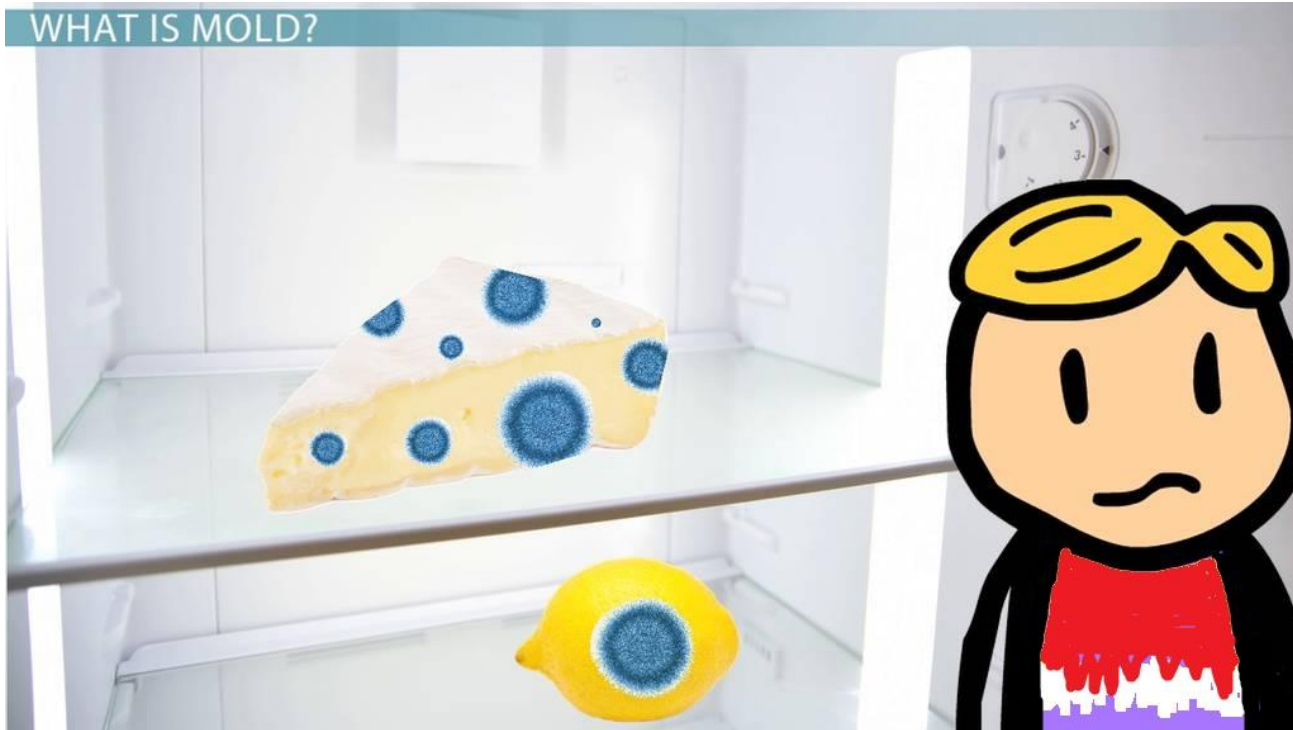




BIOLOGY AND DIVERSITY OF VIRUSES, BACTERIA AND FUNGI (PAPER CODE: BOT 501)

WHAT IS MOLD?



By

Dr. Kirtika Padalia

Department of Botany

Uttarakhand Open University, Haldwani

E-mail: kpadalia@uou.ac.in

OBJECTIVES

The main objective of the present lecture is to cover the topic and make it easy to understand and interesting for our students/learners.

BLOCK – IV : FUNGI – II

Unit –15 : Mastigomycotina and Zygomycotina

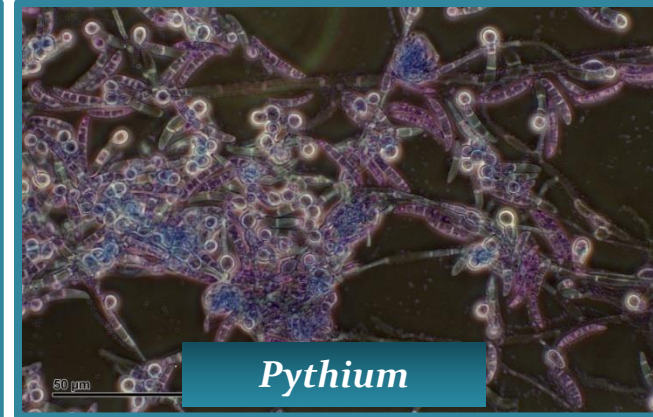
CONTENT

- ❑ General characteristics of Mastigomycotina
- ❑ Classification of Mastigomycotina
 - ❖ Class Chitridiomyces
 - ❖ Class Hypochitridiomyces
 - ❖ Class Oomycetes
- ❑ General Characteristics of Zygomycotina
- ❑ Classification of Zygomycotina
 - ❖ Class Zygomycetes
 - ❖ Class Trichomycetes
- ❑ Key points of the lecture
- ❑ Terminology
- ❑ Some Assessment Questions

MASTIGOMYCOTINA

❑ General Characteristics of Mastigomycotina:

- ❖ They are commonly known as zoosporic fungi.
- ❖ They are mostly aquatic while another group are primarily terrestrial, although the organisms still form motile zoospores when open water is available.
- ❖ Three types of zoospores are common in this group. These are: (a) Laterally biflagellate, (b) Posteriorly uniflagellate, and (c) Anteriorly uniflagellate type having “9 + 2” arrangement of component fibrils.
- ❖ Most of them are filamentous and have coenocytic mycelium. However, unicellular forms are present, and some genera show the pseudosepta (false cross wall) formation. Rhizoids are present in some of unicellular forms.
- ❖ Live either as saprophytes or parasites. Due to presence of haustoria in a majority of Mastigomycotina, the mode of nutrition is typically absorptive.
- ❖ Sexual reproduction takes place by gametic copulation, gametangial copulation and gametangial contact. Oospores formation are common in almost all Mastigomycotina.



