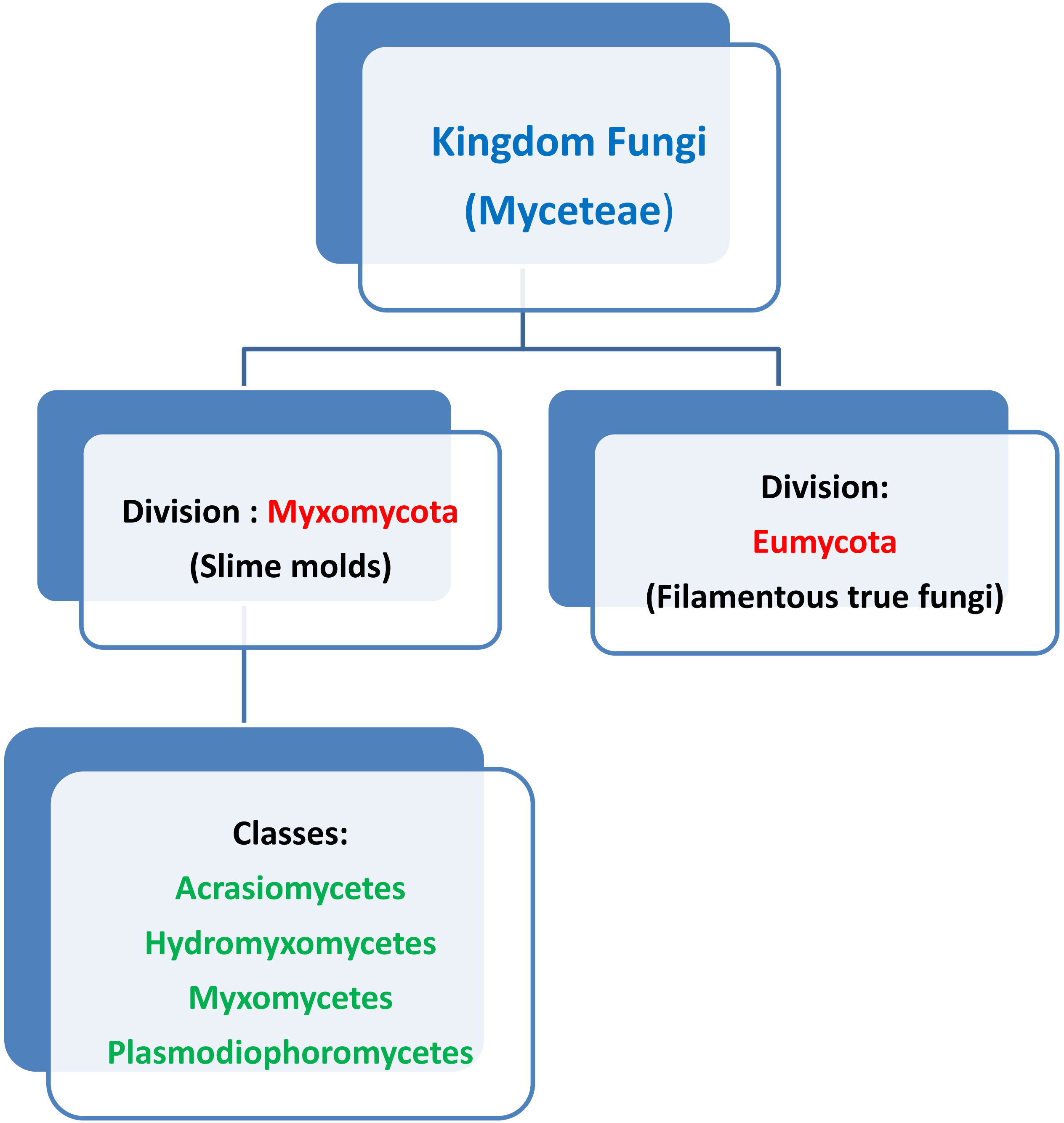
Myxomycota

The Slime Molds

Ainsworth 1973



Phylogeny of Myxomycota

- Although the members of the Myxomycota have some characteristics in common, certain differences are of major magnitude, with the result that a single evolutionary series seems quite unlikely
- Macbride (1899) believed that the slime molds are fungi
- Karling (1944) suggested that the slime molds are closely related to Protozoa than to fungi
- Martin (1932, 1960-61) has pointed out that if the algal origin of fungi is accepted, then the slime molds are not fungi; but if the fungi have been descended from colourless flagellates, the slime molds can well be regarded as fungi, derived from the same general ancestral types as other fungi, but independent and highly specialized to constitute a group of their own—the Myxomycota

- Sparrow (1958) proposed that the parasitic slime molds be regarded as a separate Class the Plasmodiophoromycetes
- The Plasmodiophoromycetes are again grouped with zoosporic fungi by some taxonomists though the Plasmodiophoromycetes have controversial affinities
- Both the Myxomycetes and the Plasmodiophoromycetes are apparently of flagellate origin
- However, the cytological details are so different that the two groups are related only to the extent of a distant flagellate ancestry
- It is possible that the Plasmodiophoromycetes arose very early from a primitive fungus of the Phycomycetes, most likely the Chytridiales

- Talbot (1971), Webster (1983), and others grouped all the four classes of slime molds under the Division Myxomycota close to fungi
- Bonner considers the Acrasiomycetes to have had their origin from the free-living amoebae of the soil
- This opinion is based largely on the absence of a flagellated stage
- It is generally assumed that the free-living amoebae themselves came from flagellates

