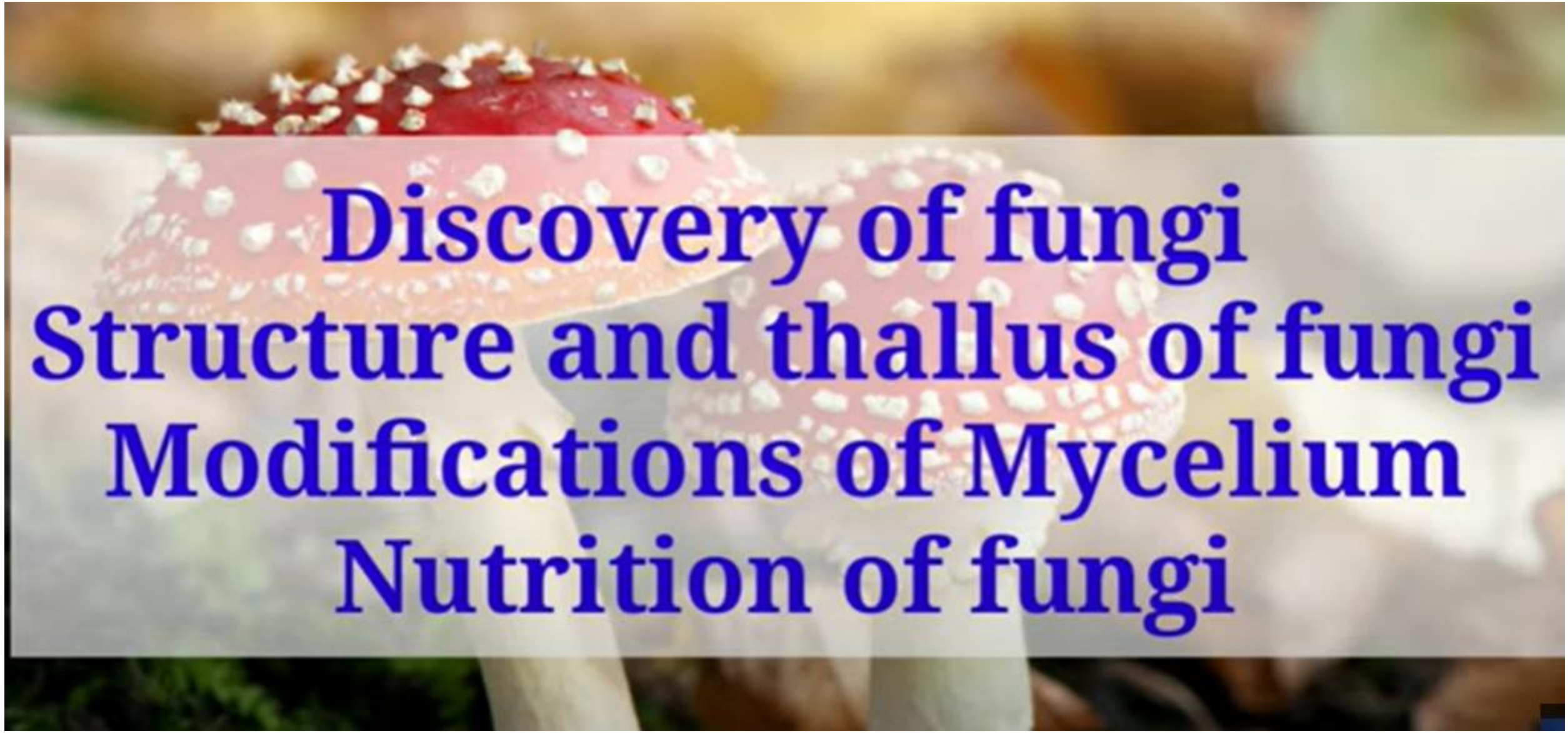

Discovery of fungi
Structure and thallus of fungi
Modifications of Mycelium
Nutrition of fungi

Mycology

- The word in Latin '*mykes*' means fungus

Mycology definition is - a branch of biology dealing with fungi.

The term fungus was used by Gaspard Bauhin (1560–1624).

Discovery of Fungi

- Father of Systematic Mycology : E.M. Fries (1794–1878).He wrote 'Systema Mycologicum' in three volume.
- Father of Modern Mycology and Plant Pathology : H.A. de Bary.
- Father of Indian Mycology and Plant Pathology:
- E.J. Butler.

1729 A. D.-Pier Antonio Micheli (Italian)

- Observed fungal spores for the first time and conducted many spore germination studies in 1729
- He published a book "**Nova Plantarum Genera**" in which he gave descriptions about 1900 species in Latin out of which 900 were fungi.

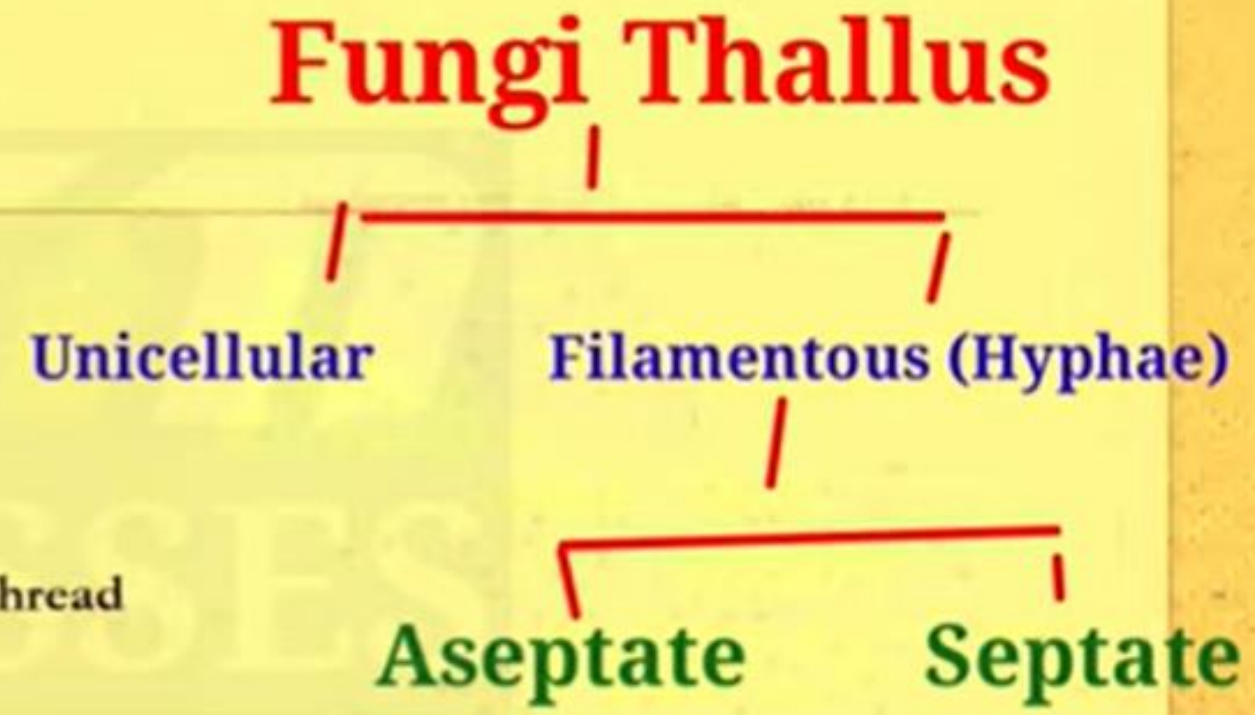
Father of Mycology.

