Biological Classification

2

Since the dawn of civilisation, there have been many attempts to classify living organisms. It was done instinctively not using criteria that were scientific but borne out of a need to use organisms for our own use – for food, shelter and clothing. Aristotle was the earliest to attempt a more scientific basis for classification. He used simple morphological characters to classify plants into trees, shrubs and herbs. He also divided animals into two groups, those which had red blood and those that did not.

Two Kingdom system of classification

In Linnaeus' time a Two Kingdom system of classification with Plantae and Animalia kingdoms was developed that included all plants and animals respectively. This system was used till very recently.

Limitations

1. This system did not distinguish between the eukaryotes and prokaryotes, unicellular and multicellular organisms and photosynthetic (green algae) and non-photosynthetic (fungi) organisms.
2. Classification of organisms into plants and animals was easily done and was easy to understand, inspite, a large number of organisms did not fall into either category.
3. Hence the two kingdom classification used for a long time was found inadequate. A need was also felt for including, besides gross morphology, other characteristics like cell structure, nature of wall, mode of nutrition, habitat, methods of reproduction, evolutionary relationships, etc. Classification systems for the living organisms have hence, undergone several changes over time.

Haeckel :

Three kingdom (Protista, Plantae & Animalia) Classification.

– **Haeckel** established the kingdom **Protista**.

– Haeckel grouped those living organisms in Protista which did **not have tissues**.

– Ist tissue origin in **animal** kingdom in - **Coelentrata**

– Ist tissue origin in **plant** kingdom in - **Bryophyta**

Kingdom Protista → Prokaryotes, **Protozoa**, **Porifera**, **Algae & fungi**.

Copeland : Four kingdom classification.

All the **prokaryotes** are grouped in Monera

eg. Bacteria, Mycoplasma, Blue Green algae.

– **Protista or Prototista :** Copeland grouped those **eukaryotes** in protista, which are visually different than normal plants and animals.

eg. Brown algae, Red algae, Fungi, Protozoa

– **Plantae or Metaphyta :** Remaining all eukaryotic plants are grouped.
– **Animalia or Metazoa :** Remaining all eukaryotic animals are grouped

Whittaker : Five kingdom classification.

– This classification was believed to be **modern**

The five kingdom classification of Whittaker was based on **5 features** which explained best in three features.

These five features are :

(i) **Cell structure -**
(a) Type of cell (b) Cell wall

(ii) **Thallus organization -**
(a) Complexity

(iii) **Nutrition -**
(a) Autotrophic / Hetrotrophic

(iv) **Reproduction**

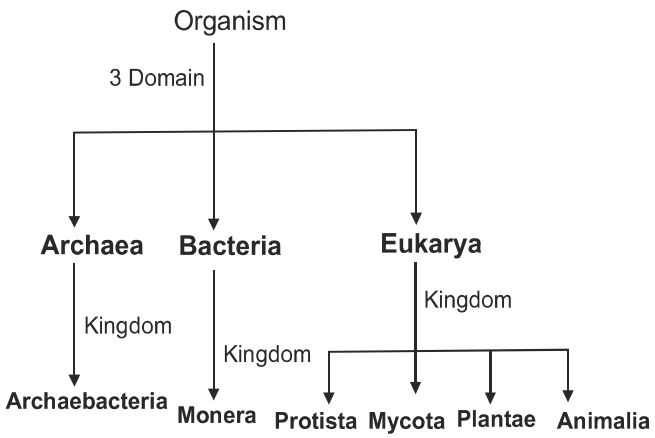
(v) **Phylogeny**

Characteristics of the Five Kingdoms

Characters	Five Kingdoms				
	Monera	**Protista**	**Fungi**	**Plantae**	**Animalia**
Cell type	Prokaryotic	Eukaryotic	Eukaryotic	Eukaryotic	Eukaryotic
Cell wall	Noncellular (Polysaccharide + amino acid)	Present in some	Present (without cellulose)	Present (cellulose)	Absent
Nuclear membrane	Absent	Present	Present	Present	Present
Body organization	Cellular	Cellular	Multiceullar/ loose tissue	Tissue/ organ	Tissue/organ/ organ system
Mode of nutrition	Autotrophic (chemosynthetic and photosynthetic) and Heterotrophic (saprophyte/ parasite)	Autotrophic (Photosynthetic) and Heterotrophic	Heterotrophic (Saprophytic/ Parasitic)	Autotrophic (Photosynthetic)	Heterotrophic (Holozoic / Saprophytic etc.)

SIX KINGDOM/THREE DOMAIN - CARL WOESE (1990) :

– Archaebacteria separated from eubacteria on the basis of some **major differences.**
– As the **absence of peptidoglycan** in the cell walls of the Archebacteria and the occurrence of **branched chain lipids** (a **monolayer** instead of a phospholipid bilayer) in the membrane.
– **Based on the sequence of 16S ribosomal RNA genes,** Woese found that the six kingdoms naturally cluster into three main categories. he called these categories as **domains**.
– These domains are **Bacteria, Archae** and **Eukarya**,



KINGDOM - MONERA

– The Kingdom Monera includes **all prokaryotes**.

– Monerans are the **most primitive forms** of life, originating from more ancient living stock termed **progenote**.

– **C.B. Van Neil :** Divided the living organisms into **prokaryotes** and **eukaryotes.**

MAIN CHARACTERISTIC OF MONERANS

Cell Type : Prokaryotic

Cell wall :

Non-cellulosic (Polysaccaride + Amino acid)

Nuclear membrane : Absent

Body organisation :

Cellular, Membrane bound organellaes are absent.

Mode of nutrition :

(1) Autotrophic (Chemosynthetic)

(2) Hetrotrophic (Mainly) Saprophytic and Parasitic.

Example of Prokaryotes / Monerans

– Eubacteria (True bacteria)

– Actinomycetes

– Blue Green Algae (Cynobacteria)

– Archaebacteria

– Mycoplasma

ARCHAEBACTERIA

These are belived to have evolved immediately after the origin of life on earth, as **even now** these are living under extremely adverse conditions like **very high temperature** (hot-water springs) and **high salt concentration** (salt marshes).

– Very few other organisms can survive under such environmental conditions. So these are termed oldest "**Living fossils**".

– All archaebacteria are **obligate anaerobes**

Cell wall :

– It is made up of complex **polysaccharides** and complex **polypeptide** not of peptidoglycan like that of eubacteria.

Cell membrane :

– Cell membrane of archaebacteria is composed of a single layer of **branched chain molecules of lipids** while the lipids present in the cell membrane of eubacteria are straight chain molecules.

Examples :

Methanogens

"**Methane producing bacteria**"

– These bacteria **convert CO_2** of swampy areas (Marshy) into **methane (CH_4)**

eg. *Methanobacterium, Methanococcus, Methanomicrobium*

– These bacteria convert the organic substance (**cellulose**) present in cow dung **into methane** by fermentation (**Gobar gas fermenter**).

eg. *Methanobacterium, Methanococcus, Methanomicrobium*

Halophiles

– These archebacteria are found in highly **saline** habitat eg. **Halobacterium halococcus.**

– Halophiles surrounded by purple membrane. This membrane **absorbs the bright light** and **directly forms ATP** i.e. They cannot prepare food (carbohydrates) like eubacteria.

– Instead of it **they directly form ATP**. Therefore Halophiles are **non photosynthetic**.

Thermo acidophiles

These are **chemoautotrophs**

– These archaebacteria are found at those places where **temperature is approx 80°C** and medium is **acidic [pH = 2]**

– They are found in **hot sulphur springs**. These can also survive at 100°C temperature

– **Exceptionally** these archaebacteria are **obligate aerobes**.

eg. ***Thermus aquaticus, Sulpholobus, Thermoplasma***

EUBACTERIA (True Bacteria)

– Bacteria are **cosmopolitan** and occur in every habitat wherever living or dead organic matter is present.

– **Anton von Leeuwenhoek** discovered in **rain water** which had been allowed to stand for many days and **tartar** scrapped from **teeth**.

SHAPE :

Bacteria have variation in their shape. On the basis of their shape bacteria are of different types.

