Lecture3

Evolution and Phylogeny of Fungi

Until the latter half of the 20th century, fungi were classified in the plant kingdom (subkingdom Cryptogamia) and were separated into four classes: Phycomycetes, Ascomycetes, Basidiomycetes, and Deuteromycetes (the latter also known as Fungi Imperfecti because they lack a sexual cycle).

These traditional groups of fungi were largely defined by the morphology of sexual organs, by the presence or absence of hyphal cross walls (septa), and by the degree of chromosome repetition (ploidy) in the nuclei of vegetative mycelia. The slime molds, all grouped in the subdivision Myxomycotina, were also included in Division Fungi.

In the middle of the 20th century the three major kingdoms of multicellular eukaryotes, kingdom Plantae, kingdom Animalia, and kingdom Fungi, were recognized as being absolutely distinct. The crucial character difference between kingdoms is the mode of nutrition: animals (whether single-celled or multicellular) engulf food; plants photosynthesize; and fungi excrete digestive enzymes and absorb externally digested nutrients.

In the middle of the 20th century the three major kingdoms of multicellular eukaryotes, kingdom Plantae, kingdom Animalia, and kingdom Fungi, were recognized as being absolutely distinct. The crucial character difference between kingdoms is the mode of nutrition: animals (whether single-celled or multicellular) engulf food; plants photosynthesize; and fungi excrete digestive enzymes and absorb externally digested nutrients.

There are other notable differences between the kingdoms. For example, whereas animal cell membranes contain cholesterol, fungal cell membranes contain ergosterol and certain other polymers. In addition, whereas plant cell walls contain cellulose (a glucose polymer), fungal cell walls contain chitin (a glucosamine polymer).

One exception to this rule is a group of fairly ubiquitous microscopic fungi (referred to as the cryptomycota), members of which average about 3 to 5 μm (1 μm is about 0.000039 inch) in length, have cell walls lacking chitin, and possess

a flagellum. Phylogenetic analyses of ribosomal RNA in this clade suggest that it is an ancient fungal group.

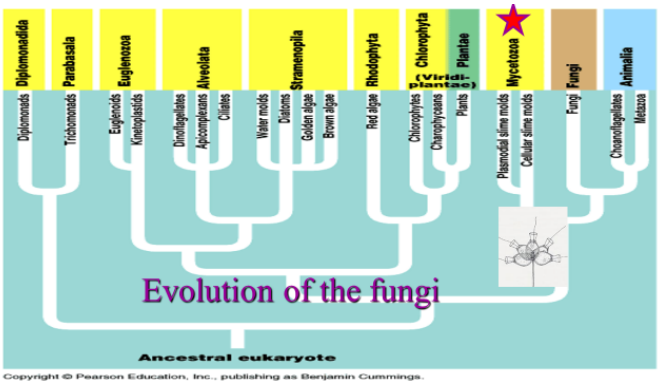
Genomic surveys show that plant genomes lack gene sequences that are crucial in animal development, animal genomes lack gene sequences that are crucial in plant development, and fungal genomes have none of the sequences that are important in controlling multicellular development in animals or plants. Such fundamental genetic differences imply that animals, plants, and fungi are very different cellular organisms.

Today many organisms, particularly among the phycomycetes and slime molds, are no longer considered to be true fungi, even though mycologists might study them. This applies to the water molds (e.g., the plant pathogen *Phytophthora*, the cause of potato late blight), all of which have been reclassified within the kingdom Chromista (phylum Oomycota).

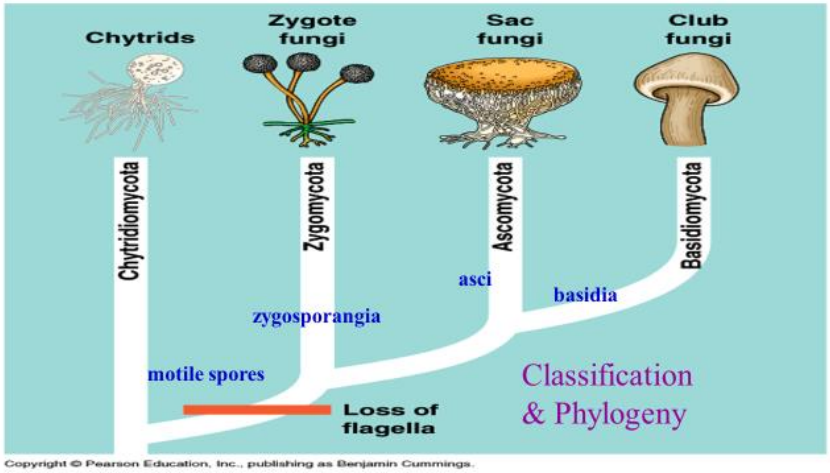
Similarly, the Amoebidales, which are parasitic or commensal on living arthropods and were previously thought to be fungi, are considered to be protozoan animals. None of the slime molds are placed in kingdom Fungi, and their relationship to other organisms, especially animals, remains unclear.