General Characters

- Fungi are the Eukaryotic organisms (mushrooms, yeasts and molds).
- Some fungi are edible, while others are poisonous. *(Amanita)*
- 3-4 million species of fungi (150,000 have been classified and studied).
- Study of fungi is called as mycology
- Mycologists are biologists who study fungi

Thallus Structure

- The plant body of true fungi is a thallus.
- It may be non-mycelial or mycelial.
- The non-mycelial forms are unicellular.
  (form pseudomycelium by budding).
- In mycelial forms, the plant body is made up of thread like structures called hyphae (sing. hypha).
- Hyphae are very thin threads that can grow and form a mycelium network.
- Fungi are able to absorb nutrients with hyphae



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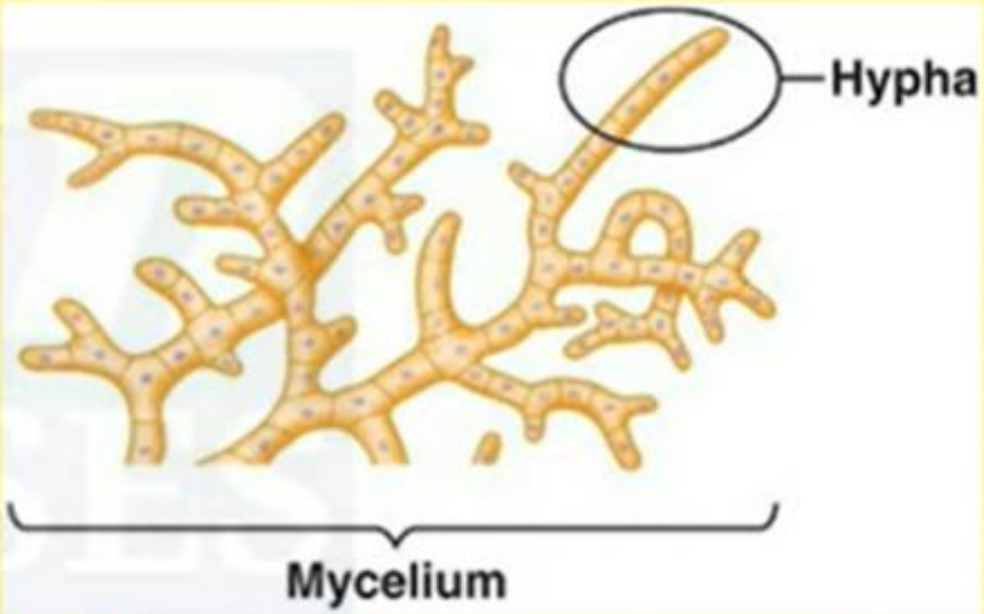
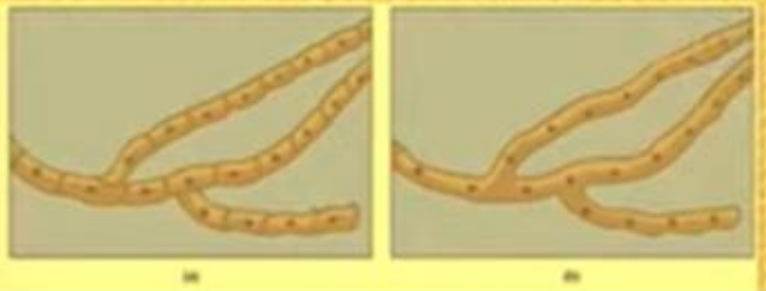
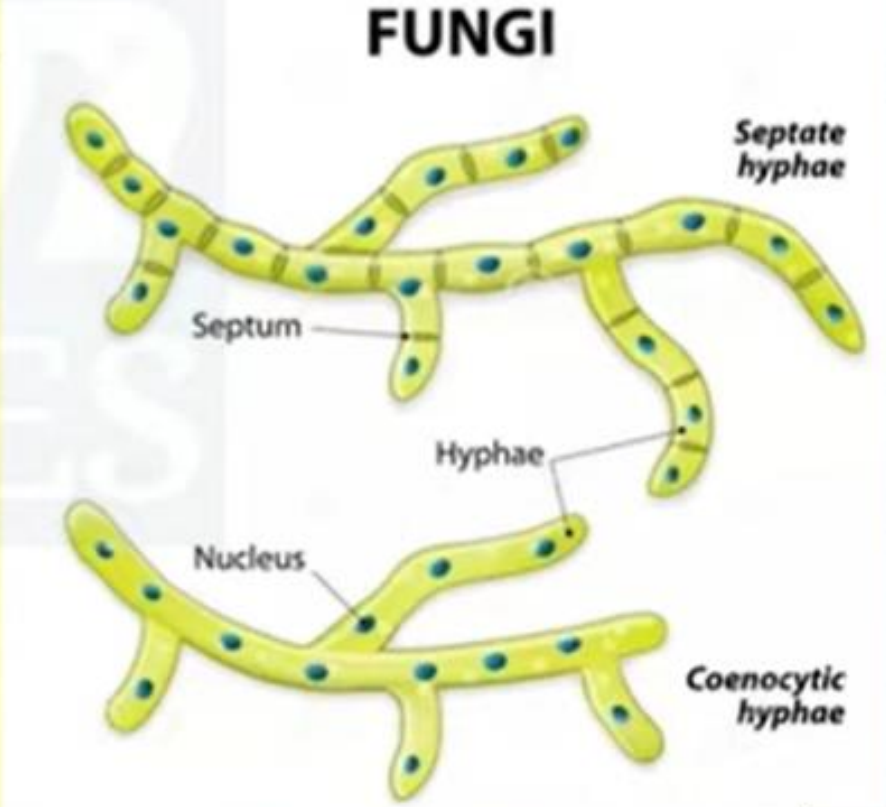


Mycelium wall



- The mycelium may be septate or aseptate (non-septate)
- Coenocytic (non-septate)
- In lower fungi the mycelium is non-septate e.g., Phycomycetae.
- In higher forms it is septate e.g., Ascomycotina, Basidiomycotina and Deuteromycotina.
- In some forms the plant body is dimorphic.



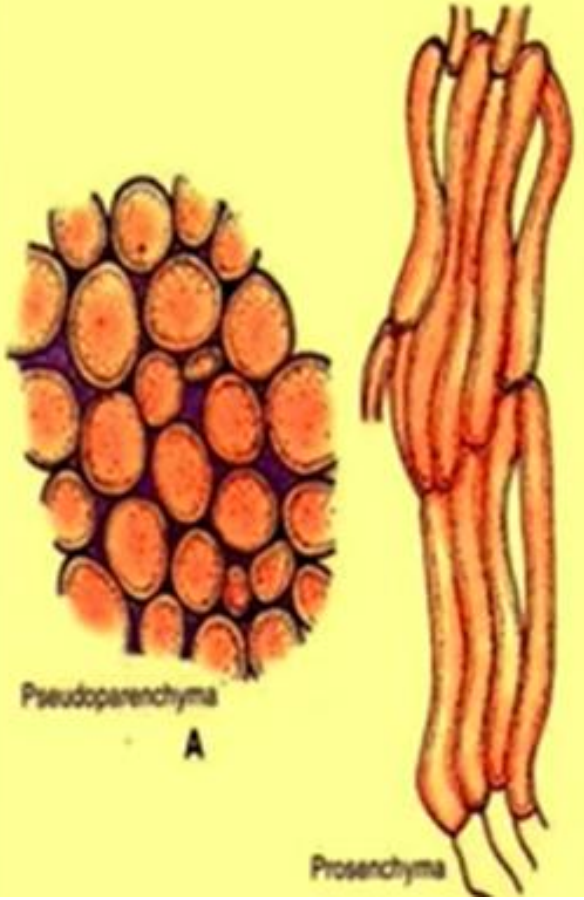
Mycelium Forms of Fungi

- **Plectenchyma:** Mycelium are into loosely or compactly woven structure

It is of two types

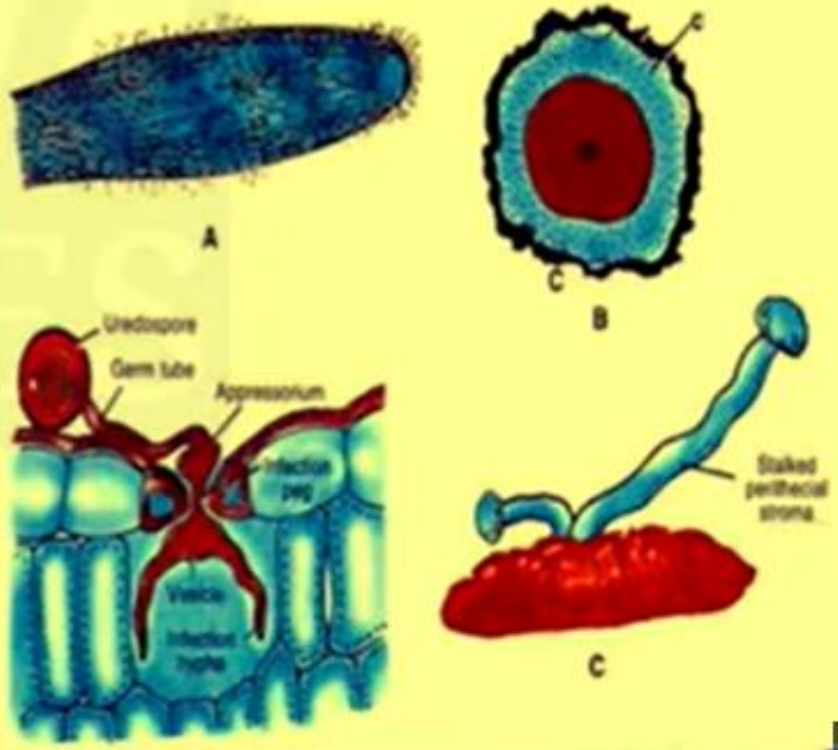
- (i) **Prosenchyma:** loosely woven hyphae lying almost parallel to each other.