Myxomycota

- Members of this division are commonly referred to as slime molds
- Although presently classified as Protozoans, in the Kingdom Protista, slime molds were once thought to be fungi (=kingdom Mycetae) because they produce spores that are borne in sporangia, a characteristic common to some taxa of fungi
- The assimilative stage in slime molds is morphologically similar to that of an amoeba and designated as myxamoeba
- However, organisms in this group continue to be studied in mycology as a matter of tradition and not because they are thought to be related to fungi

Difference between Slime molds and True Fungi

Myxamoeba

- The myxamoeba, is a uninucleate, haploid cell which is not enclosed in a rigid cell wall, and ingests its food by means of phagocytosis
- The food particles, usually bacteria, become surrounded by the pseudopodia of the myxamoeba
- Once the food has been engulfed in this matter, it is surrounded by a membrane or food vacuole where hydrolytic enzymes are secreted that will digest the food

True Fungi

- In fungi, the assimilative stages are mycelium and yeast, both of which are surrounded by a rigid cell wall and obtain their food by means of absorption

Myxomycota

- It is a group of organisms of great scientific interest
- Some of these are of remarkable beauty, have delicate structure and brilliant colours
- They exist in non-green slimy masses of protoplasm sending out pseudopodia
- This has earned for them the name slime molds or slime fungi
- They are found in cold, moist shady places in dead organic matter such as decaying logs and fallen dead leaves in the woods

Classes of the Myxomycota

A. Free-having plasmodium bearing haploid or diploid nuclei

AA. Amoeboid cells aggregating into a pseudoplasmodium

- Acrasiomycetes

AAA. Amoeboid cells spindle-shaped to oval interconnected by slime filaments forming a net commonly known as 'net plasmodium' or 'filo-plasmodium'