Kingdom Fungi has gained several new members on the basis of molecular phylogenetic analysis, notably *Pneumocystis*, the Microsporidia, and *Hyaloraphidium*. *Pneumocystis jirovecii* causes pneumonia in mammals, including humans with weakened immune systems; pneumocystis pneumonia (PCP) is the most common opportunistic infection in people with human immunodeficiency virus (HIV) and has been a major cause of death in people with AIDS.

Pneumocystis was initially described as a trypanosome, but evidence from sequence analyses of several genes places it in the fungal subphylum Taphrinomycotina in the phylum Ascomycota.



1- Kingdom: Protista or Protozoa
Phylum: Myxomycota
Phylum: Plasmodiophoromycota
2- Kingdom: Straminpilia (Cromista)
Phylum Hyphochytriomycota
Phylum Labyrinthulomycota
Phylum: Oomycota
3- Kingdom: True Fungi (Fungi)
Phylum: Chytridiomycota
Phylum: Zygomycota
Phylum: Ascomycota
Phylum: Basidiomycota



Some fungi have more than one scientific name – Why?
Teleomorph: the sexual reproductive stage (morph), typically a fruiting body (e.g., *Morchella esculenta*, *Agaricus brunescens*).
Anamorph: an asexual reproductive stage (morph), often mold-like (e.g. *Aspergillus flavus*, *Fusarium solani*).

Holomorph: the whole fungus, including all anamorphs and the teleomorph.

Fungi classified into divisions (phyla) according to sexual reproductive process:

Chytridiomycota (primitive fungi)
Zygomycota (conjugation fungi)
Ascomycota (sac fungi)
Basidiomycota (club fungi)
Deuteromycota (imperfect fungi)
anamorphic fungi

1- Kingdom: Protista or Protozoa
Phylum: Myxomycota
Phylum: Plasmodiophoromycota
2- Kingdom: Straminpilia (Cromista)
Phylum Hyphochytriomycota
Phylum Labyrinthulomycota
Phylum: Oomycota
3- Kingdom: True Fungi (Fungi)
Phylum: Chytridiomycota
Phylum: Zygomycota
Phylum: Ascomycota
Phylum: Basidiomycota

Kingdom:Protista or Protozoa (Phylum: Myxomycota) The Latin name *Myxomycota* comes from the Ancient Greek words *μύξα (myxa)*, which means "mucus", and *μύκης (myces)*, which means "fungus"..
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 which includes lower and higher fungi**) because they produce **spores** that are borne in **sporangia**
A characteristic common to some taxa of fungi. However, the assimilative stage in slime molds is morphologically similar to that of an amoeba. This assimilative stage has been designated a **myxamoeba** .The myxamoeba, as is the case of the amoeba, is a uninucleate, haploid cell which is *not* enclosed in a rigid cell wall, and ingests its food by means of **phagocytosis**. 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. These are some of the reasons why mycologists no longer recognize slime molds as being fungi.
1- lack cell wall
2- somatic phase is uninucleate flagellated swarm cell (1n) or an amoeba is called

myxoamoeba (1n) others multinucleate is called plasmodim a mass ameoboid protoplasm has many nuclei (multinucleate) , 2n cell wall lost.
3-produce spores that are borne in sporangia,
4- Most of these individuals are saprophyte , and its nutrition phagotrophic .
5- life cycle:- spores are germinated to form myxamoebae(non flagellated) or swarm cells (flagellated cell). And fused swarm cells or myamoebae sexually to produce zygote (2N) , zygote germinate forming plasmodium (2N) During favorable conditions, the plasmodium will migrate and feed for a period of time before being converted to numerous sporangia .