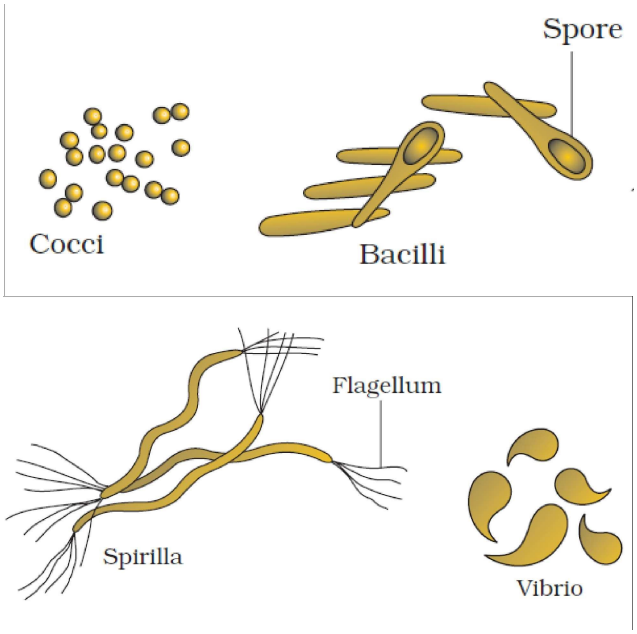


Figure: Bacterio of different shapes

Coccus (Pl. Cocci → Sing. Coccus) -

– These bacteria are **spherical, Non-flagellate**

– These are **smallest** bacteria

– These are highly (Maximum) **resistant**.

These are following types on basis of cell arrangement :

– Monococcus - These spherical bacteria live alone (**single** sphere)

e.g. Micrococcus

– Diplococcous - These are found in group of **two** cocci.

e.g. Diplococcus pneumoniae

– Tetra coccus - These are found in group of **four** cocci. **e.g. Micrococcus luteus**

– Streptococcus - These are found in form of **chain**

e.g. Streptococcus lactis

– **Sarcinae** - 8 to 64 or more bacteria are found in **cubical** mass form

e.g. Sarcina lutea

– **Staphylococcus** - These bacteria are found in a **irregular bunch** like **cluster of grapes**

e.g. Staphylococcus aureus

Bacillus (Pl. Bacilli-Sing. Bacillus) -

– This group includes **most of the bacteria.** (Most **common Shape**)

– These are **rod shaped**

Spirillum (Pl. Spirilli - Sing Spirillum)

– These are **spiral** shaped bacteria

e.g. Spirillum volutans, Spirochete, Heliobacter, Treponema

Comma (Vibrio) -

– These are **comma shaped** bacteria

e.g. Vibrio cholerae, Vibrio comma

NUTRITION IN BACTERIA

– Most of the bacteria are **heterotrophic** but some are autotrophic.

– On the basis of nutrition bacteria are classified into following three categories.

AUTOTROPHS

– These bacteria use **light** or **chemical** energy for their own food synthesis.

– On the basis of **source of energy** autotrophs are of following two types

PHOTOSYNTHETIC AUTOTROPHS-

(PHOTOAUTOTROPHS)

– These bacteria use **light energy** for food synthesis.

– In these bacteria photosynthesis is **non oxygenic**. (No oxygen liberation)

CHEMOSYNTHETIC AUTOTROPHS -

(CHEMOAUTOTROPHS)

– These are **nonphotosynthetic autotrophs** i.e. photosynthetic pigments are **absent**.

– They use **chemical energy** instead of light energy for food synthesis.
– Chemical energy is obtained from **oxidation of inorganic or organic compounds**.

HETEROTROPHS

– Most of the bacteria are **heterotrophic** i.e. they can not manufacture their own food.
– They receive their own food from **dead organic matter** or **living organism.**

these are following types

Saprotrophic bacteria :

These bacteria obtain food from **dead** and decaying organic matter.

Parasitic bacteria :

These bacteria obtain food **from living organism**.

SYMBIOTIC

– These bacteria convert atmospheric nitrogen into nitrogenous compounds like Amino acid, NO_3 or Salts of ammonia.

e.g. Rhizobium

Note : Some **Nitrogen fixers** are **free living** and **aerobic** are **Azotobactor, Beijerinckia, Kelebsiella**.

REPRODUCTION

Bacteria reproduce by three methods :

– Vegetative reproduction
– Asexual reproduction
– Genetic recombination

ECONOMIC IMPORTANCE OF BACTERIA

HARMFUL ACTIVITIES

Disease in Human beings :

Disease		**Bacterium**
Tuberculosis (T.B.)	–	*Mycobacterium tuberculosis*
Tetanus	–	*Clostridium tetani*
Typhoid	–	*Salmonella typhi*
Pneumonia	–	*Diplococcus pneumoniae or Pneumococcus pneumoniae*
Jaundice	–	*Leptospira ictero haemorahgeii*
Cholera	–	*Vibrio cholerae*
Citrus canker	–	***Xanthomonas citri***
Crown gall in many plants	–	***Agrobacterium tumefaciens***

MYCOPLASMA :

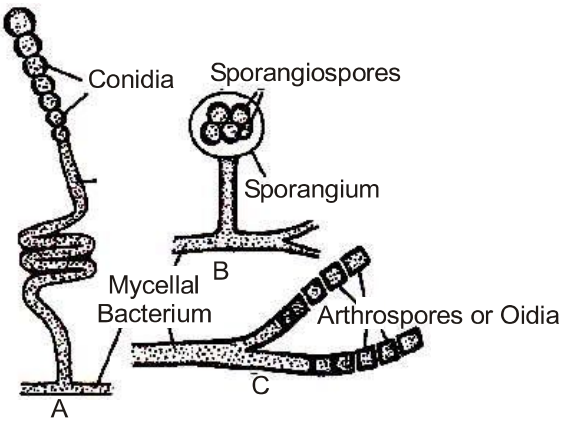
– **E.Nocard and E.R.roux** (1898) – Two French Scientists, discovered these organisms from **pleural fluid of cattles** suffering from **pleuropneumonia**.
– These are **pleomorphic** and were called **PPLO** (Pleuropneumonia Like Organisms) or **Jokers of plant Kingdom**.

Structure :

– These are **unicellular**, simplest **free living prokaryotes**.
– **They do not have cell wall so** they are highly **pleomorphic** and can assume various shapes like spherical, granular, filamentous, coccoid etc.

ACTINOMYCETES - FILAMENTOUS BACTERIA / RAY FUNGI :

– These are branched, **filamentous bacteria** and are considered as **Intermediate form between bacteria and fungi.**
– The body of fungi is known as **mycelium** and the structure of **actinomycetes is also similar to mycelium**. Therefore they were **included in fungi**. But fungi are **eukaryotic** while actinomycetes are **prokaryotic**. So these are **now placed in kingdom Monera**.



Modes of asexul reproduction in Actinomycetes (A) Conidia, (B) Sporangiospores (C) Anthrospores or oidia

eg. *Streptomyces, Mycobcterium*

CYNOBACTERIA [BLUE GREEN ALGAE]

INTRODUCTION

– According to **Two kingdom** system B.G.A. was included in class **Cyanophyceae** or **Myxophyceae** of Algae.

– But now it is included in **Kingdom Monera**, becuase it is a **prokaryotic** cell.

– The name cyanobacteria was suggested by **ICNB [Internal Code of Nomenclature for Bacteria]** in 1978.

– Cyanobacteria are **Gram negative photosynthetic prokaryotes**.

– Being the most primitive organisms to have **Oxygenic photosynthesis**.

– They added **oxygen** to the atmosphere, which is indispensible for the **existence of aerobic forms of living organisms**.

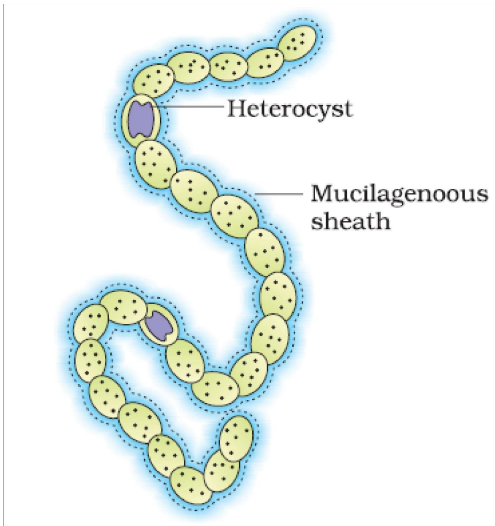


Figure 2.2 A filamentous blue-green algae – *Nostoc*

	Cyanobacteria	Eubacteria
(1)	They have membrane bound structure ***thylakoids***. photosynthetic pigments are present on the surface of these thylakoids	Photosynthetic pigments are scattered in groups in the cytoplasm, these groups are known as **chromatophore**. Chromatophores are **membranous** structure
(2)	In it photosynthesis is **oxygenic** i.e. **O_2 is evolved** during photosynthesis.	In it, photosynthesis is **non-oxygenic** i.e. **O_2 is not evolved** during photosynthesis.
(3)	They have following pigments. • Chlorophyll 'a' – green • Carotenoids – yellow • C - Phycocyanin – blue • C - Phycoerythrin – red	They have following pigments : • Bacteriochlorophyll 'a' and Bacteriochlorophyll-b (In purple bacteria) • Bacteriochlorophyll-a-and Bacteriovirdin (In green bacteria)

STRUCTURAL ORGANIZATION

– The structure of B.G.A. is **similar to Gram (–ve) eubacteria**

– Trichome is surrounded by a **mucilagenous sheath**.