CLASSIFICATION OF MASTIGOMYCOTINA

❖ Ainsworth (1973) classified the subdivision Mastigomycotina into three classes:

- **Chytridiomycetes:** They produce posteriorly uniflagellate zoospores. Chytridiomycetous fungi occur as saprobes on plants and animals and remain in water while other members occur as parasites on algae and aquatic animals.
- **Hyphochytridiomycetes:** Zoospores are anteriorly uniflagellate. The hyphochytridiomycetes are those aquatic fungi whose thallus is holocarpic or eucarpic, monocentric or polycentric and their vegetative system is rhizoidal or hypha-like with intercalary swellings.
- **Oomycetes:** The Oomycetes contain 74 genera and 580 species, which are mostly aquatic, though some are terrestrial and live as parasites or saprophytes. Includes classic “water molds” in the Order Saprolegniales and the “downy mildews” in the Order Peronosporales.

❑ Key to classes of Mastigomycotina:

❖ On the basis of zoospore and oospore Mastigomycotina comprise 204 genera and 1160 species.

a. Zoospores uniflagellate.

b. Flagellum posteriorly placed and whiplash type Chytridiomycetes.

bb. Flagellum anteriorly placed and tinsel type Hyphochytridiomycete.

aa. Zoospores biflagellate (one whiplash and other one tinsel type).....Oomycetes.

Class: Chitridiomycetes

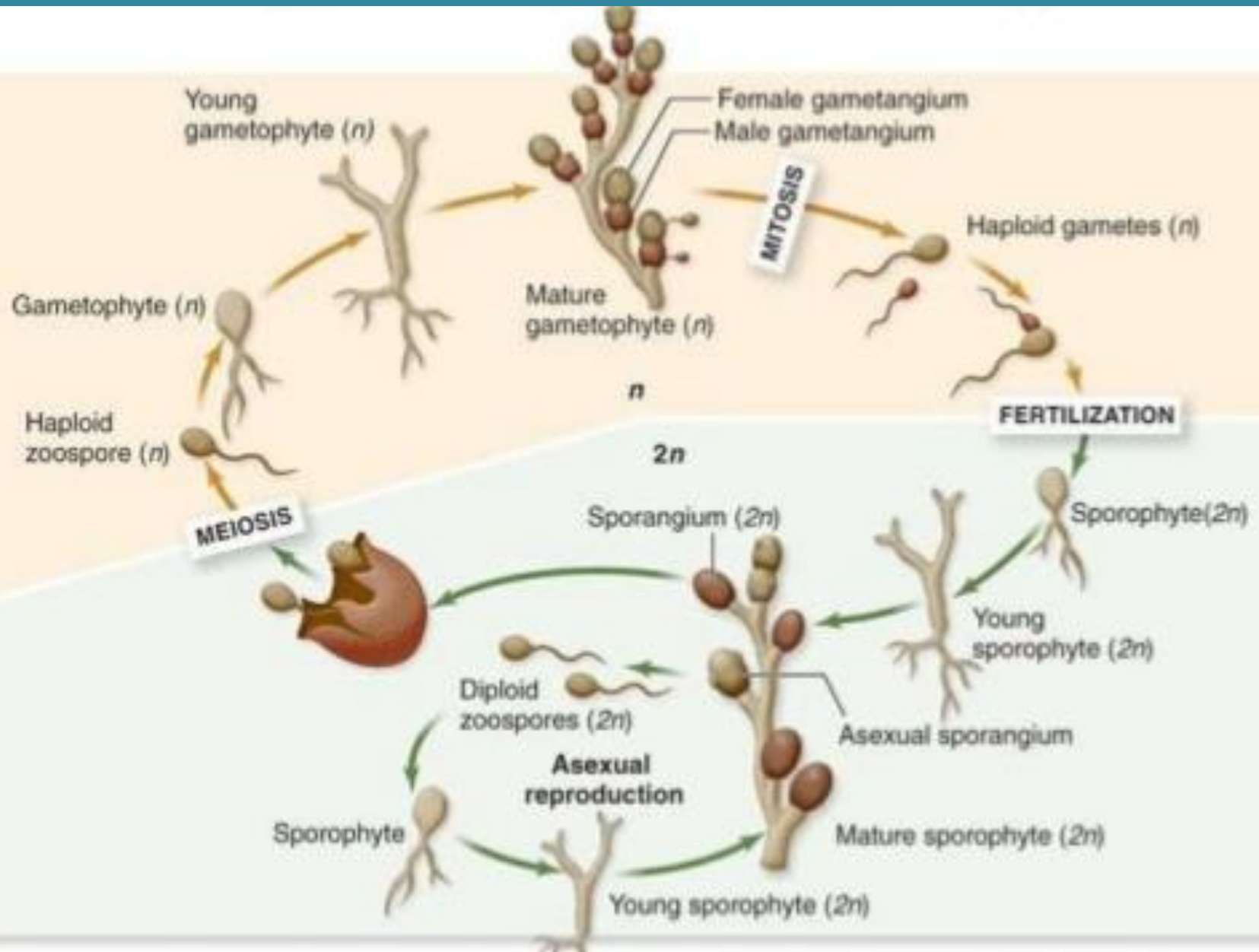
❑ Main distinguishing characteristics :