Myxomycetes

-plasmodium

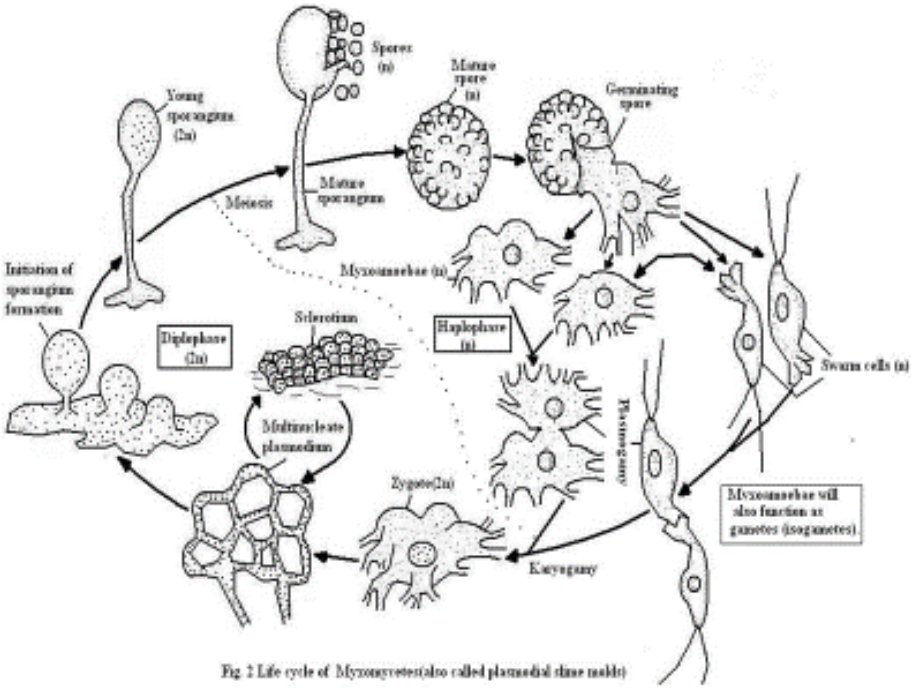


Fig. 2 Life cycle of Myxomycetes(also called plasmodial slime molds)

Features of Myxomycota:
The Myxomycota or slime molds, are fungus-like organisms. They are characterised by the absence of cell wall from their amoeboid, animal-like vegetative or assimilatory phase.

The amoeboid assimilatory phase may consist of a free-living multinucleate mass of protoplasm called a plasmodium or simple uninucleate amoeboid cells, the myxamoebae (sing, myxamoeba) often aggregating into a pseudoplasmodium (Fig. 4F) or amoeboid cells interconnected by slime filaments giving rise to a structure known as net plasmodium

The true slime molds are mostly saprophytic with a few parasitic ones. In the former the entire plasmodium is consumed in the formation of fructifications. Whereas, in the latter there is absence of development of fructifications, the plasmodium is converted into masses of spores. All the true slime molds produce flagellated cells, the swarm cells.

But the formation swarm cells is absent in the cellular slime molds. In the cellular slime molds fructifications are developed from the pseudoplasmodia. But in the net slime molds each cell is converted into a mucilaginous sporocyte in which spores are developed.

The spores escape as biflagellate zoospores which after swimming for some time, lose their flagella become surrounded by delicate envelope and give rise to new net plasmodium.

Class Myxomycetes:
The Myxomycetes, or true slime molds often designated as slime molds, or slime fungi, or Mycetozoa as they are called, are a unique group of fungus-like organisms concerning whose origin and relationships there is no common agreement. They exhibit characteristic of both animals and plants.

Their somatic phase of multinucleate mass of protoplasm without cell wall exhibiting creeping movement, known as plasmodium, is definitely animal-like, resembling a giant amoeba in its structure and

in its physiology. The reproductive process of the Myxomycetes, however, is plantlike producing spores with definite cell walls.

Occurrence of Myxomycota:

The Myxomycetes are common but inconspicuous inhabitants of moist dead wood, rotting logs, damp soil, leaf mold, moist sawdust, bark of trees, decaying fleshy fungi, or other organic matter. They often spend most of their lives within the substrate and emerge only when about to produce sporangia. Following periods of rainy weather they may occur on leaves of grasses or other plants on lawns.

Sexual Reproduction of Myxomycota:

The myxamoebae or swarm cells as the case may be, behave as gametes and as such take part in the sexual reproduction. Fusion may take place between the two swarm cells or two myxamoebae or between a swarm cell and a myxamoeba resulting in the formation of a zygote, when plasmogamy is followed by karyogamy.