- Hydromyxomycetes

B. Plasmodium non-parasitic, fructification present

- Myxomycetes

BB. Plasmodium parasitic, fructification lacking

- Plasmodiophoromycetes

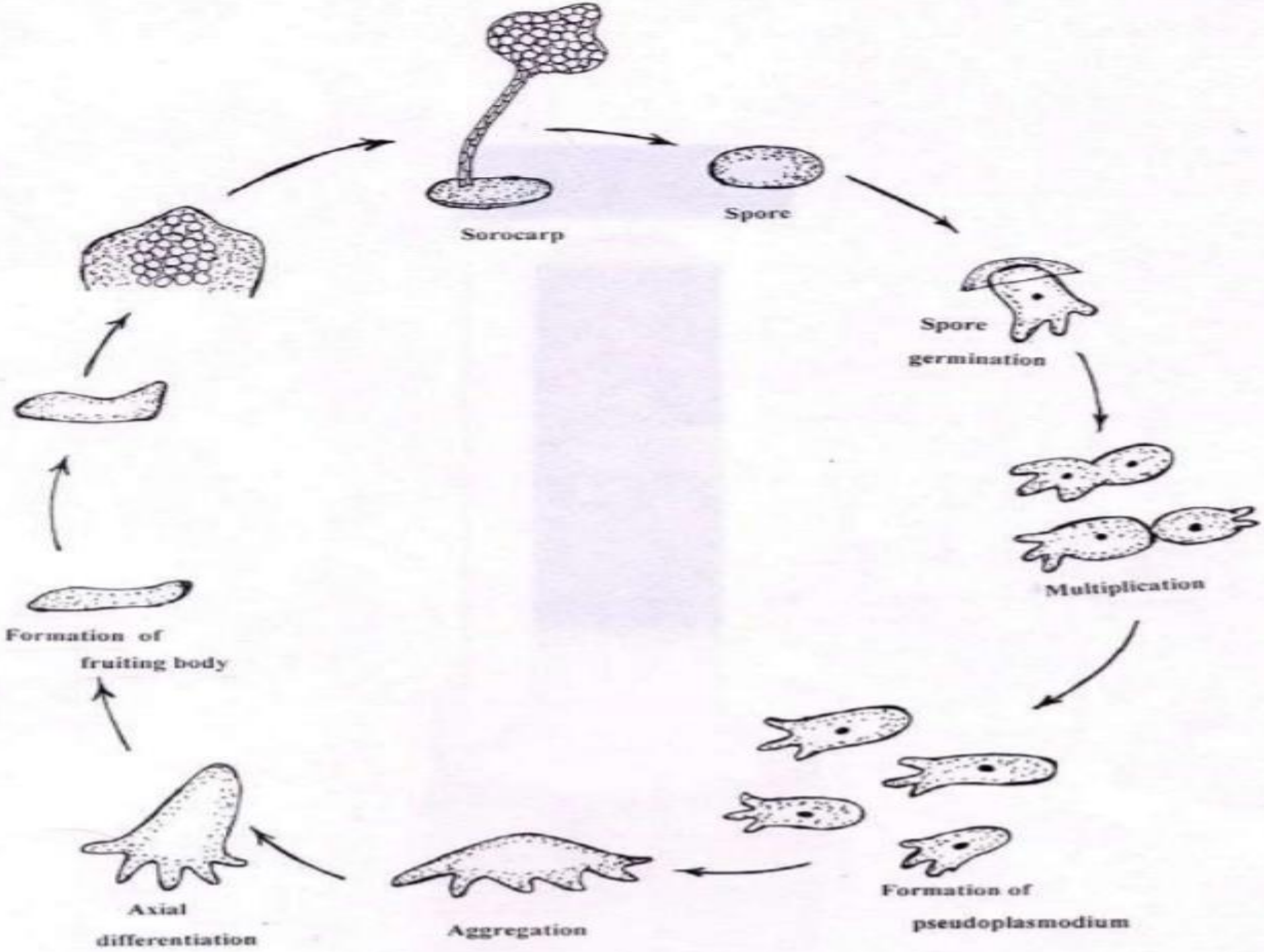
A. Class: Acrasiomycetes

- These are commonly known as cellular or amoeboid slime molds, and are found profusely in the upper layer of humus in deciduous forests and also in cultivated lands
- Somatic phase commonly consists of amoeboid cells or myxamoebae
- Myxamoebae aggregate by a large number of cooperating individual cells to form a pseudoplasmodium, which develops into fruit bodies and called as ‘social amoebae’
- Spore wall contains cellulose
- The class comprise about two dozen species which are free living soil inhabitants
- The most extensively studied are Dictyostelium mucoroides and D. discoideum

Life cycle

- The basic units of Acrasiomycetes are naked, uninucleated, haploid amoebae
- They move over solid media by means of pseudopodia, feed by phagocytosis of bacteria and multiply
- Eventually, the amoebae migrate towards an aggregation centre and form an aggregation plasmodium, (pseudoplasmodium) to distinguish it from the multinucleate
- Although the individual amoebae maintain their identity the pseudoplasmodium functions as a unit
- It forms a ‘slug’

- A ‘cap’ is formed in which the axis of the fruiting body, the sorophore becomes differentiated
- The cells on the upper surface form a stem, which is enclosed in a cellulose coat, while the cells from the posterior or lower part migrate to the apex of the stem where they form a spherical head, the sorocarp, and develop into spores
- The spores are encysted amoebae
- On germination of a spore, a pore appears in the cellulose coat through which the amoeba is liberated to begin a new cycle


Sorocarp
Spore
Spore
germination
Multiplication
Formation of
pseudoplasmodium
Aggregation
Axial
differentiation
Formation of
fruiting body

B. Class: Hydromyxomycetes

- This group shows uncertain affinities
- The thallus forms net plasmodium or filoplasmodium
- They are commonly aquatic and saprobic, but rarely parasitic
- The thallus consists of uninucleate spindle shaped cells, forming extensive filaments
- The filaments are tubular and form net-like structure, the net-plasmodium or filoplas- modium
- Reproduction by cyst formation, zoospore formation or by congregation

C. Class: Myxomycetes

- This group is commonly known as acellular true slime molds or plasmodial slime molds because the plasmodium stage of the lifecycle is not composed of many cells
- They are commonly found in damp places, other decomposing plant parts and old fence posts
- The vegetative body is a free-living plasmodium, that consumes food by phagocytosis on yeast cells, protozoa, fungal spores and other substances
- They are sometimes conspicuously colored fruiting bodies, about 0.5 - 1 cm in size and are easily visible
- Some of the representatives are Lycogala epidendron, Cribaria rufa, Fuligo septica etc.

- **The somatic phase is represented by a multinucleate apparently naked acellular slimy protoplasmic mass called the Plasmodium**
- **The Plasmodium is the product of syngamy, hence a diploid structure**
- **The diploid Plasmodium is holocarpic, free living and active. It contains and secretes slime**
- **Normally at the fruiting time, the entire Plasmodium is organised into one or more plantlike reproductive structures, the sporangia (sporophores) or under conditions of stress and strains it becomes converted into an irregular hard structure, the sclerotium**

- The reproductive phase is stationary
- With the exception of three species which are exosporous, all the others are endosporous and produce spores within sporangia
- The sporangium generally develops a tough noncellular layer or wall called the peridium which is often studded with tiny crystals of calcium salts
- Within the peridium is usually an intricate network of fine tube-like structures constituting the capillitium
- The numerous spores are differentiated from the diploid protoplast of the sporangium by meiosis
- The encapsulated haploid spores or meiospores are close packed between the fine tubes of the capillitium but are free from them when mature

- The spore wall is differentiated into two layers, the outer of which is sculptured or spiny
- On germination, the haploid spores or meiospore give rise either to myxamoebae or biflagellate swarm cells which function as gametes
- The swarm cells or myxamoebae do not produce slime
- The sporangium in Physarum thus functions as on organ of sexual reproduction
- Sexual reproduction is of isogamous type
- The diploid zygote, by repeated mitoses but no cytokinesis, directly gives rise to multinucleate Plasmodium

- The creeping multinucleate apparently naked Plasmodium varies in structure in the different species of Myxomycetes
- Alexopoulos described three types of Somatic phases in Myxomycetes