- The vegetative body is unicellular or chain of cells attached with the substratum by rhizoids.
- Cell wall is mainly made up of chitin and glucans.
- The plant body is normally haploid, except *Allomyces*.
- Asexual reproduction takes place by zoospores produced in zoosporangium; zoospores are uniflagellate, flagellum whiplash type and posteriorly placed.
- Sexual reproduction takes place by piano- gametes developed in gametangia.
- The fused gametes form zygote. After resting period, it undergoes meiosis and forms new haploid thallus.
- Most of the members of the class is aquatic.
- Some of them are terrestrial and parasitic.
- Important parasitic members are *Synchytrium endobioticum* causes wart disease of potato; *Olpidium brassicae*, in roots of Crucifers; *Urophlyctis alfalfae* causes crown wart of alfalfa (Medicago); and *Physoderma maydis* causes brown spot of maize etc.
- *Coelomomyces anophelescia* is an endoparasite on mosquito larvae and can be utilized for the biological control of Anopheles mosquito.

❑ **Classification:**

- ❖ On the basis of vegetative and reproductive structures, the class Chytridiomycetes is divided into following orders:
- ✓ **Order Chytridiales:** It is by far the largest order and includes the most primitive members of the class.
- ❖ The somatic phase is microscopic, holocarpic or eucarpic, single celled structure which in some species is drawn out at a point into fine branching extensions constituting the rhizomycelium.
- ❖ True mycelium is lacking. The zoospore has a refractive oil globule but may lack of nuclear cap.
- ❖ It swims with a hopping movement or creeps over solid substratum like an amoeba.
- ✓ **Order Harpochytridiales:** It is a small order represented by the two genera *Harpochytrium* and *Oedogoniomycei*. They are placed in the family Harpochytriaceae.
- ✓ **Order Blastochytridiales:** The vegetative body is a typical mycelium. Sexual reproduction is or aniso-planogamous. They are paced in the family Hypochytriaceae.
- ✓ **Order Monoblepharidales:** The vegetative body is a typical mycelium as in the Blastochytridiales.
- ❖ Sexual reproduction is heterogamous and takes place by the fusion of a motile male gamete and a non motile female gamete. Resistant sporangia are lacking.
- ❖ The zoospores are similar to those of the Blastochytridiales.

Life cycle of Chytridiomycetes



Class: Hypochitridiomyces

- ❖ They are distinguished by an anterior tinsel flagellum on their zoospores. Also they have a rhizoidal or hypha-like vegetative system (hence the prefix "Hypho-").

❑ Classification:

- ❖ This group may be put alternatively at the phylum, class, subclass or order level, being referred to as Hyphochytriomycota, Hyphochytriomycetes (or Hyphochytrea), Hyphochytriomycetidae (or Hyphochytridae) and Hyphochytriales, respectively.
- ❖ The variants Hyphochytridiomycota and Hyphochytridiomycetes are also sometimes used, presumably by analogy to the Chytridiomycetes, or due to the perpetuation of a typographical error. However, the stem is Hyphochytri- (from *Hyphochytrium*) and not Hyphochytridi- (from *Chytridium*). The class include
- ❖ Order Hyphochytriales