– This sheath is made up of **mucopolysaccharides** [Pectic acid].

– The cytoplasm of prokaryotes lacks membrane bound cell organelles but exceptionally in B.G.A. **two membrane bound structure** are present.

– **Gas vacuole** – It provides the buoyancy to the B.G. algae in water.

– **Thylakoids** – Photosynthetic pigments are present on its surface.

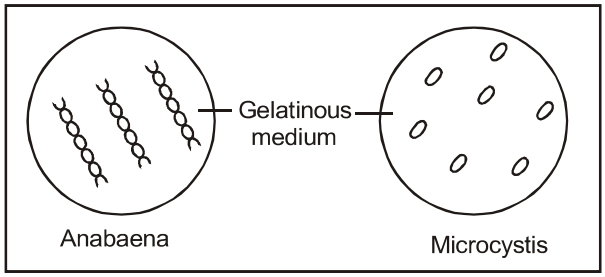
DIFFERENT FORMS OF CYNOBACTERIUM FILAMENT

– **Unicellular :** Some B.G.A. are unicellular eg. **Spirulina**

– **Spirulina** is an edible B.G.A. because it has very large **Amount of proteins**. It can be grown artificially in water tanks. It is used as a **fodder** for **cattle**.

– **Colonial :** Some B.G.A. are found in colony i.e. cell colonies.

eg. ***Anabaena, Microcystis***



– **Filamentous :** Some B.G.A. are filamentous. There are many cells arranged in a row in their body. The filament of B.G.A. is known as **trichome**. eg. **Oscillatoria**

Nitrogen fixation :

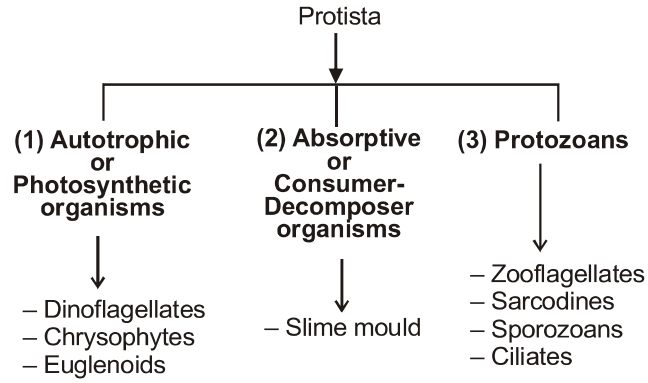
– Most of the B.G.A., can perform Nitrogen fixation. They converts atmospheric nitrogen in to nitrogenous compounds like amino acids, nitrates.

– These **nitrates** increases the fertility of soil.

– Hence B.G.A. improves the fertility of soil by nitrogen fixation under **anaerobic** conditions occurs mainly in large, specialized cells called **heterocysts**.

KINGDOM – PROTISTA

KINGDOM PROTISTA INCLUDES



All the organism included in Protista are **unicellular (acellular) eukaryotes**.

NUTRITION

Mode of nutrition in protist is different types

– **Holophytic or Photosynthetic :**

They prepare their own food through photosynthesis. (Chloroplast and pigments present)

– **Holozoic**

Some protist have holozoic mode of nutrition, which is **similar to animals** i.e. food is first ingested and then digested.

– **Absorptive :**

Some protists obtain their food from **dead organic substances**.

REPRODUCTION

Protists reproduce Asexually and Sexually

Asexual Reproduction :

– This is the most common method of reproduction in protists.

– Asexual reproduction takes place in favourable condition.

– **It is of following types**

– **Binary Fission :** Two daughter cells are formed by the division of one mother cell.

– **Spore Formation :** Some protists have special structure known as **sporangia**. Spores are formed in this sporangia.

Sexual Reproduction :

– Sexual reproduction was **first of all seen in protists**.

– In sexual reproduction two haploid gametes fuse to form a diploid zygote. This process is known as **syngamy.**

Syngamy is of three types

– **Isogamy :**

In isogamy the fusing gametes are **morphologically** (i.e. shape, size structure) similar **but physiologically** (functionally or genetically) they may be **similar or dissimilar**.

– When fusing gametes are **physiologically dissimilar** process is called **physiological anisogamy**.

– **Anisogamy :**

The fusing gametes are **morphologically** and **physiologically dissimilar** (smaller – motile, larger-immotile).

– **Oogamy :**

It is the developed form of anisogamy.

– Male gamete is **small and motile** while female gamete is **large and immotile**. this female gamete is known as egg.

– In it the formation of male & female gametes take place in **sex organs.**

DINOFLAGELLATES - BIFLAGELLATED PROTIST

– Dinoflagellates are **green, red, blue, golden** and **brown photosynthetic protists**.

– Dinoflagellates are mainly **marine**. They are found on the **surface of water**.

STRUCTURE

– The body is enclosed by a rigid **coat** called **theca** or **lorica** consisting of 2 to many **articulated** or **sculptured** plates of **cellulose and pectin**, hence are also called **armoured dinoflagellates**.

– Dinoflagellates have two flagella - one **transverse** and other is **longitudinal** (Hetrokont).

– Dinoflagellates shows a special type of movement which is like **whorling whips**, therefore they are called as "**Whorling whips**"

– Dinoflagellates are **haploid**.

– **Histone** protein is **absent** in its chromosome. Due to this reason Dinoflagellates are called **as mesokaryote**.

– They have an osmoregulatory structure which is called '**pusule**' (a non contractile vacuole).

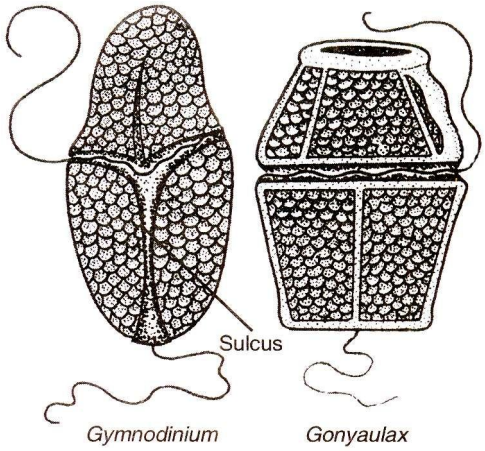
– Dinoflagellates are **yellow brown** or **golden brown** in colour.

– The colour of Dinoflagellates are due to the pigments present in them – **Chlorophyll 'a'**, **Chl. 'c'** α-**carotene and Xanthophylls** (Dinoxanthin & Didinoxanthin).

– They have **starch** as stored food.

– In Dinoflagellates, the nutrition is mainly **holophytic**, because they **have chloroplast**.

eg. **Noctiluca, Ceratium, Gonyaulax, Gymnodinium, Pyrocystis**



Some Dinoflagellates

SPECIAL FEATURES OF DINOFLAGELLATES

– Maximum Dinoflagellates (eg. – ***Noctiluca***, ***Gonyaulax***, ***Procystis***) show '**Bioluminescence'**.

– So that these dinoflagellates are also known as **'night light / Fire algae'**

– ***Gonyaulax*** spreads on the surface of sea water, due to which the **sea water appears red.** It is called as **red tide**.

– Both ***Gymnodinium & Gonyaulax*** are toxic. They secrete toxins, which are known as "**Saxitoxin**".
– These toxins cause **paralysis** in human beings. Humans acquire these toxins through food chain.
– These protist affect the marine animals.