Fusion between the two swarm cells or between a swarm cell and a myxamoeba leads to the development of a flagellated zygote which sheds its flagella and becomes amoeboid. The zygote formed in any one of the processes grows, along with which the diploid nucleus also divides mitotically giving rise to a multinucleate amoeboid structure, the plasmodium.

According to some, karyogamy takes place during zygote formation. To them, the plasmodium represents the diplophase in the life history of a myxomycete and meiosis takes place during the formation of spores in the fructification (fruit body).

Whereas, others are of opinion that karyogamy takes place just before meiosis during the development of spores in the fructification and as such the plasmodium is in the dikaryophasic condition.

Life Cycle Pattern of Myxomycota:

The general life cycle pattern of the Myxomycetes is more or less clear. The spores on germination produce one to four swarm cells or myxamoebae. The swarm cells or myxamoebae behave as gametes.

They fuse in pairs, plasmogamy is followed by karyogamy. The zygote so formed grows accompanied with repeated mitotic division of the diploid zygotic nucleus resulting in the development of a plasmodium.

Many zygotes may also coalesce to produce a plasmodium. A mature plasmodium thickens and gives rise to the fructification of varied nature. During the development of the fructification (fruiting body) and spore formation the diploid nuclei divide reductionally. Each haploid nucleus with a portion of cytoplasm enveloped by a thick wall develops into a spore.

The spores vary greatly in colour and characteristics of the wall which are of taxonomic importance. Life cycle pattern of a myxomycete is indicated in Figure 327.

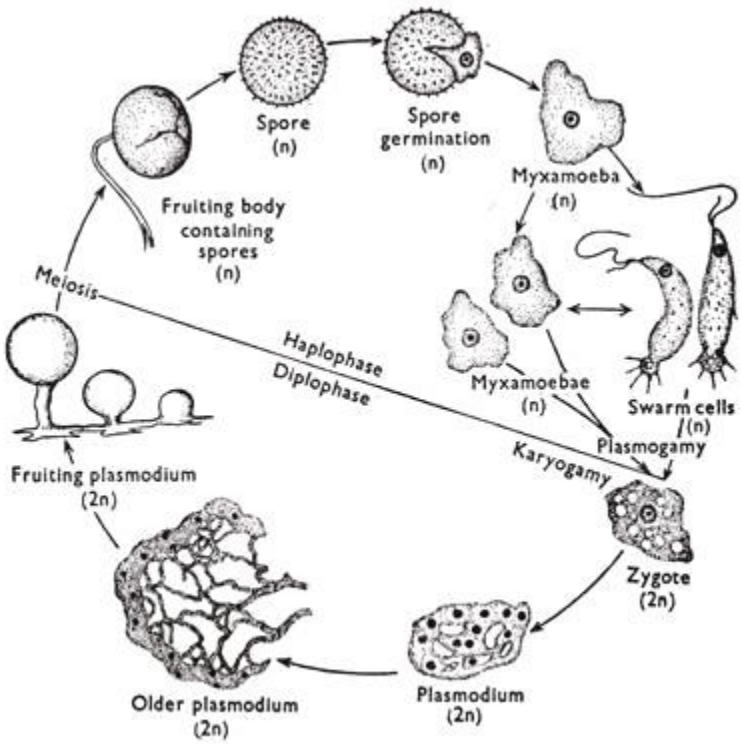


Fig. 327. Life cycle of a myxomycete.

PLASMODIOPHOROMYCOTA

Type: Plasmodiophora

Occurrence

Plasmodiophora has single specie. *Plasmodiophora brassicae. It* is intracellular parasite in the roots of members of family brassicae like cabbage. turnips etc. It causes disease club roots or linger-andtoe disease. In this disease the roots are swelled and become club like.

General structure

This fungus is present in the form of mass of protoplasmic bodies in the infected roots. Each plasmodium contains thirty nuclei. These nuclei are haploid.

Reproduction

Asexual reproduction

Asexual reproduction occurs by zoospore formation. Zoospores are produced in the infected host cells.

1. **Spore formation:** Many mitotic divisions occur in the haploid nuclzus of Plasmodiophora. Thus it becomes multinucleate. The body of Plasmodiophora is divided into large number of uninucleate pieces. These pieces secretes wall of chitin and become spores. The root tissues of host disintegrate and release sporef Spores pass unfavourable conditions.
2. **Zoospore formation:** The spores germinate in spring and form zoospores. Zoospores are naked uninucleate, pear shaped. They have single flagella.
3. **Myxamoeba:** Zoospores penetrate into the host root through root⁻, hairs. The zoospore loses its flagella. It becomes amoeboid in shape. It is now called **myxamoeba.** Myxamoeba penetrates into new host tissues. Myxamoeba increases in size. Its nucleus divides repeatedly and it is changed in to multinucleate proplast called plas.nodium.