1. Protoplasmodium
2. Aphanoplasmodium
3. Phaneroplasmodium

1. Protoplasmodium:

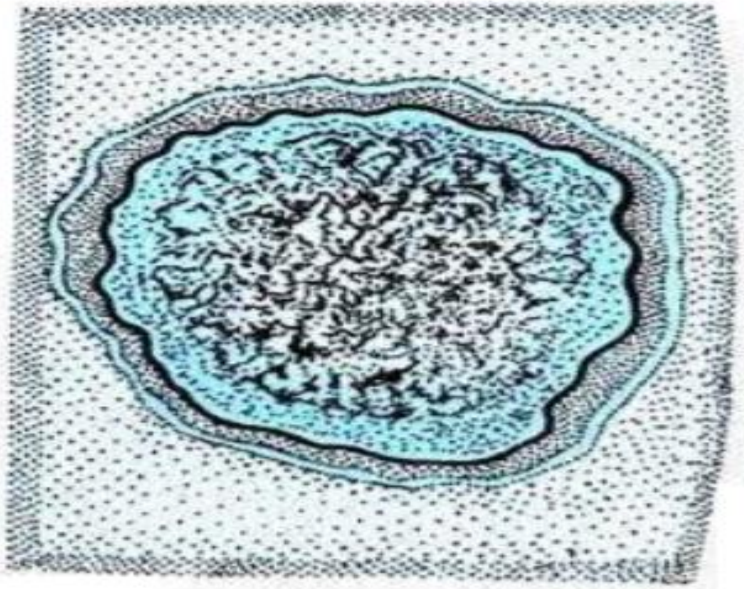
- The Plasmodium in some Myxomycetes (order Echinosteliales) is simple and of a primitive type
- It is a uninucleate tiny mass of nearly homogeneous slimy protoplasm which form pseudopode but shows no distinction into veins
- It is the smallest among the Myxomycetes and remains microscopic as long as it exists
- The cytoplasmic stream is indistinct, slow and irregular
- At the fruiting time it gets converted into a single sporangium

2. Aphanoplasmodium:

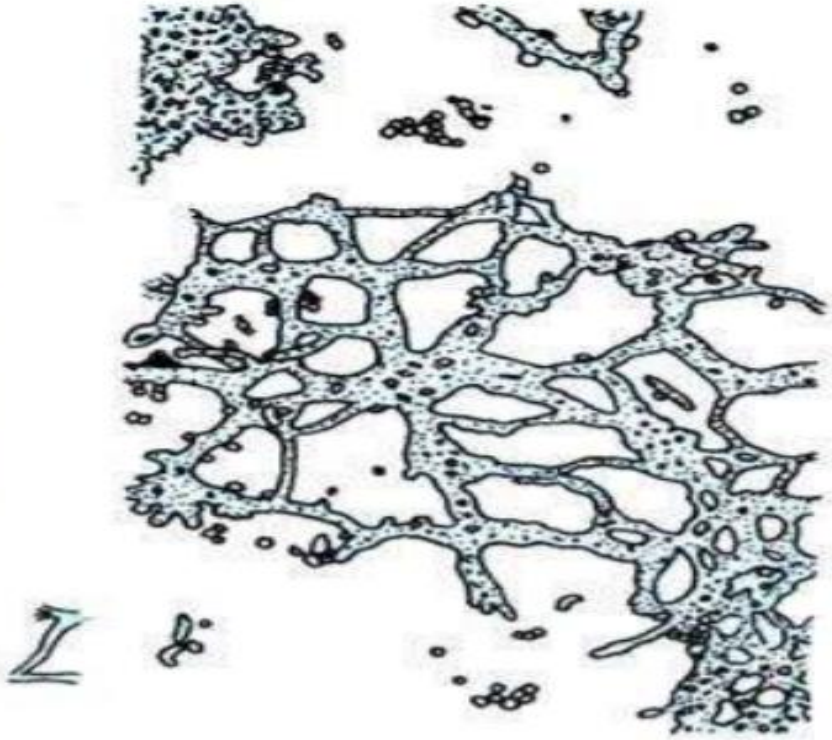
- This type of Plasmodium is characteristic of the order Stemonitomycetales
- Early in its development the aphanoplasmodium looks very much like a protoplasmodium
- During further growth it elongates and branches, finally resulting in a network of delicate strands
- The aphanoplasmodium lacks the slimy sheath
- The plasmodial protoplasm is less granular and thus transparent and not easily visible
- The distinction into ectoplasm and endoplasm is not conspicuous
- The cytoplasmic streaming is, however, rapid and confined by a fine membrane

3. Phaneroplasmodium:

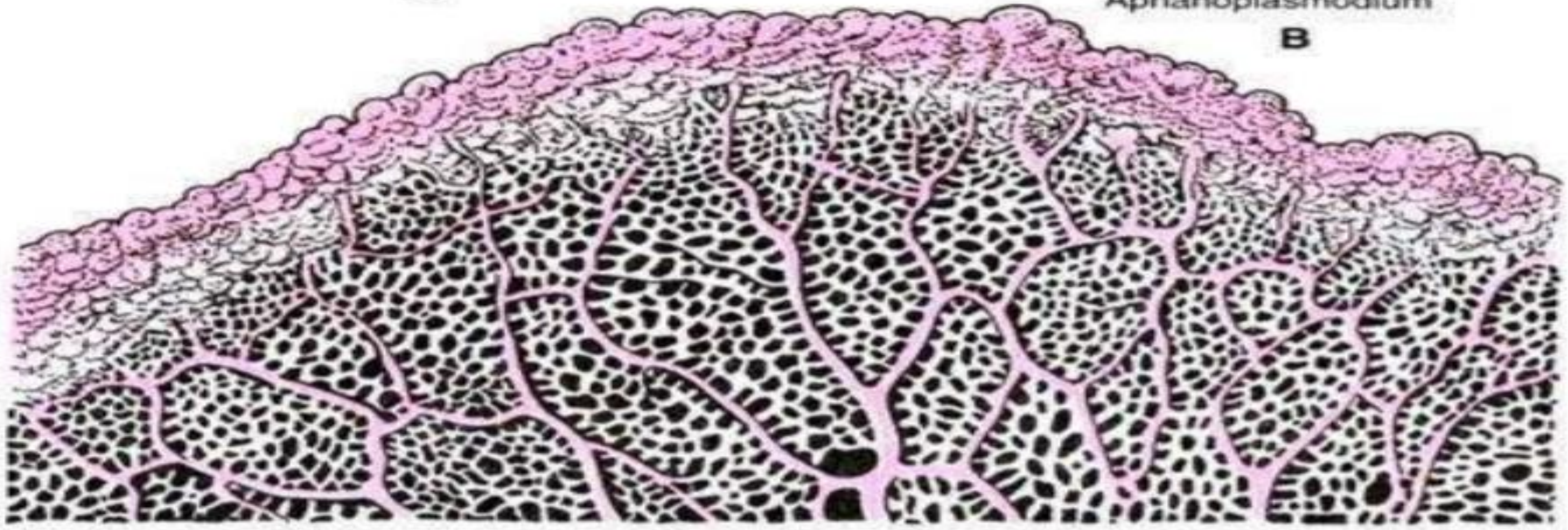
- It is the most common type and characteristic of the order Physarales
- The mature phaneroplasmodium is a massive structure
- In its initial stages of development it is very much like the proloplasmodium
- The multinucleate slimy protoplasm of the phaneroplasmodium is highly granular
- It is differentiated into ectoplasm and endoplasm
- At maturity it is divisible into an anterior fan- shaped perforated sheet of protoplasm and posterior zone consisting of a reticulate network of tubular veins or strands in which flows the rapid endoplasmic stream