CHRYSOPHYTES \ DIATOMS
"GOLDEN ALGAE OR JEWELLS OF SEA"

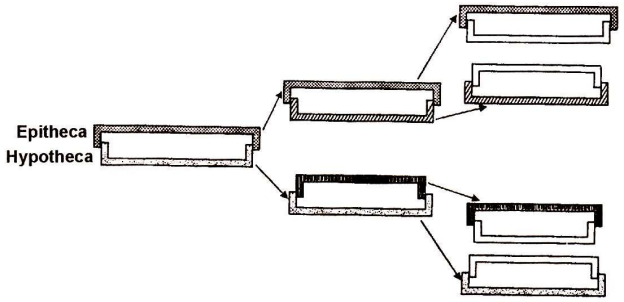
– Diatoms means -"**Cut in to two**". This name s based on the **cell wall** of diatoms which is divided into two parts.
– They have **holophytic** mode of nutrition because they **possess chloroplast**. (**Photo synthetic protist**)
eg. – *Navicula, Cyclotella, Pinnularia.*

STRUCTURE

– They are found different **shapes** such as circular, rectangular, triangular, elongated and boat shaped.
– They are basically **unicellular**, but may form pseudofilament and **colonies**.
– They **Lack Flagella except in the reproductive stage**.
– **Cell wall : Cellulosic**, Impregnated with **silica** to form transparent **siliceous shell**, known as **frustule**
– It is made up of **two halves**; one half covering the other **(epitheca** over **hypotheca**) resembling a **soap box**
– Their cell wall have **silica** in very large quantity. Due to this reason their **cell wall is hard**.
– The cell wall does not get destroy after their death so at the bottom of sea, very huge **rocks** of dead diatoms are formed which are known as "**diatomite**" or "**diatomaceous earth**" or "**keiselgurh**"
– **Diploid** nucleus present in Diatom.
– Their cells **have chloroplasts**, in which pigments are present, **Chlorophyll 'a', Chl 'c', and xanthophyll (fucoxanthin).** Due to these pigments it appears **golden** coloured.
– **Stored food – Leucosin** (Chrysolaminarian) & **fats (Oil)**.
– **Movement –** They are **immotile**, because **flagella are absent** in them.
– They **float** on the surface of water. They floats with the help of **stored fats.**

REPRODUCTION

– Mainly **asexual** – binary fission.



Diagrammatic representation of cell division in diatoms

– **Sexual** reproduction Very rare - by **gametic meiosis** (**Diplontic Life Cycle**)

Use of Diatoms :

– Sound proofing
– Filteration of oil and syrup
– Stone polishing
– Water pollution indicator
– As "**Heat insulator**" in steam boilers i.e. they are used as **thermostate** because the wall of diatoms are bad conductor of heat

EUGLENOIDS

– Previously euglenoids were placed in **plant** kingdom due to their **photosynthetic ability**. But due to the **absence of cell wall** and **animals like nutrition** some scientists placed them in animal kingdom. But Now according to five kingdom classification they are included in **Protista**.
– It is a group of **chlorophyllous** and **non chlorophyllous** protists.
– Their mode of nutrition is called as **mixotrophic** because they have **holophytic**, **holozoic** and **saprophytic** mode of nutrition.
eg. – Euglena, Paranema

STRUCTURE

– **Cell wall is absent** around them.
– They are surrounded by a **cell membrane** which is made up of **lipoprotein** and is covered with **pellicle**.
– Pellicle is made up of **lipoprotein** and it is **elastic** in nature.

– At the anterior end of Euglenoids, a **cavity** is present, which is known as **reservoir**.
– Flagellum is orginated from the base of reservoir.
– Euglenoids have only **one functional flagellum**.
– They have a **contractile vacuole**. These contractile vacuoles helps in **osmoregulation**.
– Euglenoids have a **haploid** nucleus and **chloroplast**.
– Chloroplast has following pigments

Chl. 'a' Chl. 'b' and Xanthophyll

REPRODUCTION

– Asexual reproduction by **longitudinal binary fission**
– During **unfavourable** conditions, **palmella stage** and **cysts** are formed for perennation.

SLIME MOULDS (CONSUMER – DECOMPOSER PROTIST)

– These organisms develop a **slimy mass** at the time of their vegetative phase, therefore they are called **slime moulds**.
– They are also called as **false fungi**.
– They are found on decaying stem, leaves etc, so these ae **saprophyte**.
– Slime moulds have characters of both **animals** & **fungus** therefore they also called **Fungus animal**.

S.No.	Characters similar to animals	Character similar to fungi
1.	Surrounded by cell membrane	Formation of **cell wall** at the time of reproduction
2.	ructure similar to **moeba**	Formation of **sporangia** at the time of reproduction
3.	Sometimes nutrition is **holozoic** or Phagotrophic	Nutrition is **absorptive or saprotrophic**

STRUCTURE

On the basis of structure they are of two types :

ACELLULAR OR PLASMODIAL SLIME MOULDS

– Their body is made up of **wall less multinucleated protoplasmic mass**. This type of body is known as **plasmodium.** (Plasmodium = **wall less coenocyte**)

CELLULAR SLIME MOULDS

– Their body consists of many **wall less amoeba like cells** (**group of amoeba** like cells is known as cellular slime mould.)

REPRODUCTION

Slime moulds have both asexual & sexual type of reproduction :

Asexual reproduction :

– It is mainly with the help of **spore** formation (sporangia).
– The mucilagenous sporangia of slime moulds is known as **capillitium / Fruiting body / sporangium**

Sexual reproduction :

– The cell of **acellular** slime moulds are **diploid**. So they reproduce by **gametic meiosis**. Therefore their life cycle is **diplontic**.
– The cell of **cellular** slime moulds are **haploid**, so they reproduce by **zygotic meiosis**. Therefore their life cycle is **haplontic**
– **Stored Food – Glycogen & Oil**

POINTS TO BE REMEMBERED

– Some **Unicellular**, **Eukaryotic** Alga are may consider in protista for eg. **Chlorella, Acetabularia, Chlamydomonas, Trebauxia etc.**

PROTOZOANS

All protozoans are heterotrophs and live as predators or parasites. They are believed to be primitive relatives of animals. There are four major groups of protozoans. Amoeboid protozoans: These organisms live in fresh water, sea water or moist soil. They move and capture their prey by putting out pseudopodia (false feet) as in Amoeba. Marine forms have silica shells on their surface. Some of them such as Entamoeba are parasites.

Flagellated protozoans: The members of this group are either free-living or parasitic. They have flagella. The parasitic forms cause diaseases such as sleeping sickness. Example: Trypanosoma.

Ciliated protozoans: These are aquatic, actively moving organisms because of the presence of thousands of cilia. They have a cavity (gullet) that opens to the outside of the cell surface. The coordinated movement of rows of cilia causes the water laden with food to be steered into the gullet. Example: Paramoecium (Figure 2.4b).

Sporozoans: This includes diverse organisms that have an infectious spore-like stage in their life cycle. The most notorious is Plasmodium (malarial parasite) which causes malaria which has a staggering effect on human population.

KINGDOM - MYCOTA

FUNGI

EUMYCOTINA OR TRUE FUNGI

- Fungi are found mostly in humus rich soil. But in the presence of moisture, these can grow on leather, wood, pickle and bread.
- Some fungi live **parasitically** in plants, animals and human body.
- Chloroplast is **absent** in fungi, so fungi are **heterotrophs**.
- Fungi obtain their own food from dead organic matter or living organisms.

On the basis of source of food fungi are of two types

- **Saprophytic :** These fungi obtain their own food from **dead organic matter** such as bread, rottening fruit, vegetable and dung etc.

  Nutrition is **absorptive** type in saprophytic fungi
- **Parasitic :** These obtain their own food from **living organism** such as plants, animals and human beings.

  They obtain nutrition with the help of **haustoria**.
- **Symbiotic :**
- Some fungi are found symbiotically associated with **algae** and form **lichens.**
- Some fungi are found symbiotically in the **roots of higher plants** and form **mycorrhiza**.

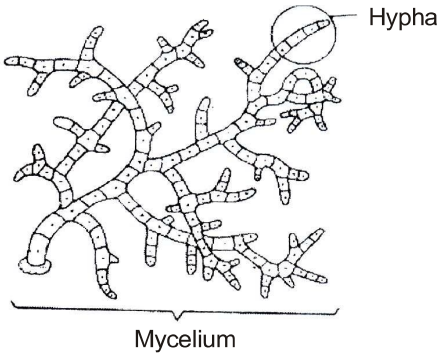
STRUCTURE

- The body is **haploid (n)** and **thalloid** i.e. not differentiated into root, stem and leaves.
- They are multicellular except **Yeast** and **Synchytrium.**
- The body of fungi is called **mycelium**. Mycelium is composed of filaments called **hypha**.