- (ii) **Pseudoparenchyma:** If the hyphae are closely interwoven, looking like parenchyma in a cross-section.



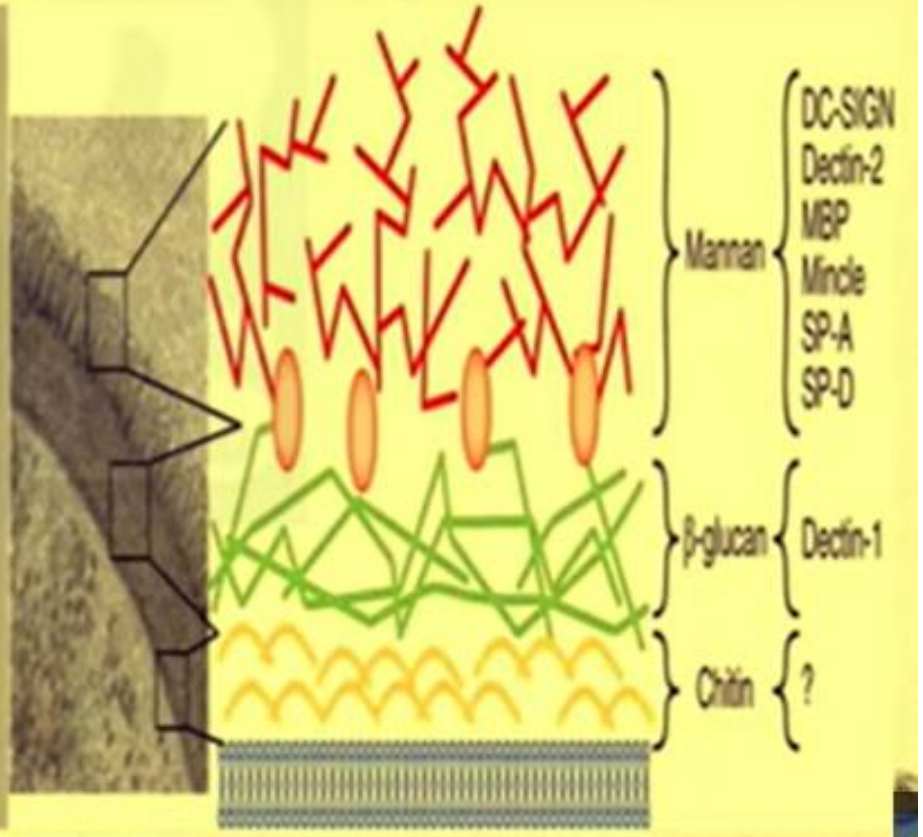
Specialised Formation

- (a) Rhizomorphs: It's a 'root-like' elongated structure of closely packed and interwoven hyphae.
- (b) Sclerotia: External hyphae becoming thickened to save the inner ones.
- (c) Stroma: It is thick mattress of compact hyphae associated with the fruiting bodies.



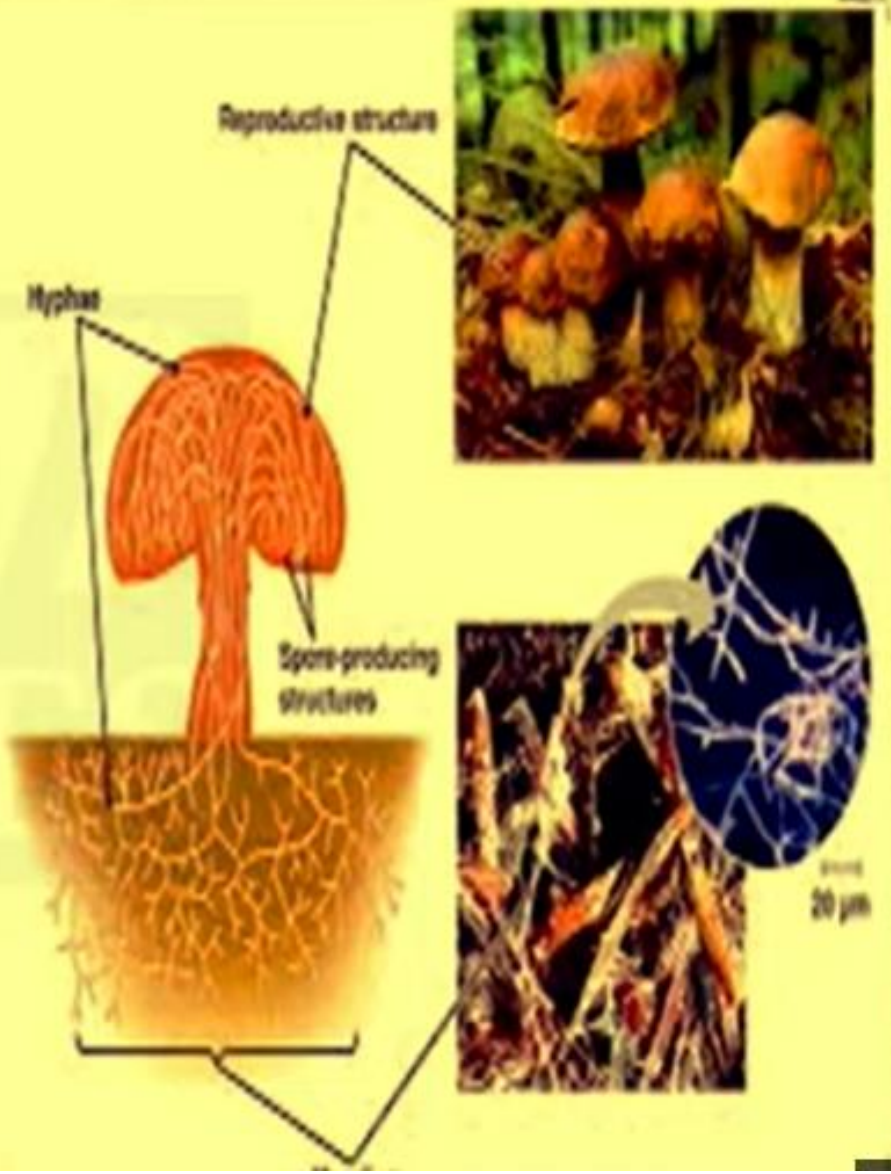
CELL COMPOSITION

- The cell wall of fungi is mainly made up of chitin and cellulose.
  - Cellulose-glucan (Oomycetes)
  - Chitin chitosan (Zygomycetes)
  - Mannan-glucan (Ascomycotina)
  - Chitin-mannan (Basidiomycotina)
- Main storage molecule is glycogen.
- Fungi help to recycle the nutrients of dead organic matter



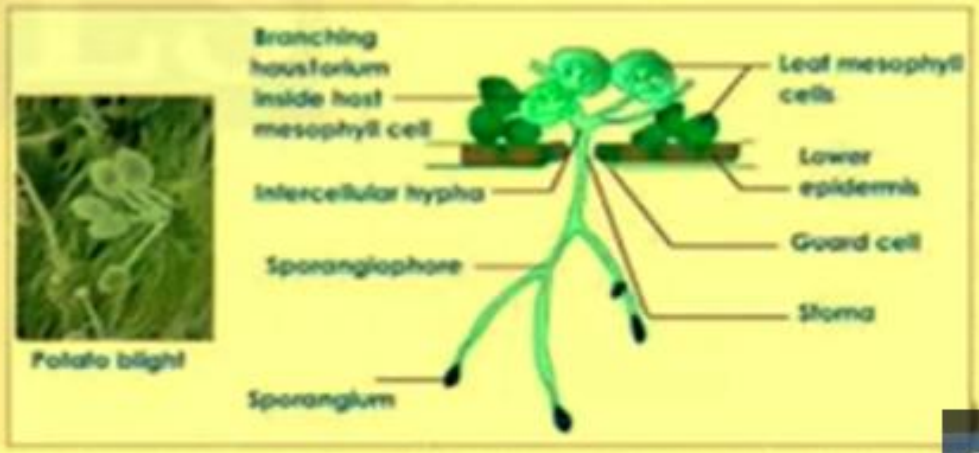
NUTRITION

- The fungi are achlorophyllous organisms
- They live as heterotrophs as parasites and saprophytes.
- Some forms live symbiotically
- with other green forms.