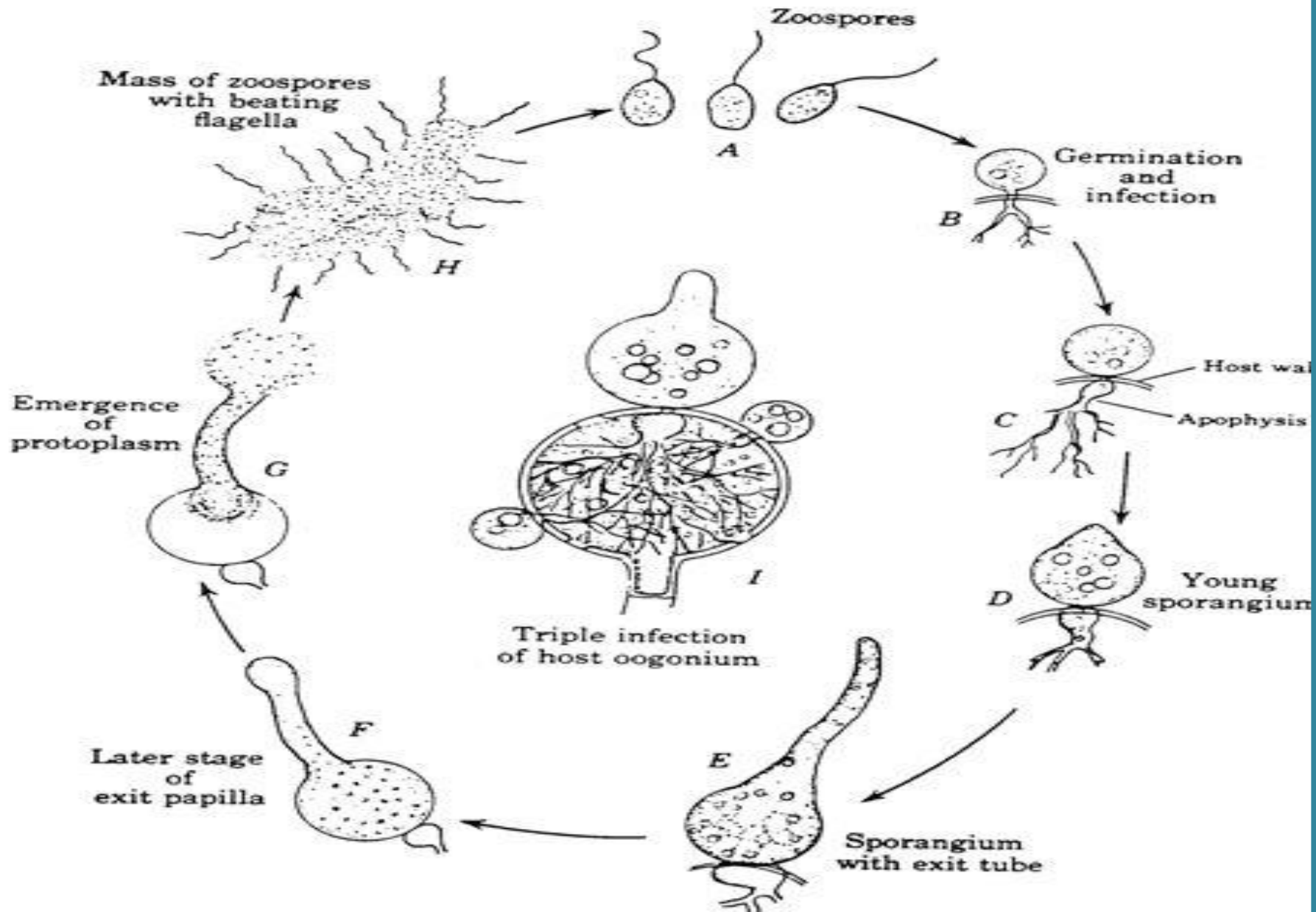
Family Hyphochytriaceae

- Genus *Canteriomyces*
- Genus *Cystochytrium*
- Genus *Hyphochytrium*

Family Rhizidiomycetaceae

- Genus *Latrostium*
- Genus *Reessia*
- Genus *Rhizidiomyces*

Life cycle of *Rhizidiomyces* (Class: Hypochytridiomycetes)



Class: Oomycetes

❑ Main distinguishing characteristics:

- ❖ Vegetative body is filamentous and coenocytic except the unicellular Lagenidiales.
- ❖ Members of this class are either holocarpic or eucarpic. Majority of species are eucarpic.
 - **Holocarpic** - Entire thallus converted into reproductive structure.
 - **Eucarpic** - Reproductive organs arise from only a portion of the thallus.
- ❖ Cell wall contains cellulose and glucans. Chitin is absent.
- ❖ Asexual reproduction is by biflagellate heterokont (different) and anisokont (unequal) zoospores that are produced in zoosporangia.
- ❖ Zoosporangia- Modified hyphae that are usually terminal and delimited by a septum
- ❖ Zoospores are diploid formed by mitosis.
- ❖ Anteriorly directed flagellum is tinsel type and posteriorly directed is whiplash type. Depending on genera single type-monomorphic or two types of zoospores are formed-dimorphic. Two types of zoospores are formed in the life cycle are:
 - **Primary zoospores** - First formed and the flagella are located anteriorly. Primary zoospore is released from the zoosporangium, encyst and germinates to form the secondary zoospore.
 - **Secondary zoospores** - The secondary zoospore which is reniform or bean-shaped and laterally flagellated.
- ❖ Zoosporangium and zoospores are the major dispersal agents for most species.

- ❖ **Sexual reproduction:**- Sexual reproduction is heterogamous (oogamous) by oogonia (female) and antheridia (male).
- ❖ Female gamete (oosphere) produced by an oogonium. Depending on taxon, there may be one to many oospheres per oogonium.
- ❖ Male gamete is produced by antheridium and transferred to the oogonium by gametangial contact and migration of male nuclei into oogonia and fertilize oospheres.
- ❖ Homothallic- self-fertile or Heterothallic- opposite mating types required for sexual reproduction.
- ❖ A swimming sperm is absent in the Oomycetes. This type of sexual reproduction is referred to as gametangial copulation.
- ❖ In antheridia and oogonia meiosis take place. The eggs and sperms are products of meiosis and the only parts of the life cycle that are haploid.
- ❖ Diploid zygote develops into thick-walled resistant oospore that germinates and give rise to vegetative diploid hyphae that reproduce asexually by production of zoospores.
- ❖ The vegetative body is diploid and the life cycle is diplontic.