Protoplasmodium
A



Aphanoplasmodium
B



Phaneroplasmodium
C

Sclerotium formation:

- Under conditions of stress and strain, the phaneroplasmodium becomes converted into an irregular hardened mass of thick-walled cellular units
- It is termed the sclerotium
- The polynucleate thick-walled units constituting the sclerotium are termed spherules
- The sclerotia and spherules remain dormant under conditions unfavourable for vegetative growth
- With the return of conditions suitable for growth, the sclerodium germinates to give rise to a new Plasmodium

Reproductive Phase of Myxomycetes:

- Normally on reaching a certain stage of maturity, the Myxomycete Plasmodium passes into the reproductive stage
- During this stage the entire Plasmodium under go sporulation and becomes converted into one or more fruit-like bodies, the sporophores or sporangia which bear the spores
- With the exception of three species belonging to the order Ceratiomyxales which bear spores externally and are termed exosporous, all other Myxomycetes are endosporous
- The latter bear spores within sporophores
- The sporophores in the endosporous Myxomycetes chiefly are of three types namely **sporangia, aethalia and plasmodiocarps**

Sporangia:

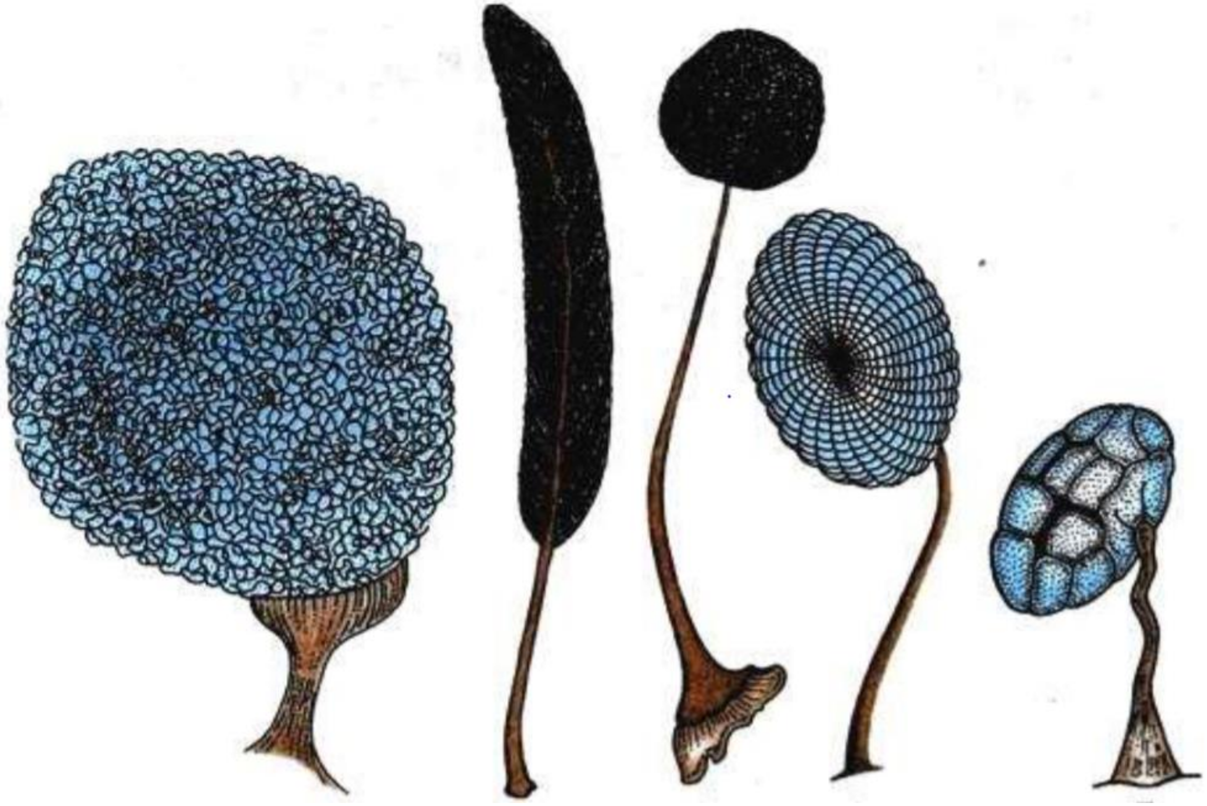
- Most of the endosporous Myxomycetes (order Physarales) produce fruit bodies of this type
- At the fruiting time the planeroplasmodium becomes converted into a group of several stalked, sometimes sessile sac-like structures, the sporangia
- The sporangia in the group remain separate from one another