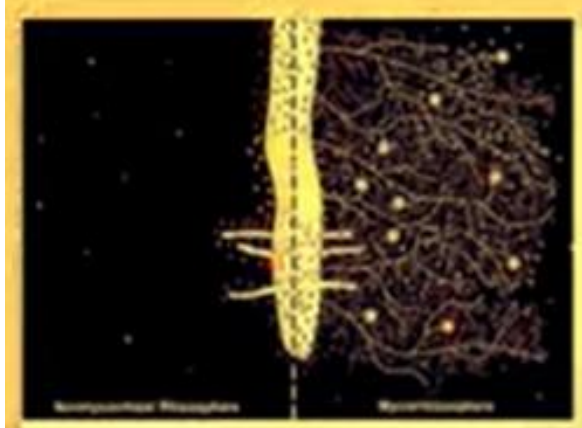
PARASITES

- They obtain their food from a living host.
- A parasite may be obligate or facultative.
- The obligate parasites thrive on a living host.
- The facultative parasites are in fact saprophytes which have secondarily become parasitic.



SAPROPHYTES

- Saprophytic food derive their food from dead and decaying organic matter.
- The saprophytes may be obligate or facultative.
- An obligate saprophyte remains saprophytic throughout its life.
- A facultative saprophyte is a parasite which has secondarily become saprophytic.



SYMBIONTS

- Some fungal forms grow in symbiotic association with the green or blue-green algae and constitute the lichen.
- The algal component is photosynthetic and the fungal is reproductive.
- Fungal forms grow in association with the roots of higher plants(mycorrhiza)
- They are two types – Ectotrophic mycorrhiza and Endotroph mycorrhiza e.g., (VAM).

Nutrition in Fungi

Saprophytic

Obligate Saprophytes
Example:
Rhizopus,
Mucor,
Penecillium

Facultative Saprophytes
Example:
Tapherina,
Phytophthora

Parasitic

Obligate Parasites
Example:
Puccinia,
Synchytrium

Facultative Parasites
Example:
Fusarium,
Pythium

Symbiotic

Example:
Mycorrhiza,
Lichens

Fungal Nutrition

- They are chlorophyll deficient organisms, hence cannot manufacture carbohydrates
- So all fungi are CHEMOHETEROTROPHIC (chemo-organotrophic) and they need pre-existing organic sources in their environment
- They are dependent on degradation of dead or living organic matter for their energy requirements

Mechanism of Nutrition

- SMALL MOLECULES (simple sugars, ami acids) and soluble campounds can be absorb directly across the fungal wall and plasma membrane
- LARGER, MORE COMPLEX MOLECULES (polymers such as polysaccharides and proteins) must be first broken down into smaller molecules, which can then be absorbed
  - ✓This degradation takes place outside the fungal cell or hypha and is achieved by EXTRACELLULAR ENZYMES which are either released through or are bound to the fungal wall

Mode of Nutrition

On the basis of mode of nutrition th are classified into four groups

- **Saprophytes**
- **Parasites**
- **Symbionts**
- **Predaceous**

Saprophytic Fungi

- Saprophytic fungi obtain their nutrition from dead organic matter may be both animal or plant origin
- Some species bear special structures for absorption of nutrition called RHIZOIDS
- These fungi mainly produce exo-enzymes for release of simple organic matter
- They may grow on the surface of organic matter or grow inside the organic matter

Ex. Mucor, Rhizopus, Aspergillus etc..

Nutrition in Fungi

Saprophytic

- Obligate Saprophytes
  Example:
  Rhizopus,
  Mucor,
  Penecillium
- Facultative Saprophytes
  Example:
  Tapherina,
  Phytophthora

Parasitic

- Obligate Parasites
  Example:
  Puccinia,
  Synchytrium
- Facultative Parasites
  Example:
  Fusarium,
  Pythium

Symbiotic

Example:
Mycorrhiza,
Lichens

Saprophytes are of two types:

(a) Obligate Saprophytes:

Fungi grow only on dead organic matter and do not have the capacity to infect the plants or animals e.g., Mucor mucedo.

(b) Facultative (partial) Saprophytes:

Normally these fungi live as parasites but in the absence of the living host they may also get their food material from the dead organic matter (saprophytes) e.g., Taphrina deformans and some smuts like Ustilago, Tolyposporium, Sphacelotheca etc.

Parasitic fungi

- These fungi take food from other living plants and animals
- The living organisms on which fungi grow are called HOST
- The growing fungi are harmful to the host as they develop DISEASE conditions in their host
- Such relationship is known as PARASITISM
- Some Parasitic fungi possess specialized structures called HAUSTORIA for absorption of nutrition from host

Ex. Erysiphae, Phytophthora, Albugo

Parasites are of two types:

(a) Obligate Parasites:

Fungi which grow only upon living host tissues are called obligate parasites e.g., Erysiphe.

(b) Facultative Parasites:

Normally these fungi are saprophytes but have the capacity to infect the living organisms also e.g., Botrytis cinerea, Pestalotia etc.

Symbiotic Fungi

- These fungi grow on or with living organisms but both of them are mutually benefitted

Ex. Lichen and Mycorrhiza

- ✓ Lichens are symbiotic association of algae and fungi
- ✓ Mycorrhiza are symbiotic association of fungi and roots of higher plants

Predacious Fungi

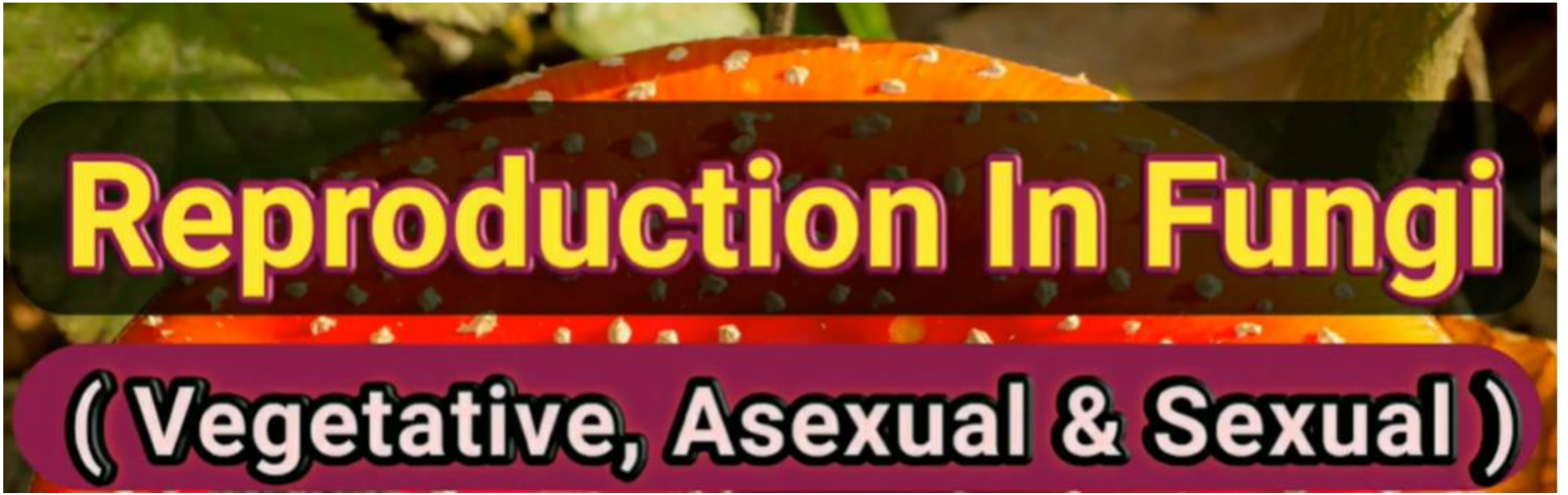
- These are animal capturing fungi
- These fungi usually inhabit in the soil
- The fungi possess special hyphal traps called SNARES which capture small animals like Amoeba and Nematodes
- Some of them also produce sticky secretions for capturing their prey

Ex. Arthrobotrys, Dactylaria

C. Predator Fungi:

1. Some fungi are active predators.
2. The **Oyster mushroom** (*Pleurotus ostreatus*) is an Carnivorous (predatory) fungus. It paralyses the nematodes (that feed on this fungus), penetrate them, and absorb their nutritional contents,

Fig 8.2 Carnivorous fungi (a) The osyter mushroom decomposes wood, and also uses nematodes as a source of nitrogen (b) A nematode is trapped in constricting ring of a soil - dwelling carnivorous fungus ***(Arthrobotrys sp.)***.