❑ **Classification:**

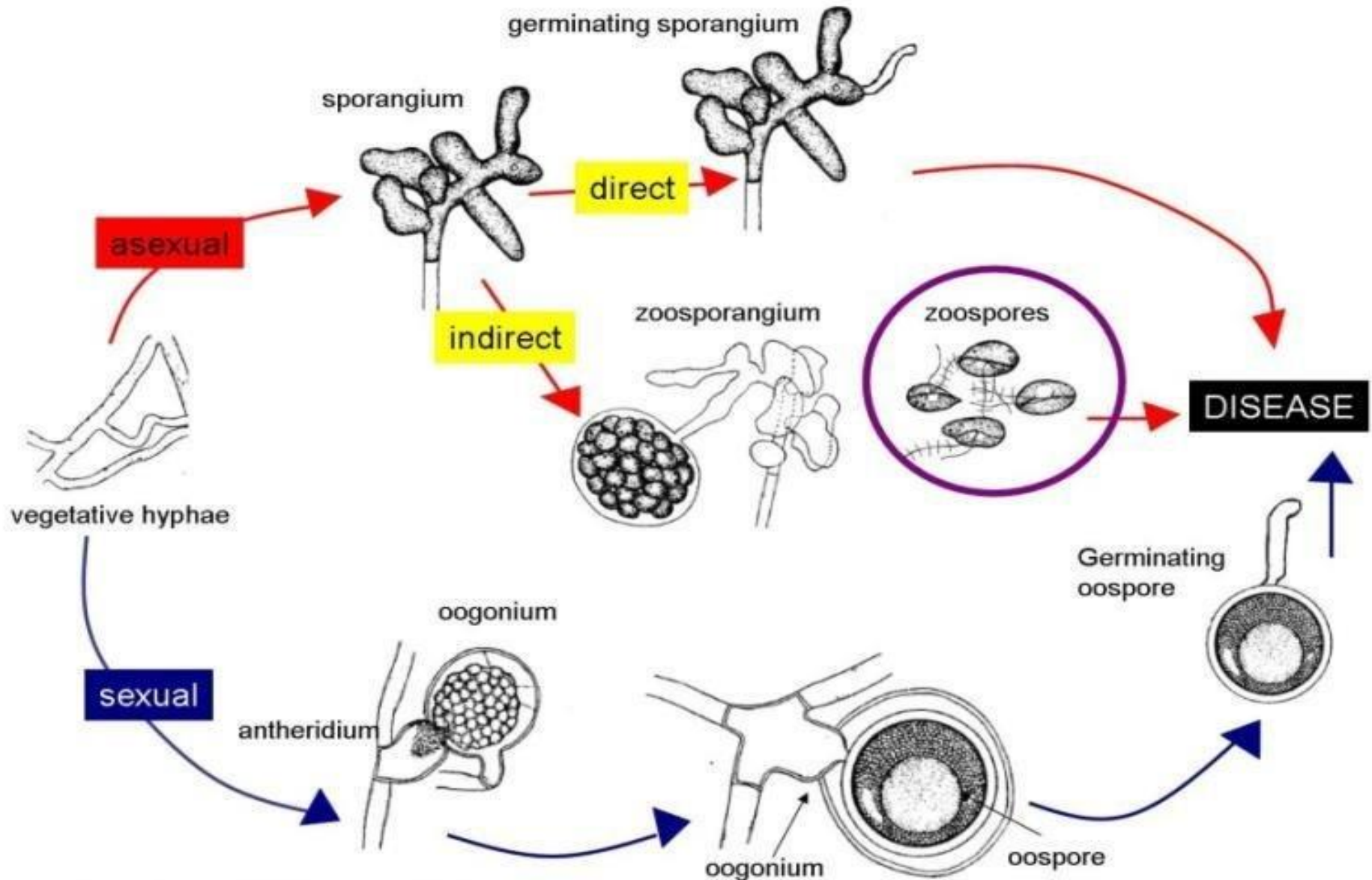
- ❖ Class Oomycetes is divided into four orders. Lagenidiales (Salilagenidiales), Leptomitales Saproleginales and Peronosporales
- ❖ Peronosporales: This order has some of the most well known pathogens (fungi cause diseases) cause diseases to many a crop plants. Peronosporales:- divided into three families :

- Family Pythiaceae, Genus: *Pithium*, *Phytophthora*
 - Family Peronosporaceae, Genus: *Plasmopara*
 - Family Albuginaceae, Genus: *Albugo*.
- ❖ Peronosporales differs from the Saprolegniales in producing only secondary zoospores in a zoosporangium.
 - ❖ That is differentiated from hyphae (eucarpic) and one oosphere (egg) per oogonium.
 - ❖ Zoosporangia often deciduous and zoospores often formed in vesicle.
 - ❖ They are aquatic, amphibious, terrestrial and some of the most destructive plant pathogens.
 - ❖ The most economically important group of Oomycetes is the Peronosporales that contain the late blight of potato fungus *Phytophthora infestans* and relatives such as *Peronospora*, *Bremia*, *Plasmopara* and others that cause “downy mildews”, the “damping off” fungi, *Pythium* spp., and the white rust fungi, *Albugo* spp.

❑ Some important parasitic members of this group are:

- ✓ *Pythium*: Different species of *Pythium* cause foot rot, fruit rot, rhizome rot and damping off.
- ✓ *Phytophthora*: *Phytophthora* cause stem and leaf blight, foot rot, leaf rot, corm rot, fruit rot etc.
- ✓ *Plasmopara*: *P. viticola* causes downy mildew of grape vine.
- ✓ *Albugo*. Different species of *Albugo* cause white rust disease of different hosts like crucifers (cabbage, Brassica, radish, rurnip etc.), spinach, sweet potato, morning glories etc. The *A. Candida* is very common causing white rust of crucifers.
- ✓ *Saprolegnia*: *S. parasitica*, a parasite on fish, is an aquatic member.

Life cycle of *Pythium* (Class: Oomycetes)



ZYGOMYCOTINA

□ General Characteristics of Zygomycotina:

- ❖ Mostly present in soil and dung, saprophytes in nature; few are parasitic on plants and animals.
- ❖ Vegetative body is haploid. Thallus is mycelial, hyphae coenocytic. Cell wall is made up of chitin and chitosan.
- ❖ Asexual reproduction occurs commonly by the formation of nonmotile, unicelled sporangiospores in uni- or multisporous sporangia. In addition, arthrospores, chlamydozoospores, and yeast cells can be formed by some species.
- ❖ Spores are dispersed either violently or passively by wind, rain or animals. Flagellated spores and gametes are absent in this division as well as in the remaining taxa of terrestrial fungi.
- ❖ Sexual reproduction occurs with the fusion of two multinucleate isogametangia or anisogametangia to produce a zygote.
- ❖ The zygote later develops into a thick-walled zygospore, the diagnostic feature of this division. Because of this the fungi of the class zygomycetes are also known as conjugation fungi.