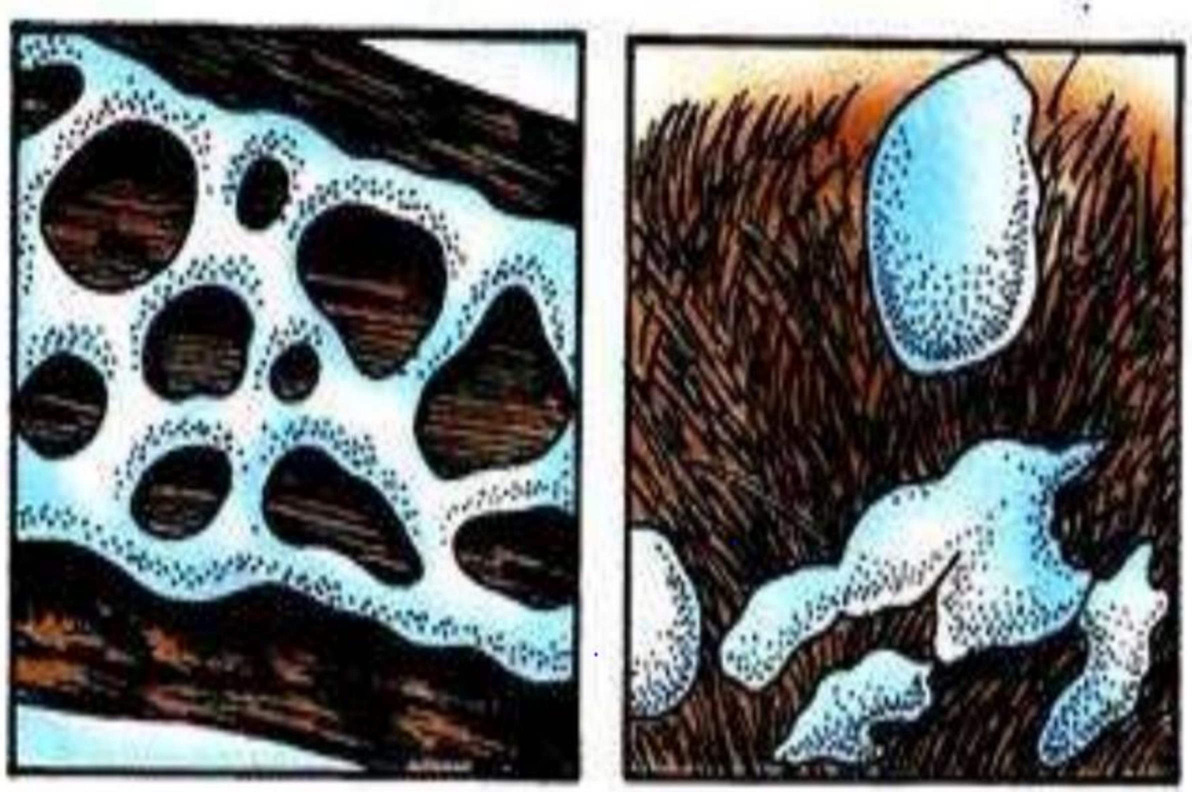
Aethalia:

- Aethalium type of fruit body is characteristic of Lycogala and Fuligo
- The Plasmodium, at the fruiting time is fairly large structure
- It becomes converted into a group of saclike sporangia that do not separate from one another
- The entire fructification which is termed aethalium, is enclosed in a common peridium and share a common hypothallus
- The sporangial walls in the aggregation may be distinct, hardly visible or not present at all

Plasmodiocarp:

- In forms like Hemitrichia the fruit body is very much like a sessile sporangium that retains the shape of the plasmodial venation
- This type of sporophore is called a plasmodiocarp
- It is formed by the concentration of the plasmodial protoplasm around some of the main veins followed by the development of peridium around each