Reproduction In Fungi
(Vegetative, Asexual & Sexual)

Reproduction in Fungi

Methods of reproduction

Holocarpic (Gr. holos = entirely + karpos = fruit). In holocarpic reproduction entire thallus is converted into one or more reproductive structures (e.g., Synchytrium)

Eucarpic (Gr. eu = good + karpos = fruit).

In eucarpic reproduction organs are formed from a part of thallus (e.g., Albugo, Phytophthora etc.) In unicellular fungi the entire thallus is converted into one or more reproductive structures and such fungi are known as holocarpic (e.g., Synchytrium). However, in majority of the fungi, the reproductive organs are formed from a portion of thallus and such fungi are known as eucarpic.

Reproduction in Fungi

Methods of reproduction

Holocarpic

Eucarpic

SM CLASSES

Types of Reproduction in Fungi

1. Vegetative reproduction

2. Asexual reproduction.

3. Sexual reproduction.

1. Vegetative Reproduction:

In this type of reproduction, the formation of new thallus takes place from vegetative parts. It does not involve the formation of spores.

The following methods of vegetative reproduction are known in fungi:

1. Fragmentation
2. Fission
3. Budding
4. Oidia
5. Chlamydospores
6. Rhizomorphs and
7. Sclerotia.

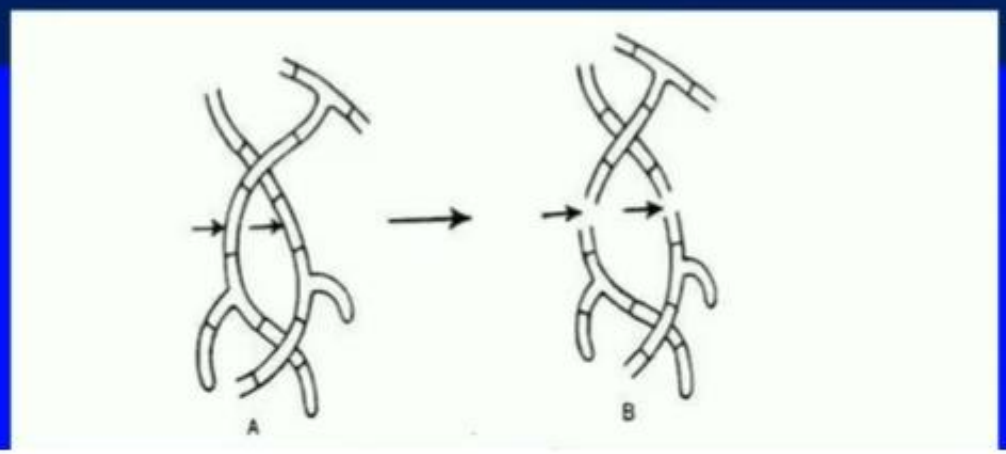
1. Vegetative Reproduction:

In this type of reproduction, the formation of new thallus takes place from vegetative parts. It does not involve the formation of spores.

The following methods of vegetative reproduction are known in fungi:

(a) Fragmentation (L. frangere = to break):

The mycelium or hyphae break up into a number of small fragments which are capable of developing into a new mycelium under favourable conditions e.g., Rhizopus, Aspergillus, etc.



(b) Fission (L. fissio = splitting):

It is the simple splitting of cell into two daughter cells by a constriction and formation of the cell wall (Fig. 13 A-D) e.g., Schizosaccharomyces (commonly known as fission yeast).

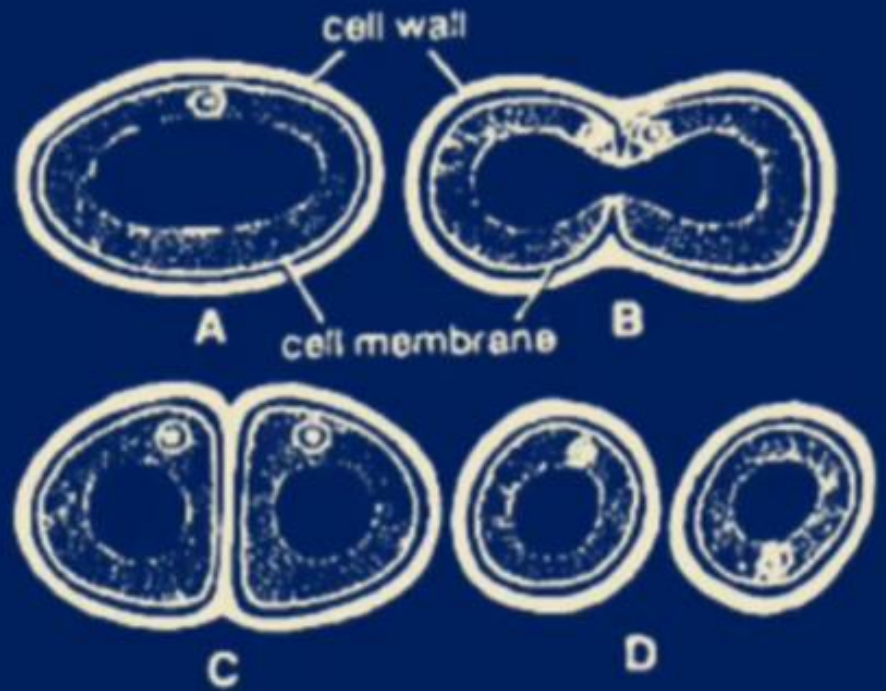


Fig. 13. (A–D). Fungi : Vegetative reproduction by fission

(c) Budding (ME. budde = bud):

It is the formation of small outgrowth(bud) from a parent cell wall which breaks up to forma new individual (Fig. 14 A, B) e.g., Saccharomyces cerevisiae. Sometimes, the bud remains attached to the mother cell and it may produce further additional buds.

This process is repeated several times and results in the formation of branched or un-branched chain of cells which gives the appearance of a short hypha and it is termed as pseudo mycelium (Fig. 14 C).

Fig. 14. (A–C). Fungi : Vegetative reproduction (A–B) budding, (C)

(d) Oidium. (Pl. oidia; Gr. oidion = small egg):

When grow in nutrient medium, the hyphae of some fungi undergo segmentation and form rounded or thin walled cells called oidia. Under favourable conditions each oidium on germination produces a new mycelium e.g., Mucor, Geotrichum. It is also called arthrospore (Gr. arthron = joint + sporos = seed, spore), it may also behave as a spermatium (Fig. 15).

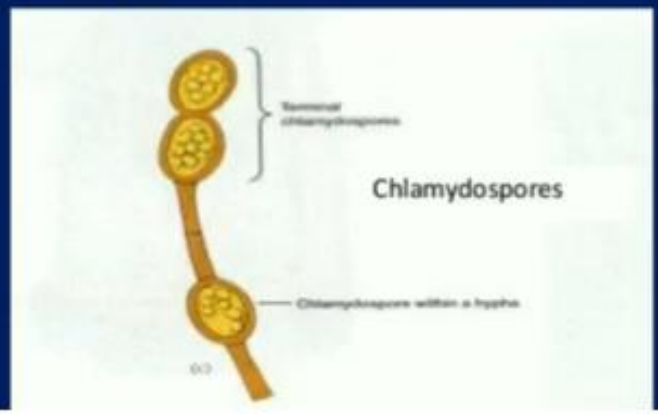
Fig. 15. Fungi : Oidia

(e) Chlamydospores:

Some hyphal cells or portions of hypha contract, loose water, round up and become surrounded by a thick wall. These are the resting bodies capable of withdrawing long un-favourable conditions (Fig. 37) e.g., Ustilago, Fusarium etc.

(f) Sclerotia:

These are hard, compact mass of dormant interwoven hyphae. The external hyphae develop hard coat or rind protecting the inner regions from dessication. These are the resting bodies formed by the fungus to pass out the un-favourable conditions. Thus, these are more a means of keeping the fungus alive than of propagation e.g., Claviceps (Fig. 11 A-C).