CLASSIFICATION OF ZYGOMYCOTINA

❖ Ainsworth (1973) classified the subdivision Zygomycotina into two classes:

- **Zygomycetes:** It comprised about 1060 species, including common bread molds, as well as both freshwater and marine species.
- **Trichomycetes:** Trichomycetes, includes organisms that are clearly protozoans though they were mistakenly classified as fungi for a long time, and are still called fungi by many people who should know better.

❑ Key to classes of Zygomycotina:

- a. Saprophytic or, if parasitic or predaceous, having mycelium immersed in host tissue.....Zygomycetes.
 - aa. Parasitic or commensals within the digestive tract of living arthropods.....Trichomycetes.



Rhizopus sp. of zygomycetes



2 μm

Smittium sp. of trichomycetes

2

Class: Zygomycetes

- ❖ It comprised about 1060 species, including common bread molds, as well as both freshwater and marine species.
- ❖ Hyphae walls are chiefly composed of chitin-chitosan.
- ❖ The motile cells are completely absent in the life cycle.
- ❖ Asexual reproduction typically take place by means of non motile sporangiospores commonly produced in large numbers within sporangia.
- ❖ Sometimes the entire sporangium functions as a single spore in the same manner as the conidium.
- ❖ Chlamydospore formation is of frequent occurrence.
- ❖ Sexual fusion involves gametangia copulation.
- ❖ The thick walled sexually produced zygospores formed by the complete fusion of the protoplast of two gametangia is a resting structure.
- ❖ The zygospore germinates to produce a hyphae, the promycelium which bears a terminal sporangium.
- ❖ Most have rapidly growing hyphae but some are unicellular.
- ❖ Hyphae may be coenocytic forming septa only where reproductive structure are formed.

❑ **Classification:**

❖ Traditionally the class comprise 3 orders:

✓ **Order Mucorales:** Chiefly saprophytes, some weak parasites on plants, a few endoparasites of vertebrates:

❖ Mycelium extensively,

❖ Asexual reproduction by sporangiospores or rarely by conidia.

❖ Zygosporangium wall may be formed by modification of gametangial walls.

✓ **Order Entomophthorales:** Typically parasites on animal; rarely saprophytes,

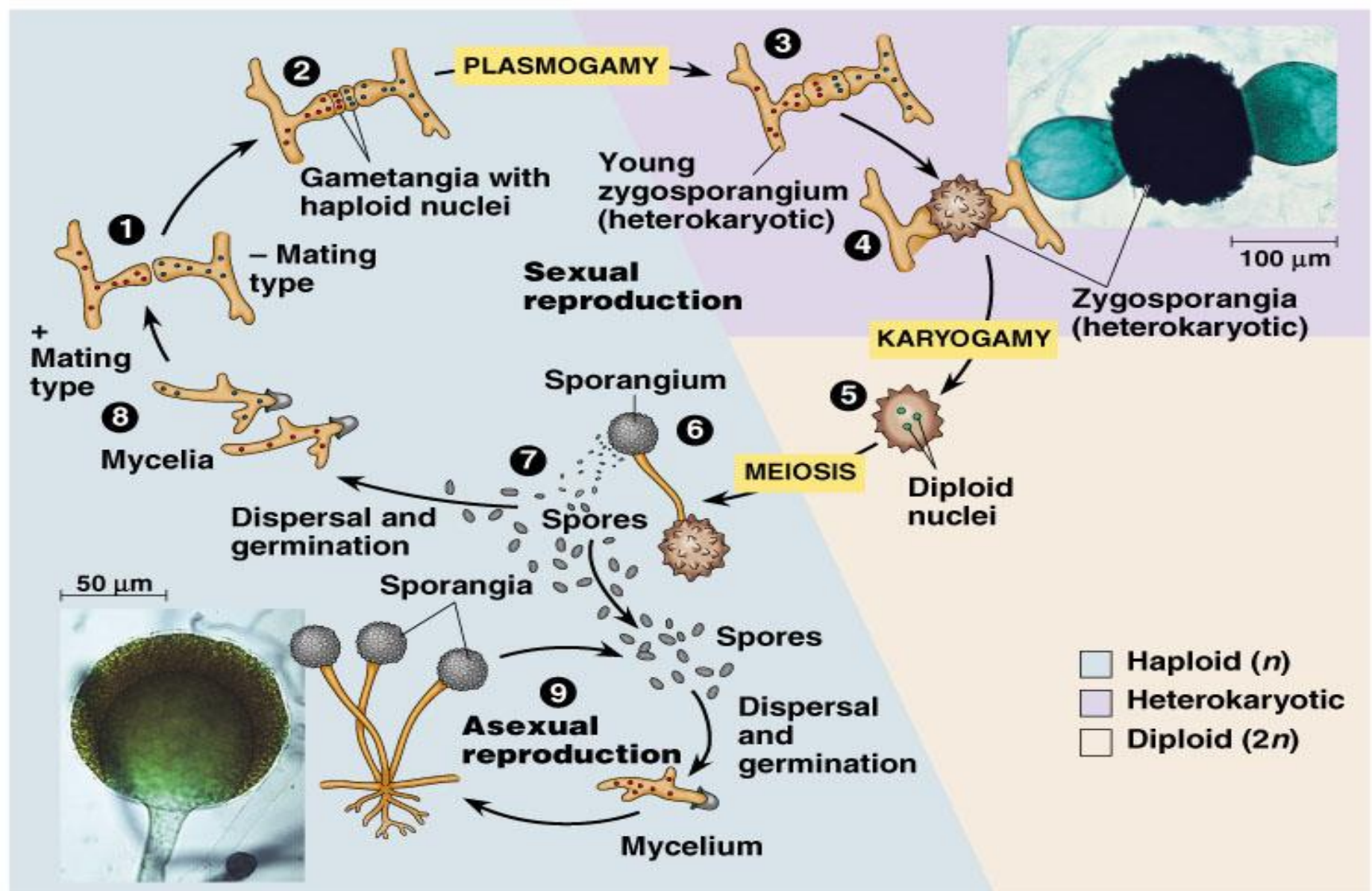
❖ Mycelium limited.