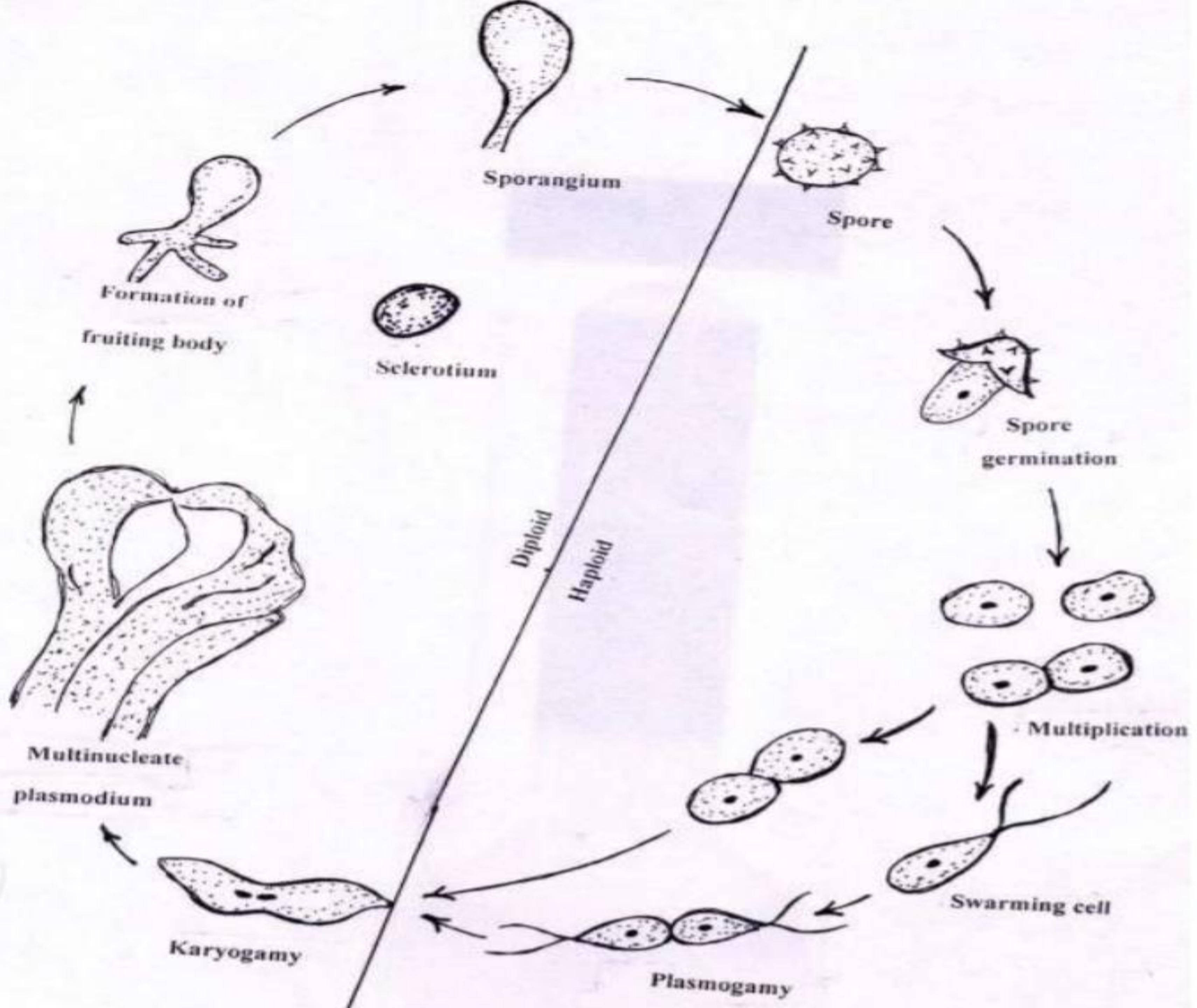
Sporangia, **Aethalia** **Plasmodiocarp**

Life cycle:

- The spores liberated from fruiting bodies germinate on moist surfaces and produce flagellated swarmers or myxamoebae
- These feed on liquid nutrients or by phagocytosis of bacteria, yeasts, fungal spores etc
- The myxoflagellates lose their flagella after a time and enter an amoeboid mononucleate stage
- Eventually, they fuse in pairs (plasmogamy and karyogamy) to become myxozygotes
- These diploid amoeba remain as such or fuse with other amoebae to form the plasmodia, which are then multinucleate
- Under favorable nutritional conditions, the number of nuclei increases by repeated mitotic divisions
- The plasmodia are negatively phototaxic (ie., light avoiding) and achieve a favourable situation by means of hydrotaxis and chemotoxis

- The plasmodia give rise to the fruiting bodies or sporangia
- The plasmodia leave their dark and moist locations and migrate towards the light
- It undergoes reduction division or (meiosis) followed by formation of a more or less complicated sporangium which has a firm envelop on its outer surface (the peridium)
- Numerous small, membrane enveloped, mononucleate spores arise in its interior
- The residues that remain between the spores form a network or ‘skeleton’, which is called the capillitium
- On maturation and opening of the peridium, the spores are blown out of the sporangium by air currents
- The capillitium arises from vacuoles, which contain various material especially calcium cabonate (CaCO3)