2. Asexual Reproduction:

This is the most common method of reproduction in fungi. It takes place by means of spores. It occurs when conditions are usually favourable. Fungi may be polymorphic (producing more than one type of spores) e.g., Puccinia. Spores may be unicellular or multicellular, motile or non-motile, may vary in colour, shape and size.

On the basis of origin and development these may be divided into two types:

(A) Accessory spores

(B) Meiospores.

(A) Accessory Spores:

These are never involved in any type of sexual reproduction. The spores may be produced endogenously (produced in sporangia which are present on simple or branched sporangiophores or exogenously (borne on the tips or sides of hyphae).

Endogenous Spores:

These are also known as sporangiospores (Gr. sporos = seed, spore + angeion = vessel + sporos). These are motile or non-motile. If they are motile they are called zoospores (Gr. zoon = animal + sporos = seed, spore).

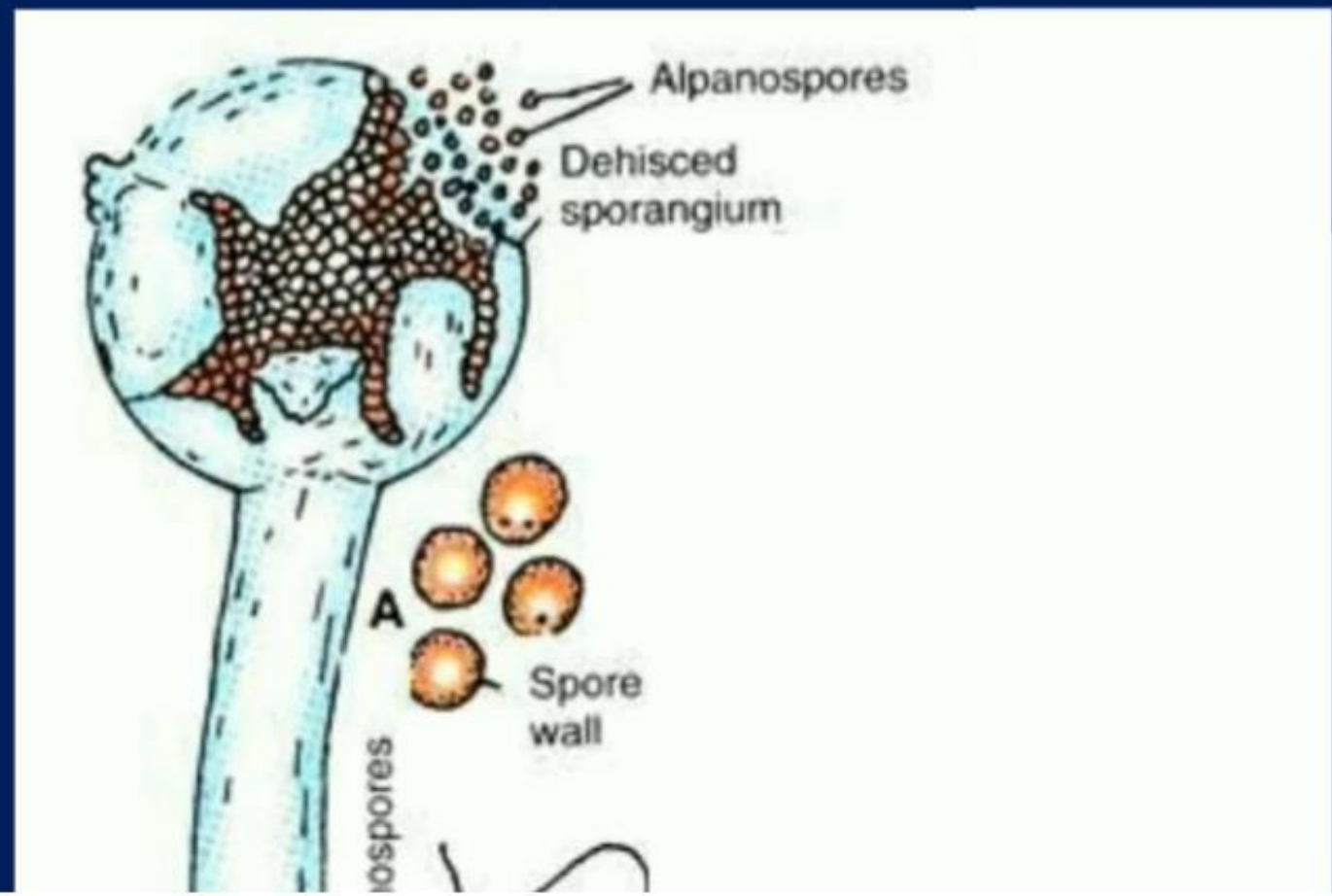
(i) Zoospores:

These are characteristic of subdivision Mastigomycotina (e.g., Synchytrium, Albugo, Phytophthora etc.) and are produced in sac-like structures called zoosporangia (Gr. Zoon = animal + sporangium). Sometimes zoospores are borne in conidiosporangia which are placed either on simple (e.g., Albugo) or branched sporangiophores (e.g., Phytophthora).

Some members of fungi (e.g., Saprolegnia) produce two kinds of zoospores in succession. The primary zoospores are pear shaped and have both the flagella at the anterior end while secondary zoospores are kidney shaped and have both the flagella attached laterally. Such members are called diplanetic (Gr. dis = twice + planetes = wanderer) and this phenomenon is called diplanetism (Fig. 16 A-H).

(ii) Aplanospores:

(Gr. a = not + planetes = wanderer + sporos – seed, spore) These are non-motile and are produced in sporangia. These spores are found in terrestrial species e.g., Rlxizopus, uredinia Mucor. Aplanospores may be uninucleate or multinucleate.

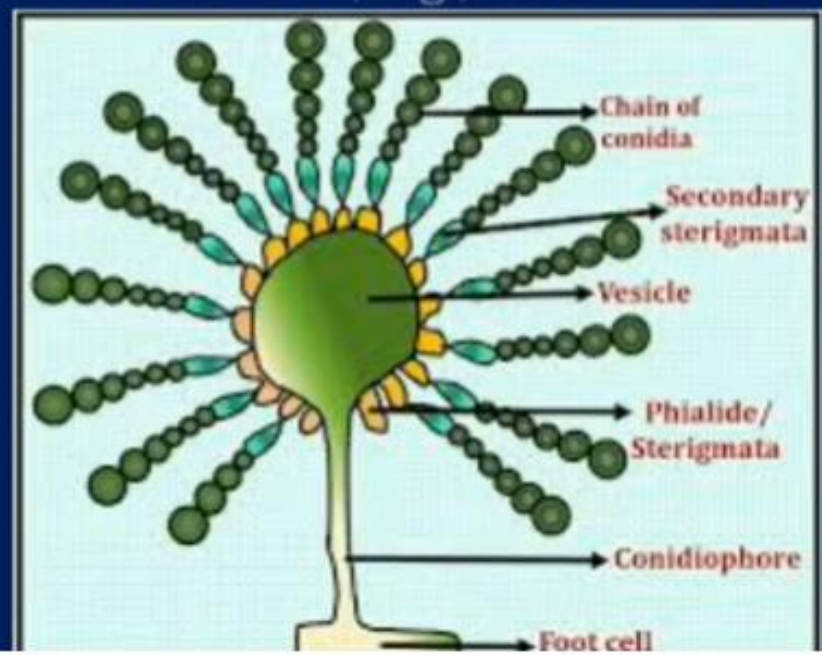


Exogenous Spores:

(i) Conidia:

These are non-motile spores and are also known as conidia (sing. conidium; Gr. Konis = dust + idion, dimin. suffix). They are produced at the tip of vertical hyphae known as conidiophores.

(Gr. Konis = dust + phoreus = bearer). Conidiophores may be scattered in mycelium (e.g., Aspergillus) or may arise in groups from some specialized structures, e.g., some members of subdivision Ascomycotina and Deuteromycotina.



Succession of conidia

- Basipetal = a chain of conidia in which new spores are formed at the base, the oldest conidia are at the apex
- Acropetal = a chain of conidia with the new spores formed at the end of the chain, oldest spores are at the base. In order for this type of conidial formation to occur, the conidia must function as conidiogenous cells (e.g., *Alternaria*, *Cladosporium*)

(ii) Meiospores:

These are the true spores of asexual reproduction. These spores are formed after meiosis or reduction division of the diploid nuclei. Thus, they are haploid to give rise to mycelium of primary nature.