❖ Asexual reproduction take place by sporangia turned conidia or true conidia. Conidia discharge forcibly, gametangial wall not transformed to zygosporangium wall.

✓ **Order Zoopagales:** Typically parasites on animal; rarely saprophytes, mycelium present with typical haustoria.

❖ Asexual reproduction take place by conidia which are passively discharges; gametangial wall not transformed to zygosporangium wall.

Life cycle of *Rhizopus* (Class: Zygomycetes)



Class: Trichomyces

- ❖ Trichomyces, includes organisms that are clearly protozoans though they were mistakenly classified as fungi for a long time, and are still called fungi by many people who should know better.
- ❖ These extremely common organisms live only in the digestive tracts of insects and other arthropods, generally as commensals, sometimes as pathogens or symbionts (mutualists), which are associated with, although not penetrating, the cuticle lining the digestive tracts of the host animal.
- ❖ Their hosts include terrestrial, marine and freshwater arthropods, most commonly midges (*Chironomidae*), mosquitoes (*Culicidae*), black flies (*Simuliidae*), beetles (*Coleoptera*), stoneflies (*Plecoptera*), and mayflies (*Ephemeroptera*), as well as several millipedes (Diplopoda) and crustaceans.

❑ Classification

- ❖ The traditional taxonomy is based on a few micromorphological characters and the traditional view was to place the class Trichomyces in the zygomycetes, the class being divided into four orders:
 - Order Amoebidiales
 - Order Asellariales
 - Order Eccrinales
 - Order Harpellales

- ✓ **Order Amoebidiales:** Which occur on the external surfaces of freshwater arthropods.
- ❖ The Amoebidiales are amoebae-producing organisms that attach to the exoskeleton of freshwater arthropods (*Amoebidium parasiticum* was the first described).
- ❖ Production of amoebae is not otherwise present in kingdom Fungi. More significantly, *A. parasiticum* has stacked dictyosomes, which do not occur in fungi, and lacks chitin in its cell wall.
- ❖ Taken together these features do not make it a good candidate as a fungus. The Eccrinales have unbranched, non-septate, multinucleate thalli, and produce sporangiospores, which form from the apex downward toward the base of the thallus, a feature found only in kingdom Fungi.
- ❖ These few distinctive morphological characters together with the fact that they share a very specialised ecological niche with genuine fungi like the Harpellales was all that classified them within the Trichomycetes.
- ✓ **Order Asellariales:** The Asellariales includes species that inhabit terrestrial, freshwater and marine isopods (Isopoda: Crustacea) such as woodlice, pill bugs, and sea slaters; as well as the hexapod springtails (Collembola) that are primitive relatives of insects.
- ❖ These are true fungi having hyphal thalli with cell walls containing chitin fibrils and being regularly septate with incomplete septa having a plugged central pore. No confirmed sexual stage has been reported generally for the Asellariales, although conjugation has been reported between cells of the one species *Asellaria ligiae*. Phylogenetic analyses confirm that the Harpellales and Asellariales both belong to the subphylum *Kickxellomycotina* which is now placed in in phylum Zoopagomycota.

- ❖ Members of the Asellariales do not produce deciduous merosporangia but the regularly septate branches fragment into single-celled arthrospores.
- ❖ In some species of Asellariales the arthrospores germinate by producing a single branch, similar in position and form to a trichospore.

✓ **Order Asellariales:**

- ❖ The Eccrinales have unbranched, non-septate, multinucleate thalli, and produce sporangiospores, which form from the apex downward toward the base of the thallus, a feature found only in kingdom Fungi. These few distinctive morphological characters together with the fact that they share a very specialised ecological niche with genuine fungi like the Harpellales was all that classified them within the Trichomycetes. Now, sequence analyses have shown that the Eccrinales share a common ancestry with the Amoebidiales, and are closely related to members of the protist class Mesomycetozoea, which is positioned at the animal-fungal boundary in the opisthokont lineage.

✓ **Order Harpellales:**

- ❖ The Harpellales are predominantly associated with larval aquatic insects, and, occasionally, with freshwater isopod crustaceans, attached to the midgut or hindgut linings. Harpellales produce branched or unbranched thalli, and either the entire thallus or lateral branches of it become regularly septate at maturity to form a series of uninucleate generative cells. From the apical region of each generative cell a single unisporous merosporangium is produced; this is the trichospore. In many genera the merosporangia are borne on short lateral branches, which form the collar region of the generative cell.

