and radiolarians) change into the limestone rock (after a lot of time). Limestone is provided by such oceanic ooze, such as that of cliffs of Dover, which have played an important role in the defense of England. Limestone-beds are used as building material, i.e. most of the buildings of Paris and even the great pyramids of Egypt were constructed from limestone.

5. **OIL EXPLORATION:** Petroleum is of organic origin. The skeletal deposit of Foraminifera and Radiolaria are often found in association with oil deposits, i.e. they help geologists and petroleum scientists to locate oil.

6. **SCIENTIFIC STUDY:** The protozoans have been found as an ideal group of organisms for cytological, cytochemical, physiological, biochemical, and genetic studies, due to their small size, simple organization, quick reproduction and easy availability. Many protozoa are used in biological and medical researches, i.e. *Tetrachymena geleii* is used in nutritional research. The effects of various foods and poison have been investigated on this protozoan.