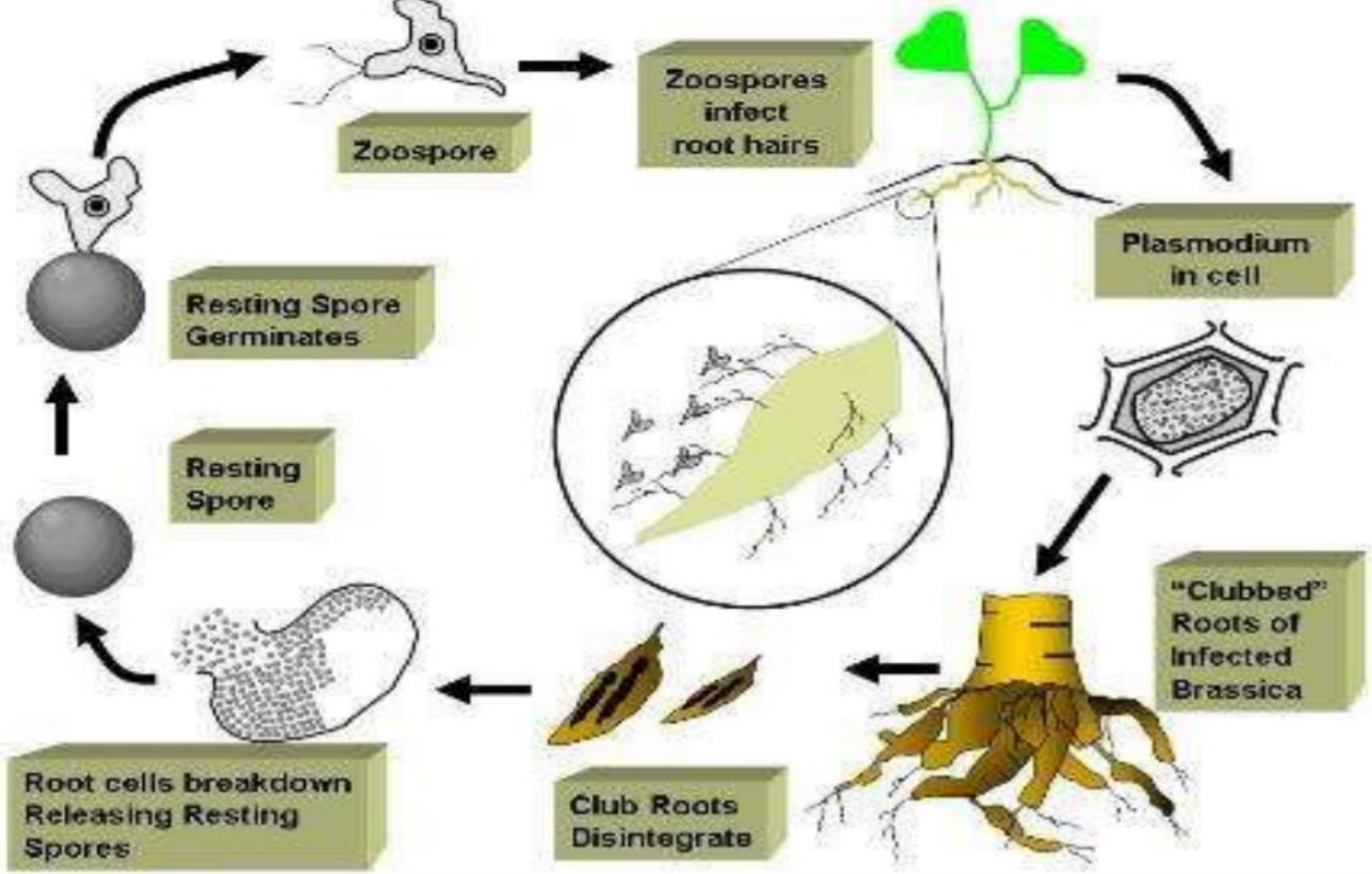
- **During favorable conditions, the plasmodium will migrate and feed for a period of time before being converted to numerous sporangia**
- **In some members, exhaustion of food is one of the stimuli that induces formation of sporangia because as long as adequate food is present in this species, the plasmodium stage will persist**
- **Light appears to be another stimulus to fruiting in this species**
- **The form and color of sporangia are variable.- stipe and sporangium**
- **The fragile, outer layer of the sporangium is the peridium (pl.=peridia), which may be persistent or degenerate by the time the sporangium is ready to disperse its spores**


Sporangium
Spore
Spore germination
Multiplication
Swarming cell
Plasmogamy
Karyogamy
Multinucleate plasmodium
Formation of fruiting body
Sclerotium
Diploid
Haploid

D. Class: Plasmodiophoromycetes

- **This group is commonly known as endo- parasitic slime molds**
- **They are obligate parasites, grow on algae, aquatic fungi and higher plants (commonly in the roots)**
- **They typically develop within plant cells, causing the infected tissue to grow into a gall or scab**
- **Important diseases caused by these members include club root in cabbage and its relatives, and powdery scab in potatoes**
- **These are caused by species of Plasmodiophora and Spongospora, respectively**

- **Somatic body consists of a naked multinucleate cell, called a plasmodium (holocarpic plasmodium)**
- **This ultimately divides to form new spores, which are released when the host's cells burst**
- **Within the plasmodium, dividing nuclei have a distinctive cross-like appearance**
- **Plasmodia are of two types in their life cycle: sporangiogenous plasmodium (form sporangia) and cytogenous plasmodium (gives rise to cysts i.e., resting spores)**
- **Both resting spores and motile zoospores, are produced at different stages**
- **Zoospores are biflagellate, having unequal flagella of whiplash type, situated in opposite direction, the shorter one in anterior and longer one in posterior side**


Zoospore
Zoospores infect root hairs
Plasmodium in cell
Resting Spore Germinates
Resting Spore
"Clubbed" Roots of Infected Brassica
Root cells breakdown Releasing Resting Spores
Club Roots Disintegrate

Economic Importance of Myxomycota

- The Myxomycetes are of relatively little economic importance, but they have been the subject of intensive laboratory studies
- They contribute to the carbon and nitrogen cycles by using various organic matter including bacteria as food
- They provide a large amount of protoplasm free from cell walls which has been used as an ideal medium to solve variety of fundamental problems of biochemists, biophysicists, mycologists and even the geneticists
- Some of the areas of studies are: the structure and chemical composition of protoplasm, the velocity of the protoplasmic movement, the chemical changes governing the production of sporangia and spores, the behaviour of nuclei and chromosomal changes during plasmodial growth, various aspects of plasmodial compatibility, etc.