  (Hypha – plural → **Hyphae**)
- The hyphae may be **aseptate** and **multinucleate**. Such a hypha is termed **coenocytic**.
- In most of the fungi, the mycelium is **septate**. The septum, however, is not complete, but has a pore through which continuity of the cytoplasm of the adjoining cells is maintained.
- The septum may have **simple central pore** as in **ascomycetes**, but in higher fungi (**class basidiomycetes**), the septum is **dolipore septum**.
- In septate mycelium, individual cell may contain **single nucleus** (**monokaryotic** – feature of **primary mycelium**) or an intermediate phase of two nuclei (**dikaryotic** – feature of **secondary mycelium**).
- Cell wall is present around fungi, which is made up of **chitin** or **fungal cellulose**.
- Some quantity of proteins, lipids and cellulose also present with chitin.

Note :

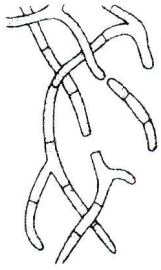
- **Cell wall** of the members of **class-oomycetes** is mainly made up of **cellulose**.
- In fungi the **stored food** remains in the form of **glycogen and oil**



REPRODUCTION

Vegetative reproduction :

– **Fragmentation :** Some times the fungi filament (mycelium) breaks into small pieces due to any reason. Now these pieces form a new fungal filament and starts working like normal filament.

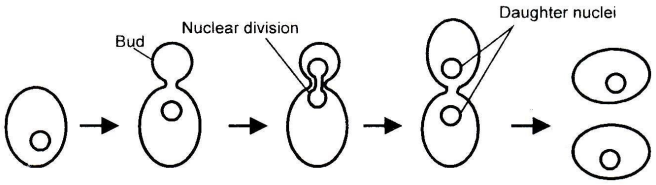


Fragmentation

– **Budding :** Some times a **bud like** protuberance is formed in **non-mycelial** fungus. Now this bud, separates from the mother fungi and functions as young fungi

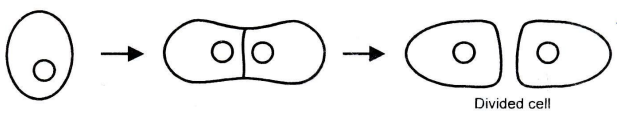
– At the time of separation of bud from its mother cell or fungi, the **nucleus** of mother cell divided **mitotically** (**or amitotically - in yeast**) into two parts.

– Out of these two nuclei, one remains with in the mother cell while the other migrates to the bud. **eg. Saccharomyces (Yeast)**



– **Fission :** Some times the fungal cell divides into two parts. Its nucleus also divides in to two parts. Now the nuclei go to both cells and each cell starts working as a new cell.

eg. Schizosaccharomyces (Yeast)



Note: Reproduction through **bud** formation and **fission** takes place only in **nonmycelial form.**

ASEXUAL REPRODUCTION

– Asexual reproduction takes place by the formation of different types of **spores.**

– These spores are formed by **mitotic division**.

Types of spores :

– **Sporangiospores :**

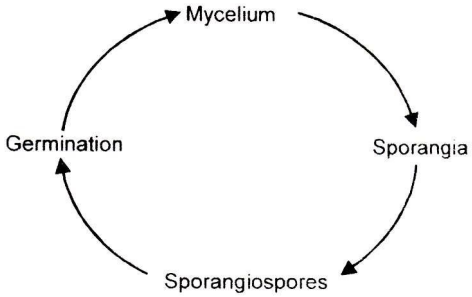
– They are formed in sporangia and sporangia is formed at the tip of fungal filament.

– Those fungal filaments on which sporangia are formed is called as **sporangiophore.**

– Numerous **spores** (sporangiospores) are present in the sporangia, that comes out by rupturing of sporangia and germinate to forms fungal filaments.

– The formation of sporangiospores takes place **endogenously**.

eg. Rhizopus, Mucor

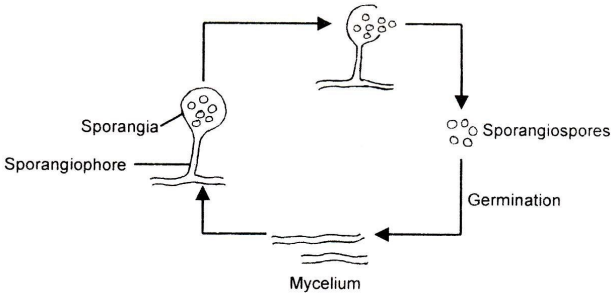


– **Sporangiospores are of Two types**

* **Zoospore :** When the sporangiospores formed in sporangia are **flagellated** and **motile.** then they are called as zoospores.

* In this condition the sporangia are called as **zoosporangia**.

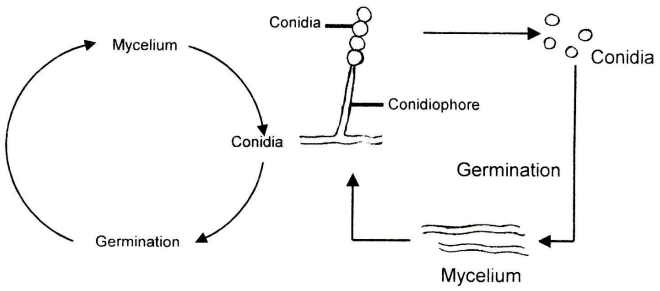
* **Aplanospore :** When sporangiospores are **non flagellated** and **non motile** then they are called aplanospores.



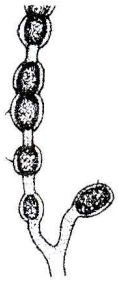
– **Conidia :** The formation of conidia takes place **exogenously**. These conidia are formed on the tip of condiophores

* **Conidiophore :** Straight fungal filament on which conidia are formed are called **conidiophore.** Conidiophore may be **unbranched, branched, septate** or **aseptate.**

* **Conidia :** Conidia are formed single or in chain. Each conidia forms fungal filament (mycelium) by germination. These are **non-motile**



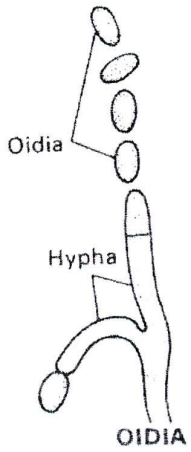
– **Chlamydospores :** They are formed in **adverse condition.** These are **thick walled** resting, resistant spores



Chlamydospores

– **Oidia :**
Sometimes in **plenty of food,** the cells of fungal hyphae gets seperated and starts working like spores. Now these cells are called **oidia.** May produced under **sugar rich conditions** in medium.

– The chain of **Oidia** is known as **Torula stage.**

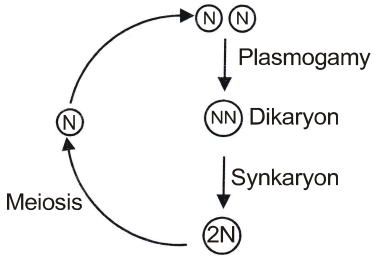


SEXUAL REPRODUCTION

– In fungi specific and **reduced type** and takes place by fusing gametes.

– The structure in which gametes are formed are called **gametangia**.

– Sexual reproduction in fungi completes in three steps.



In fungi, sexual fusion is of many types :

– **Plasmogamy :** This is the first stage of sexual reproduction. In this stage two sex cells fuse with each other but their **nuclei do not fuse,** due to which **a single cell has two nuclei**. This binucleate stage is called **dikaryon**

– **Karyogamy :** In this stage the **nuclei** present in the cell **fuse with each other** (delayed in Fungi) to form a diploid nucleus which is known **synkaryon**.

– **Meiosis :** In this stage, **meiosis** takes place in the **diploid** nucleus due to which again **haploid** nuclei or haploid cells are formed.

METHODS OF SEXUAL REPRODUCTION

* **Planogametic Copulation :**

– In this process **whole mycelium** (vegetative cell) starts as a **sex cell** i.e. whole cell starts working as **gametangia.**

– Each **nucleus** of gametangia behaves like **gametes**.