Sexual reproduction

I. Formation of planogametes: The protoplast of plasmodium splits into many pieces in host cells. Each piece has one haploid nucleus. Each protoplast is surrounded by a thin colourless wall and develops into **gametangium.** The nucleus

divides mitotically and eight nuclei are formed. The protoplast of gametangium divides into fragments. Each fragment gets one nuclei. Each fragment become spindle shaped and develops flagella.

Formation of diploid myxamoeba and plasmodium: Planogametes are released in the host cells. They fuse in pairs to form diploid zygotes. The zygote loses flagella and become myxamoeba. The myxamoeba divides many times by mitosis and form diploid plasmodium.

2. **infection of plasmodium:** The diploid plasmodia migrate from cell to cell in the host tissues. Some plasmodia reach cambium cells of the host. They reach in the cells. They multiply in the cortex of root cells. The infected cortical cells enlarge very much. This is called hypertrophy. It causes enlarged club roots.

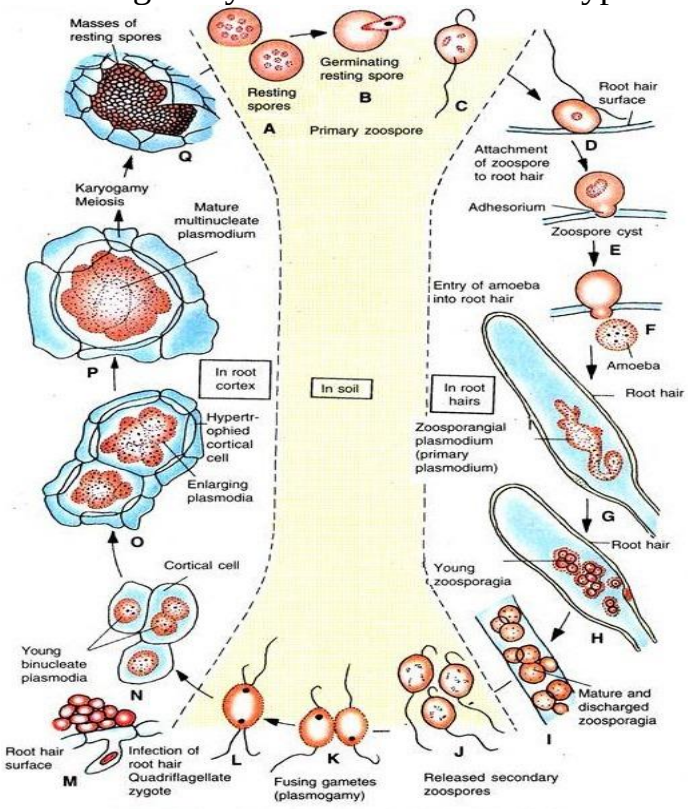


Fig. 5.8. Pictorial diagram of the life cycle of *Plasmodiophora brassicae*.

4. Haploid spore and zoospore formation: The diploid zygote full) tills up the host cells. Its nuclei undergo repeated divisions (protomitosis). These are mitotic division. But the last division is meiotic. Plasmodium divides and many haploid spores are produced. These spores are librated in the soil by the disintegration of root cell. They germinate to form zoospores in the soil. Zoospores infect the 2 young seedlings.

Alternation of generation

Plamodiophora shows distinct alternation of generation. The diploid zygote and diploid plasmodium represents sporophytic generation. The haploid plasmodium, resting spores, gametangia and gametes represents the gametophytic generation. Both these generations alternates with each other.

Life Cycle of Plasmodial Slime Mold

Phylum : Plasmodiophoromycota
are a group of obligate parasites commonly referred to as endoparasitic slime molds. Has the same characteristic of phylum myxomycota , All members are obligate parasites of algae, fungi, or plants, causing cell enlargement, especially of the roots. They are distinguished by the production of motile cells (zoospores) with two unequal anterior whiplash (flagella).

The best-known examples attack higher plants, causing economically significant diseases such as club-root of brassica (*Plasmodiophora brassicae*) and powdery scab of potato (*Spongospora subterranea*:
Plasmodiophora brassicae causes

1.Hypertrophy : enlargement of cell size.