These are of two types:

(A) Ascospores (Gr. askos = sac + sporos = seed, spore):

They are produced within special sac like structures called the asci (singular Ascus). They are endogenous in origin. The number of ascospores produced within each ascus is typically eight. Ascospore formation is the characteristic feature of the subdivision Ascomycotina (Fig. 18).

(A) Ascospores (Gr. askos = sac + sporos = seed, spore):

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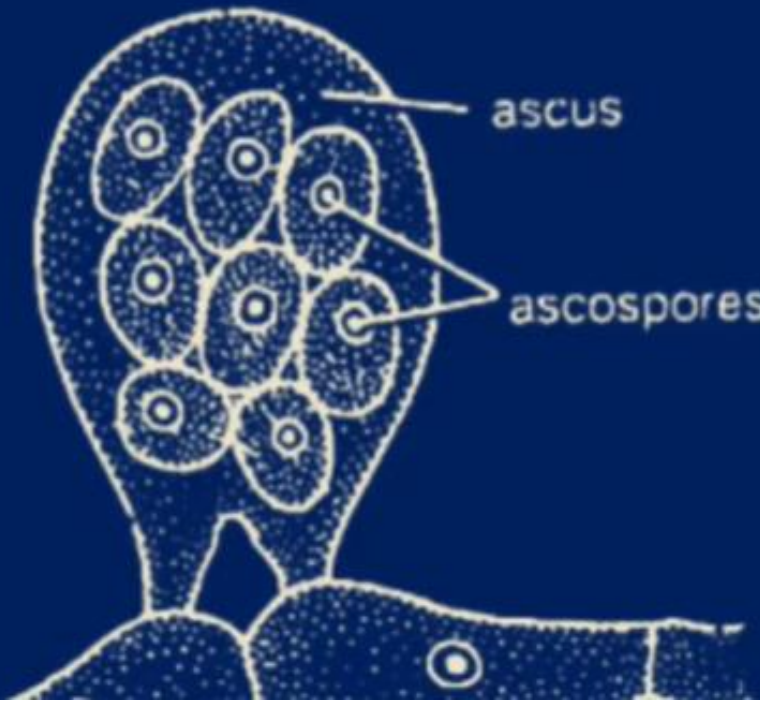


(B) Basidiospores (Gr. basidion = small base + sporos = seed, spore):

These are borne outside on the club shaped structures called basidia, resulting from karyogamy and meiosis. Thus, they are exogenous in origin. Formation of basidiospores is characteristic feature of members of subdivision Basidiomycotina (Fig. 19).

3. Sexual Reproduction:

Sexual reproduction in fungi consists of three distinct phases:

(1) Plasmogamy (Gr. plasma = a molded object + gamos = marriage, union):

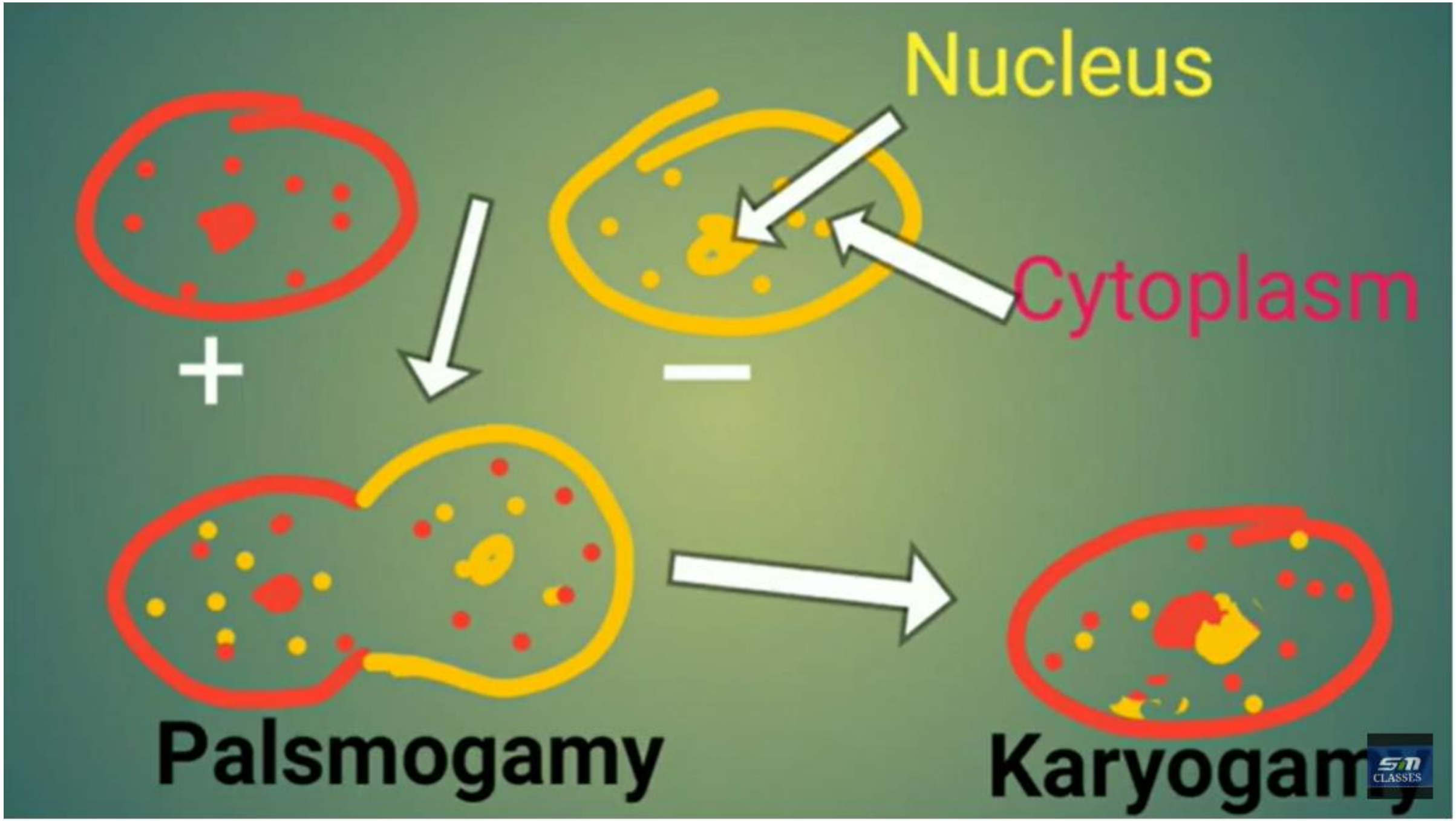
In this process only the protoplasm of the two fusing sex cells or gametes fuse and the nuclei of the fusing bodies come close to each other.

(2) Karyogamy (Gr. karyon = nut, nucleus + gamos = marriage, union):

Plasmogamy is followed by the fusion of the nuclei resulting in the formation of diploid zygote nucleus.

(3) Meiosis (Gr. meiosis = reduction):

Karyogamy is followed by meiosis or reduction division which reduces the number of chromosomes to haploid.


Nucleus
Cytoplasm
+
−
Palsmogamy
Karyogamy

Types of Sexual Reproduction in Fungi

(1). Planogametic copulation

(2). Gametangial contact

(3). Gametangial copulatin

(4). Spermatization

(5). Somatogamy

(1). Planogametic copulation

- Planogametic copulation involves the fusion of two naked motile gametes (planogametes)
- Based on the structure and size of fusing gametes, three types of planogamy is can occur in fungi

(a). Isogamy

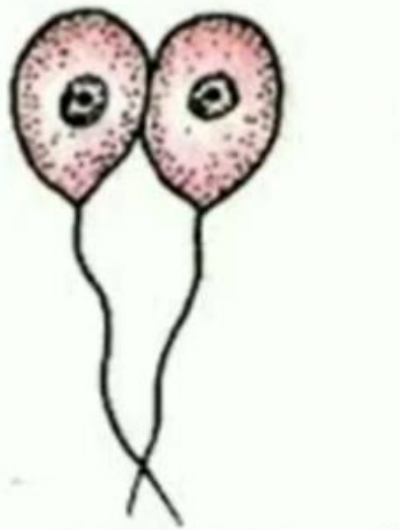
(b). Anisogamy

(c). Oogamy

(a). Isogamy:

Ø Fusing gametes are morphologically similar but physiologically they are two strains (+ and -)