KEY POINTS OF THE LECTURE

- ❖ Mastigomycotina are commonly known as zoosporic fungi. Three types of zoospores are common in this Mastigomycetes. These are: (a) Laterally biflagellate, (b) Posteriorly uniflagellate, and (c) Anteriorly uniflagellate type having “9 + 2” arrangement of component fibrils.
- ❖ Ainsworth (1973) classified the subdivision Mastigomycotina into three classes: Chytridiomycetes, Hyphochytriomycetes, and Oomycetes.
- ❖ Chytridiomycetes produces posteriorly uniflagellate zoospores. They occur as saprobes on plants and animal remains in water while other members as parasites on algae and aquatic animals.
- ❖ Hyphochytriomycetes produced anteriorly uniflagellate zoospores. They are those aquatic fungi whose thallus is holocarpic or eucarpic, monocentric or polycentric and their vegetative system is rhizoidal or hypha-like with intercalary swellings.
- ❖ Oomycetes contain 74 genera and 580 species, which are mostly aquatic, though some are terrestrial and live as parasites or saprophytes. Includes classic “water molds” in the Order Saprolegniales and the “downy mildews” in the Order Peronosporales.
- ❖ Zygomycotina mostly present in soil and dung, saprophytes in nature; few are parasitic on plants and animals. Ainsworth (1973) classified the subdivision Zygomycotina into two classes: Zygomycetes and Trichomycetes.
- ❖ Zygomycetes comprised about 1060 species, including common bread molds, as well as both freshwater and marine species.
- ❖ Trichomycetes, includes organisms that are clearly protozoans though they were mistakenly classified as fungi for a long time, and are still called fungi by many people.

TERMINOLOGY

- ❑ **Cellulose:** Component of plant cell walls and of wood composed of glucose units
- ❑ **Chlamydo spores:** Asexual spores formed by the breaking up of fungal hyphae
- ❑ **Coprophilous:** Growing on dung
- ❑ **Cuticle:** The surface layer of the cap or stem of a fruitbody
- ❑ **Dichotomous:** Forking/divided into pairs – as in logical decision-making trees
- ❑ **Dikaryon:** A pair of closely associated, sexually compatible nuclei
- ❑ **Endophyte:** Fungus living within a plant without causing visible symptoms of harm
- ❑ **Hypha:** (Pl., hyphae) filamentous thread of fungal mycelium
- ❑ **Inferior:** (Describing a ring) located near the base of the stem
- ❑ **Mucilaginous:** (Often describing a mushroom cap) covered with slime
- ❑ **Mycelium:** Body of a fungus, most of which is underground or hidden within wood
- ❑ **Mycology:** The study of fungi
- ❑ **Organelle:** A differentiated (separate) structure within a cell
- ❑ **Parasitism:** Process whereby an organism feeds at the expense of another (host)
- ❑ **Photosynthesis:** Process by which plants convert carbon dioxide and water to sugars
- ❑ **Rhizomorph:** A root-like mycelial strand comprising bunched parallel hyphae
- ❑ **Saprophyte:** An organism that obtains its nutrients from dead organic material
- ❑ **Septate:** (Describing hyphae) partitioned by cross walls known as septa
- ❑ **Septum:** (Pl., septa) a cross wall separating cells of a hyphal thread
- ❑ **Spore:** Reproductive structure of a fungus, usually a single cell
- ❑ **Sporophore:** Fungal fruiting body
- ❑ **Superior:** (Describing a ring) located near the top of the stem
- ❑ **Taxonomy:** The - Classification of organisms based on their natural relationships
- ❑ **Thallus:** (Pl., thalli) the body of a fungus or a lichen
- ❑ **Zygomycota:** A - Class of simple fungi whose hyphae generally lack cross walls

SOME QUESTIONS RELATED TO THE LECTURE

- ❑ **Question 1:** Give the silent features and classification of Mastigomycotina in detail
- ❑ **Question 2:** Briefly describe the class Chitridiomycetes and give their classification.
- ❑ **Question 3:** Write a note on classification of class Hypochitridiomycetes.
- ❑ **Question 4:** Write down the general characteristics of class Oomycetes.
- ❑ **Question 5:** Give the classification class Oomycetes.
- ❑ **Question 6:** Illustrate the Life cycle of *Pythium*.
- ❑ **Question 7:** Write the note on parasitic members of class Oomycetes.
- ❑ **Question 8:** Give the general characteristics of Zygomycotina in detail.
- ❑ **Question 9:** Discuss the classification of Zygomycotina with key.
- ❑ **Question 10:** Describe the general characteristics of class Zygomycetes.
- ❑ **Question 11:** Illustrated the life cycle of any fungi belongs to class Zygomycetes.

BIBLIOGRAPHY

- ❑ <https://www.biologydiscussion.com/fungi/division-eumycota-meaning-characteristics-and-classification/46501>
- ❑ <https://www.peoi.org/Courses/Coursesen/bot/bot14.html>
- ❑ Vashistha BR and Sinha AK (2010) Botany for degree students: Fungi. S. Chand & company limited, Ram nagar, New Delhi.
- ❑ Webster J and Weber R. W. S. (2007) Introduction to fungi (3rd edition). Cambridge University Press, New York.
- ❑ Willey JM, Sherwood LM, Woolverton CJ (2017) *Prescott's Microbiology* (10th Ed). McGraw-Hill Education, 2 Penn Plaza, New York, NY 10121. ISBN 978-1-259-28159-4

श्रद्धावाँल्लभते ज्ञानं