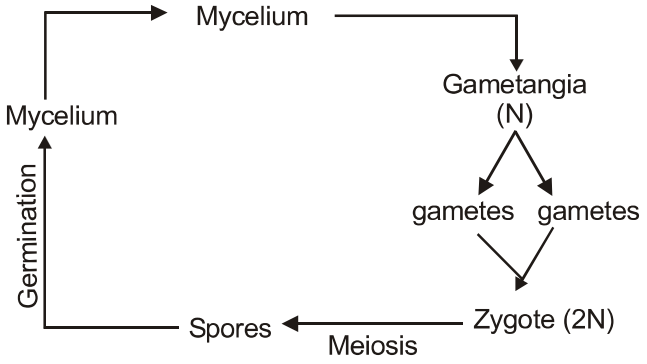
– After that the gametangia ruptured and its nuclei (gametes) becomes free.

– Now these gametes fuse with each other to form zygote.

– Now **meiotic** division takes place in **zygote**. As a result of which **haploid spores** are formed.

– Now each spore germinates and gives rise to a new mycelium.

eg. **Chytridiomycetes, plasmodiophoromycetes**



* **Gametangial Contact**

– In this process, first of all male and female sex organs are formed on **two different mycelium.**

– Male sex organ is called **antheridium** and female sex organ is called **oogonium.**

– Both **antheridium** & oogonium have one nucleus. Now **antheridium** and oogonium come close to each other.

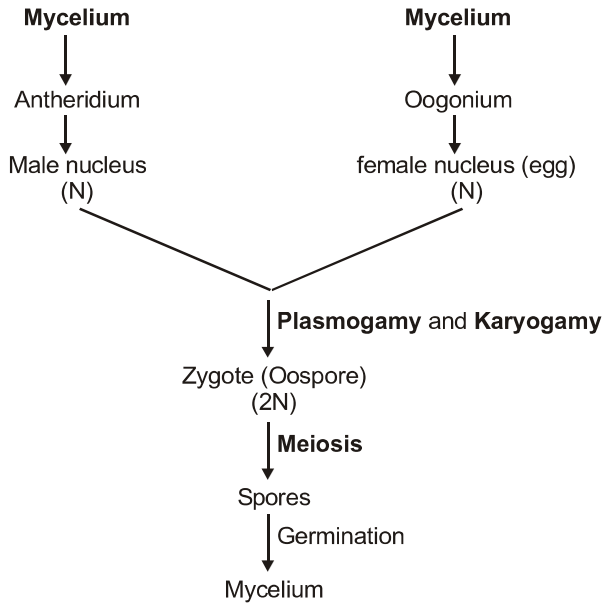
– After that a **fertilizing tube** comes out from antheridium, through this tube **nucleus** move to oogonium and fuse with its nucleus.

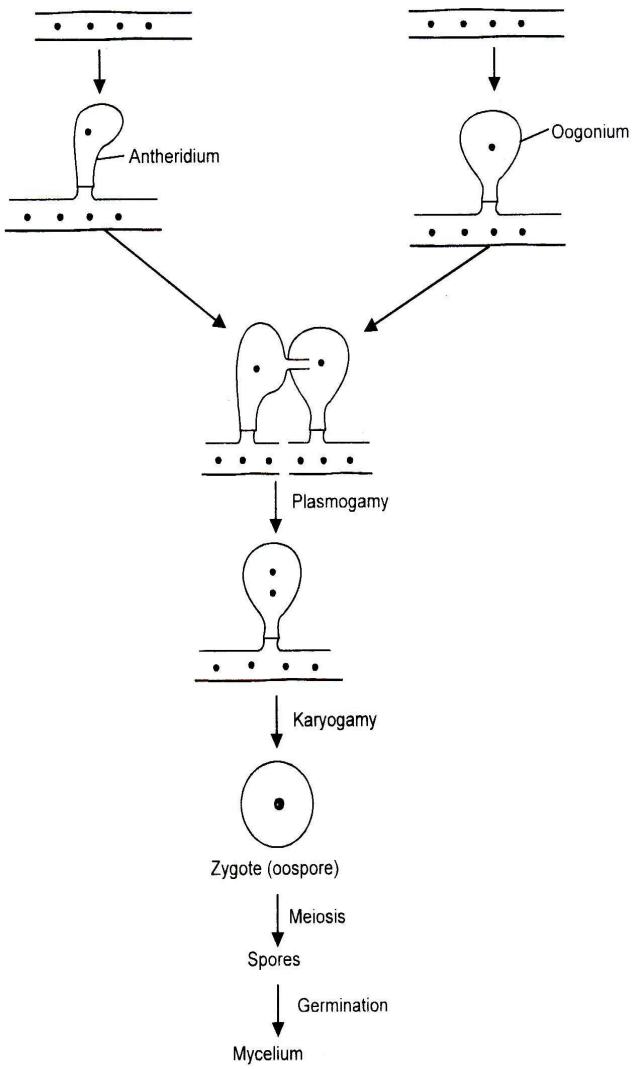
– As a result of which a **diploid zygote** is formed, which is called **oospore.**

– Now **meiotic** division takes place in the nucleus of oospore, as a result of which **haploid spores** are formed.

– Now each **spore germinates** and gives rise to a new mycelium.

eg. Oomycetes (Albugo)





* **Gametangial copulation :**

– In this process, gametangia formed on two different mycelium.

– First of all the **apical** part of mycelium become swollen and form **gametangia**.

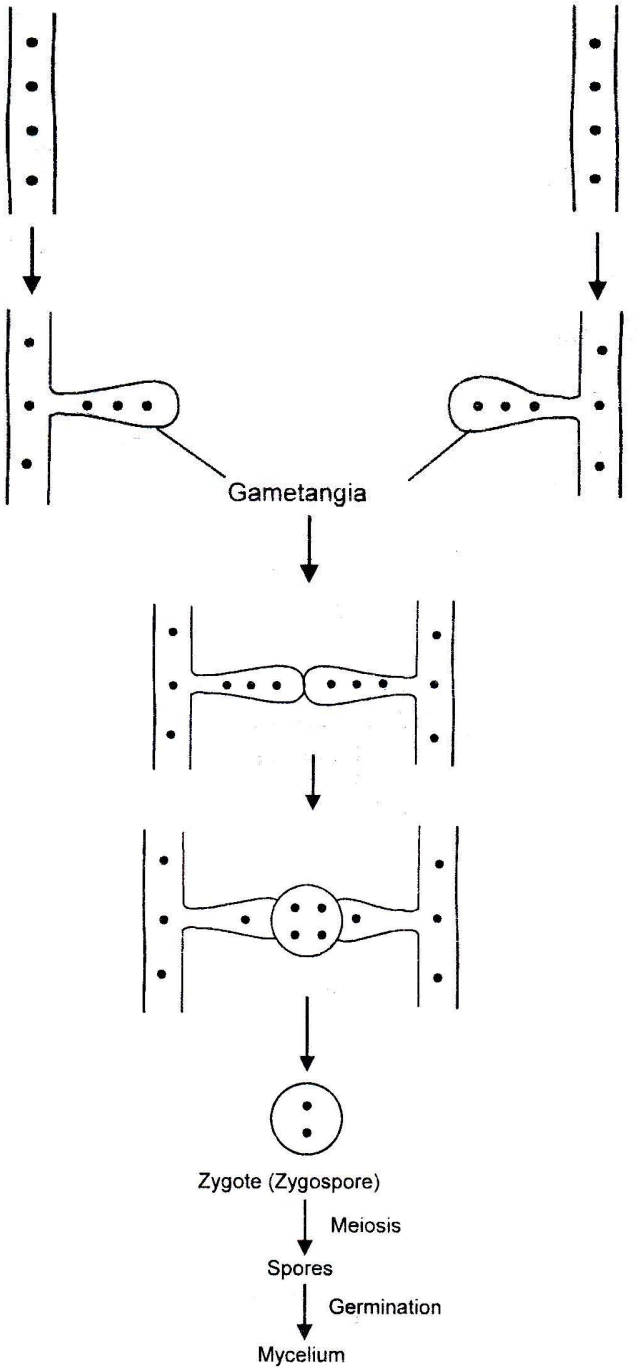
– Both the gametangia have **many nuclei**.

– Now these gametangia come close and fuses with each other. Due to which **zygote** is formed which is known as **zygospore**.

– Now **meiotic division** takes place in zygospore, as a result of which **haploid spores** formed.

– Now each spore germinates and gives rise to a mycelium.

eg. **Zygomycetes** (Mucor, Rhizopus)



* **Somatogamy :**

– This takes place in most of the **higher true fungi,** where **formation of gametes is absent.**

In such fungi, direct fusion of somatic hyphal cells occur to establish **dikaryophase**,

e.g. **Ascomycetes and Basidiomycetes.**

* **Spermatization :**

– Some fungi produce many minute, **spore like, single-celled** structure called **spermatia (non motile male gametes)** on **spermatiophores** (hyphae).