2.Hyperplasia : uncontrolled cell divisions (increase in cell divisions).

3.The infect cells are filled with the resting spores of the fungus.

club root disease
Toes and fingers disease

Kingdom Protista
Phylum Plasmodiophoromyota
Class Plasmodiophoromycetes
Order Plasmodiophorales
Family Plasmodiophoraceae

The first observable above ground symptom is day wilting.

Diseased plants are obviously stunted compared to uninfected plants and will often be localized in low, wet areas of the field.
When dug up, roots exhibit a variety of symptoms. New infections cause small knot like galls on roots, where as more developed infections display long spindle shaped clubs

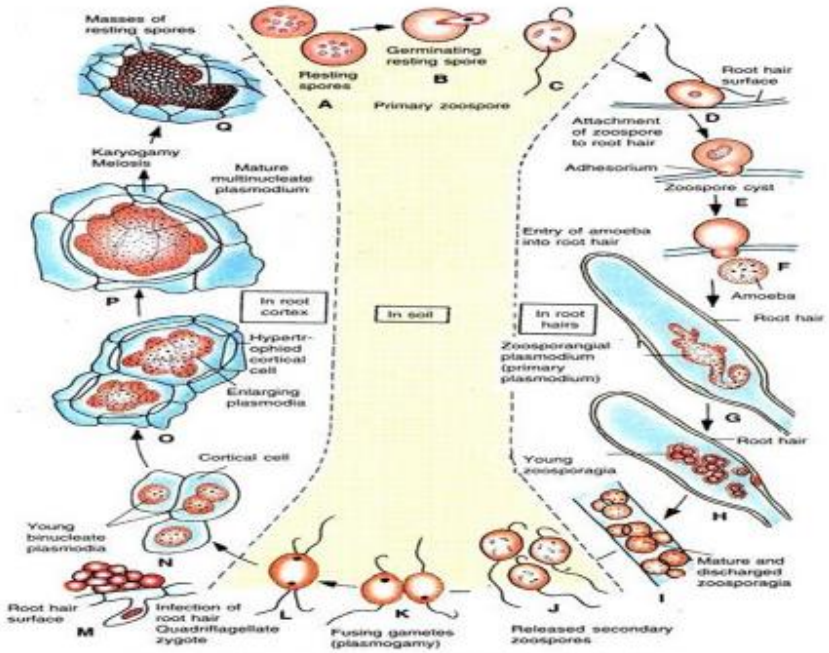
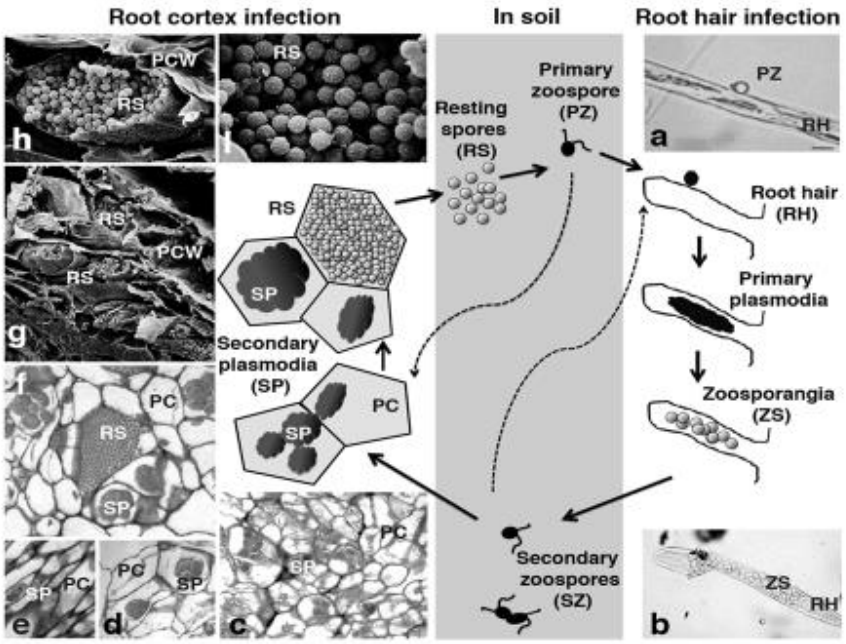


Fig. 5.8. Pictorial diagram of the life cycle of *Plasmodiophora brassicae*.



Powdery scab
Spongospora subterranea

spore balls of *Spongospora subterranea*