– These structures are transfered through agencies like **water**, **wind** and **insects** to special **female receptive hyphae.**

– The contents migrate into receptive structure where, by **plasmogamy**, **dikaryotic** condition is established

– eg. **Basidiomycetes (Mostly rust fungi)**

TRUE FUNGI

– Fungi divided into following classes on the basis of **structure of mycelium & sexual reproduction**

* **PHYCOMYCETES**

* **ASCOMYCETES**

* **BASIDIOMYCETES**

* **DEUTEROMYCETES**

v **PHYCOMYCETES :**

All the fungi included in this class are called as **lower fungi**

– The fungal filament (mycelium) of all the fungus included in this class are **coenocytic and aseptate.**

– This type of filament is known as **acellular coenocytic**.

Members of phycomycetes are found in aquatic habitats and on decaying wood in moist and damp places or as obligate parasites on plants. The mycelium is aseptate and coenocytic. Asexual reproduction takes place by zoospores (motile) or by aplanospores (non-motile). These spores are endogeneously produced in sporangium. Zygospores are formed by fusion of two gametes. These gametes are similar in morphology (isogamous) or dissimilar (anisogamous or oogamous). Some common examples are Mucor , Rhizopus (the bread mould mentioned earlier) and Albugo (the parasitic fungi on mustard).

Mucor

ASCOMYCETES :

– **"The sac fungi"**

– They are saprophytic, decomposers, parasitic or coprophilous (growing on dung).

* **Mycelium : Uninucleate and septate**

– Septa are found in mycelium of ascomycetes.

– **Pores** are present in septa. These pores allow cytoplasm to pass from one cell to other cell.

– Pores do **not** allow passing of nucleus.

* **Asexual reproduction :**

– Mostly by **conidia (Exogenously)** formed on conidiophores.

* **Sexual reproduction : Mostly by "Somatogamy"**

– **Ascospores** are formed during sexual reproduction. On this basis they are named as **Ascomycetes**.

– There are three stages in sexual reproduction of Ascomycetes.

  * **Plasmogamy**

  * **Karyogamy**

  * **Meiosis**

– In it two different mycelium come close to each other and fuse to form **dikaryon.** so there is delay in Karyogamy

– After this an outgrowth originates from **dikaryon** which is called **ascogenous hypha**.

– Ascogenous hypha develops and form a **sac** like structure which is called **ascus** (Plural – Asci).

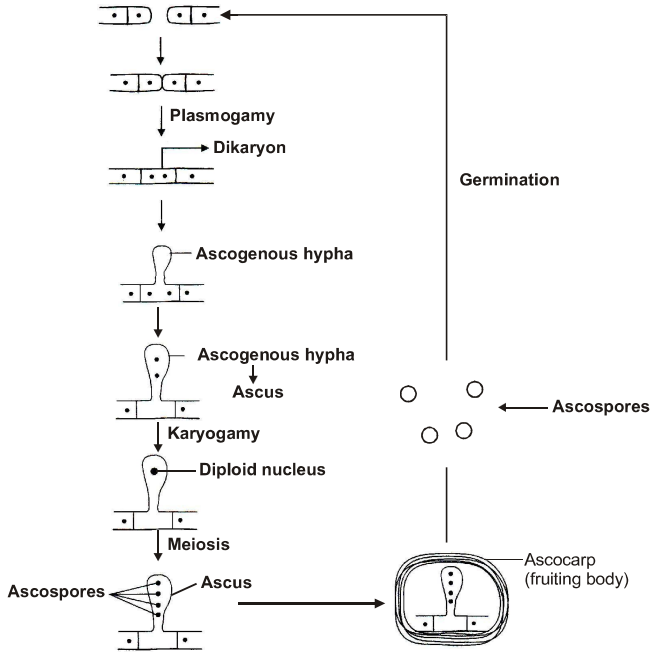
– Due to this sac like **ascus,** ascomycetes are called as **sac fungi**.

– Now both the **nuclei** reach in **ascus** and **fuse.** As a result **diploid nucleus** is formed.

– Now **meiosis** takes place in the nucleus of Ascus, as a result of which **haploid spores** are formed, which are called **ascospores**.

– Ascospore produced **endogenously**

Note: Minimum **four** ascospores are formed in **one ascus** but generally **8 ascospores** are formed in one Ascus.



– After the formation of ascospores, the **mycelium** grows around the ascus and forms **a covering** which is called as **fruiting body** or **ascocarp**,

– 1 to 4 ascus are present in one **ascocarp**

– 4 or 8 ascospores are present in one **ascus**.

– By the rupturing of ascoarp & ascus, ascospores becomes free and each ascospore forms a new mycelium.

* **Special Note :**

– The fruiting body of **Morchella** is **edible,** because it is delicious.

– The classification of class ascomycetes is based on fruiting body.

– Ascus are naked in **Yeast**, because fruiting body is absent in it.

Examples of Ascomycetes :

* **Penecillium :**

Aspergillus, claviceps and neurospora

Neurospora is used extensively in biochemical and genetic work. Many members like morels and buffles are edible and are considered delicacies.

BASIDIOMYCETES : "Club fungi'

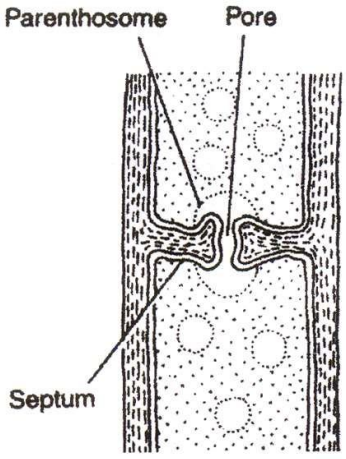
Mycelium : Septate and uni or binucleate (dikaryotic)

– Mycelia are of two types, **primary** and **secondary.**

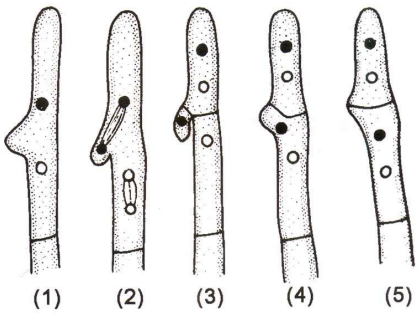
– **Primary mycelium** contains **monokaryotic** cells and is short lived

– **Secondary mycelium** is long lived and **dominant phase of life cycle**. It is represented as **dikaryophase**.

– It consists of profusely branched **septate hyphae.**



Dollpore Septum



Clamp connections and formation of dikaryotic hyphae

– In **basidiomycetes,** septum are of special type and they are called **dolipore septum.** One big pore is present between every septum.

– The boundry of pore is spread on both sides, this boundry is called as **parenthosome.**

– Due to the spreading of the boundry on both sides, the shape of septum becomes **dome shaped** due to which it is called as **dolipore septum.**

– These septa allow cytoplasm and nucleus to pass from one cell to other cell.

– **Clamp connection :** It is a tubular relationship between two neighbouring cells With the help of the connection the nucleus of one cell can migrate to the neghbouring cell, due to which the other cell becomes **dikaryotic (binucleate).**

– Clamp connection is used to change **monokaryotic** mycelium to **dikaryotic** in basidiomycetes.

– These are best **decomposer of wood**

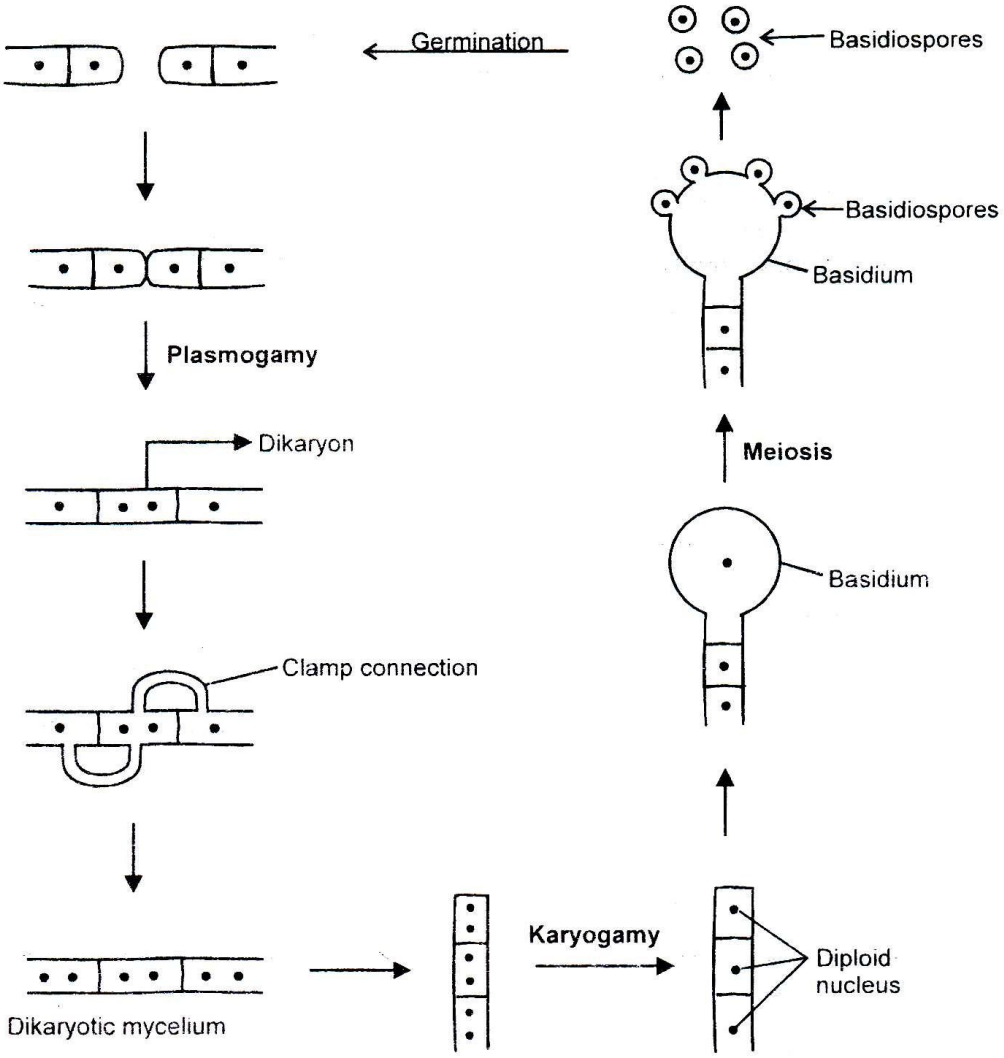
Sexual Reproduction

Sexual reproduction is done by two methods

(1) **Somatogamy**

(2) **Spermatization**

It is belived that **basidium is similar to ascus.** because both of them produces spores but basidiospore is different from ascopores because the origin of **ascospores** is **endogenous** and that of **basidiospores** is **exogenous**.



Puccinia graminis – Black rust or stem rust

Ustilago (smut) and agaricus (mushroom)

Agaricus

DEUTEROMYCETES :

- It is also called "**Fungi Imperfecti**", because perfect stage or **sexual reproduction is absent** in this class of fungi.
- When the sexual forms of these fungi were discovered, they were move into classes they belongs to.
- **Mycelium :**

  Septate and **multinucleate** or **uninucleate**.
- **Asexual reproduction :**

  Takes place with the help of **conidia**. Conidia have **oblique septa**

– **Sexual Reproduction :**

* Sexual reproduction is **absent** in this class. Instead a ***parasexual*** cycle is present.

* Parasexual cycle was discovered by **Potecorvo** & **Roper**.

– Parasexual cycle is a method for producing **variation** in these fungi.

– Importance of Parasexual cycle – **Mitotic recombination**

– During mitosis, recombination takes place in these fungi due to which variations are develop.

These are **entomophagous** fungi i.e. insect predating fungi. These fungi can be used in biological control of **insect pests.**

The fungi included in this class causes many disease.

	Fungi	Disease
(1)	*Alternaria solani*	Early blight of Potato
(3)	*Colletotrichum falcatum*	Red rot of sugarcane

Note : Leaf spot of rice *(Helminthosporium oryzae)* - This disease in known as **famine of Bengal (1945)**

VIRUSES, VIROIDS AND LICHENS

In the five kingdom classification of Whittaker there is no mention of some acellular organisms like viruses and viroids, and lichens. These are briefly introduced here.

All of us who have suffered the illeffects of common cold or 'flu' know what effects viruses can have on us, even if we do not associate it with our condition. Viruses did not find a place in classification since they are not truly 'living', if we understand living as those organisms that have a cell structure. The viruses are non-cellular organisms that are characterised by having an inert crystalline structure outside the living cell. Once they infect a cell they take over the machinery of the host cell to replicate themselves, killing the host. Would you call viruses living or non-living?

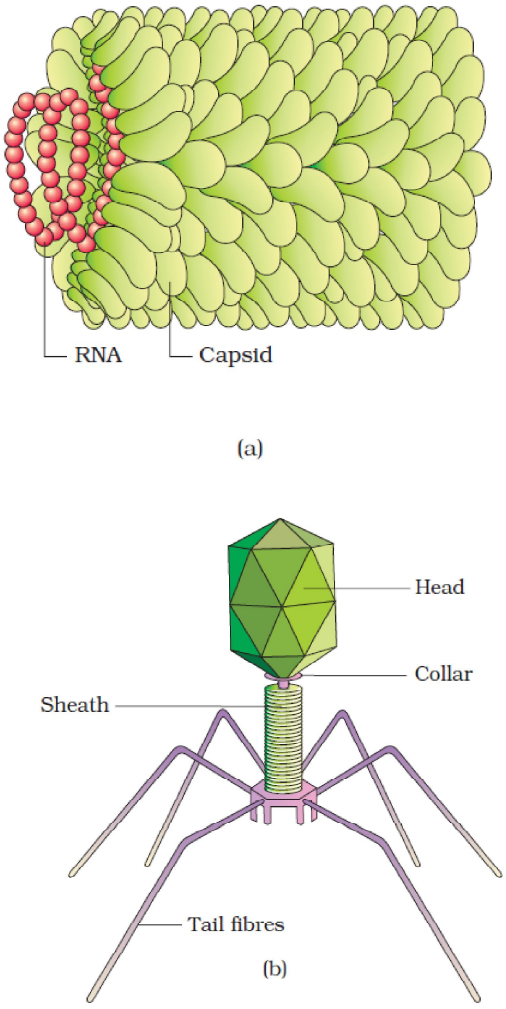


Figure: (a) Tobacco Mosaic Virus (TMV)
(b) Bacteriophase

The name virus that means venom or poisonous fluid was given by Pasteur. D.J. Ivanowsky (1892) recognised certain microbes as causal organism of the mosaic disease of tobacco. These were found to be smaller than bacteria because they passed through bacteria-proof filters. M.W. Beijerinek (1898) demonstrated that the extract of the infected plants of tobacco could cause infection in healthy plants and called the fluid as Contagium vivum fluidum (infectious living fluid). W.M. Stanley (1935) showed that viruses could be crystallised and crystals consist largely of proteins. They are inert outside their specific host cell. Viruses are obligate parasites.

In addition to proteins viruses also contain genetic material, that could be either RNA or DNA. No

virus contains both RNA and DNA. A virus is a nucleoprotein and the genetic material is infectious. In general, viruses that infect plants have single stranded RNA and viruses that infect animals have either single or double stranded RNA or double stranded DNA. Bacterial viruses or bacteriophages (viruses that infect the bacteria) are usually double stranded DNA viruses. The protein coat called capsid made of small subunits called capsomeres, protects the nucleic acid. These capsomeres are arranged in helical or polyhedral geometric forms. Viruses cause diseases like mumps, small pox, herpes and influenza. AIDS in humans is also caused by a virus. In plants, the symptoms can be mosaic formation, leaf rolling and curling, yellowing and vein clearing, dwarfing and stunted growth.

Viroids : In 1971 T.O. Diener discovered a new infectious agent that was smaller than viruses and caused potato spindle tuber disease. It was found to be a free RNA; it lacked the protein coat that is found in viruses, hence the name viroid. The RNA of the viroid was of low molecular weight.

Lichens : Lichens are symbiotic associations i.e. mutually useful associations, between algae and fungi. The algal component is known as phycobiont and fungal component as mycobiont, which are autotrophic and heterotrophic, respectively. Algae prepare food for fungi and fungi provide shelter and absorb mineral nutrients and water for its partner. So close is their association that if one saw a lichen in nature one would never imagine that they had two different organisms within them. Lichens are very good pollution indicators – they do not grow in polluted areas.