Ø The gametes are formed on different thalli



ISOGAMY A

(b) Anisogamous (Gr. a — not + isos = equal + gamos = marriage, union):

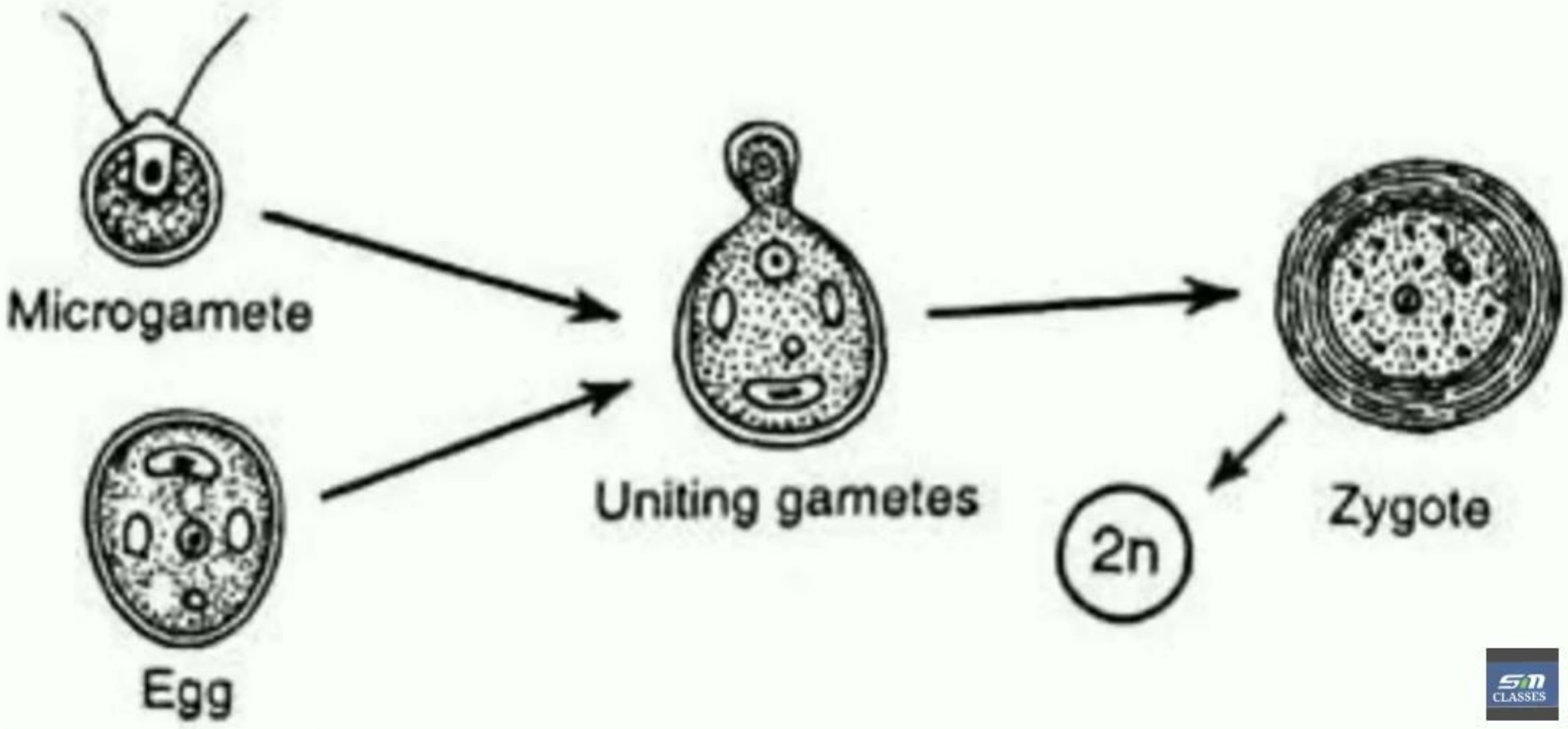
Motile gametes are similar in shape but differ in size e.g., Allomyces (Fig. 20 B).

ANISOGAMY

(c). Oogamy:

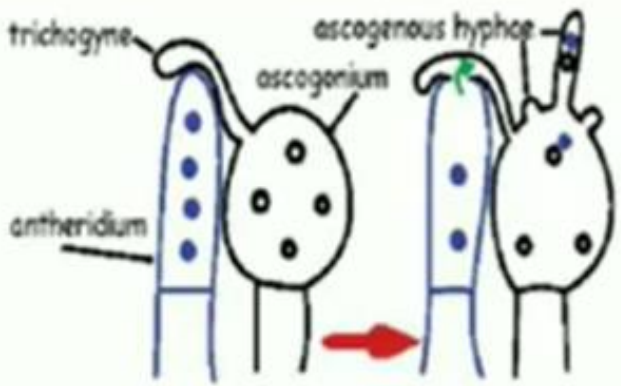
- Ø Female gamete is large and non-motile
- Ø Male game is smaller and motile (flagellated)
- Ø Male gametes are called antherozoids
- Ø They are formed on specialized reproductive structures called antheridium
- Ø Female gamete is called oogonium
- Ø Oogamy is an advanced type of sexual reproduction

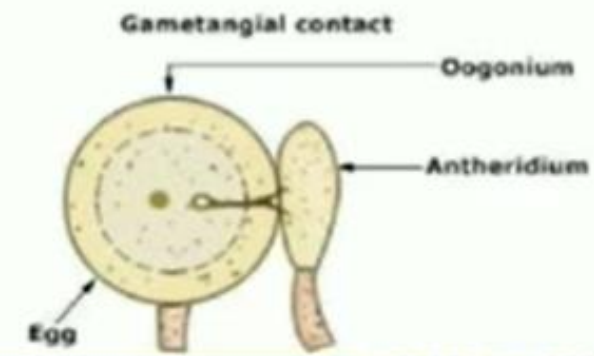
(c). Oogamy:

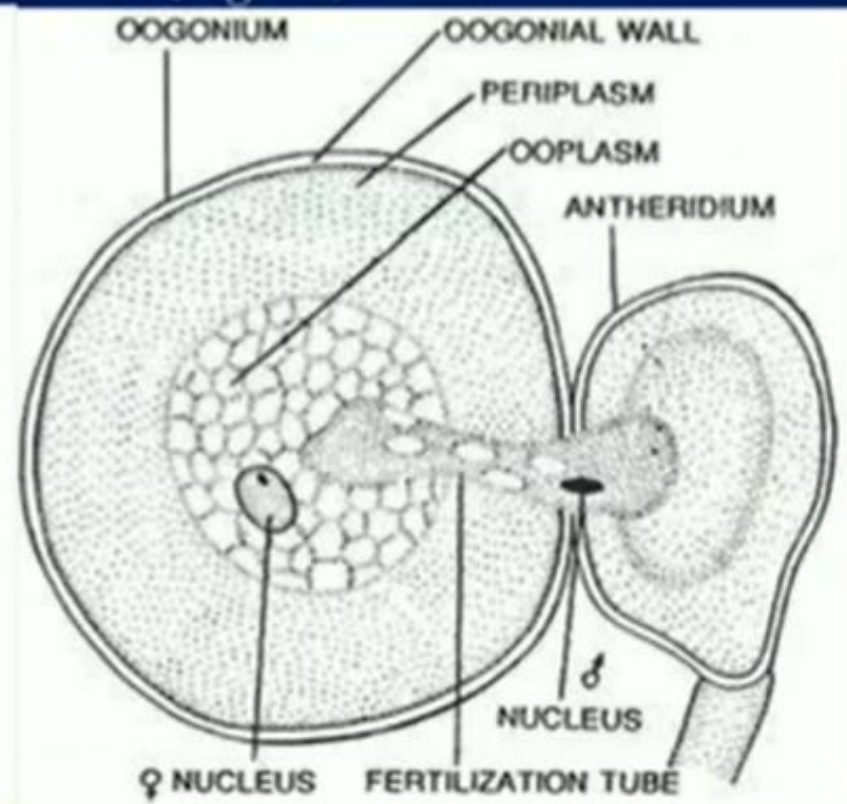


(ii) Gametangial Contact:

In this method gametes are never released. Two gametangia of opposite sex come in contact and one or more gametic nuclei migrate from the male gametangium to the female. The gametangia are non-motile and the male contents are transferred either through a pore (e.g., Sphaerotheca) or through a fertilization tube e.g., Albugo, Phytophthora, Pythium (Fig. 21).

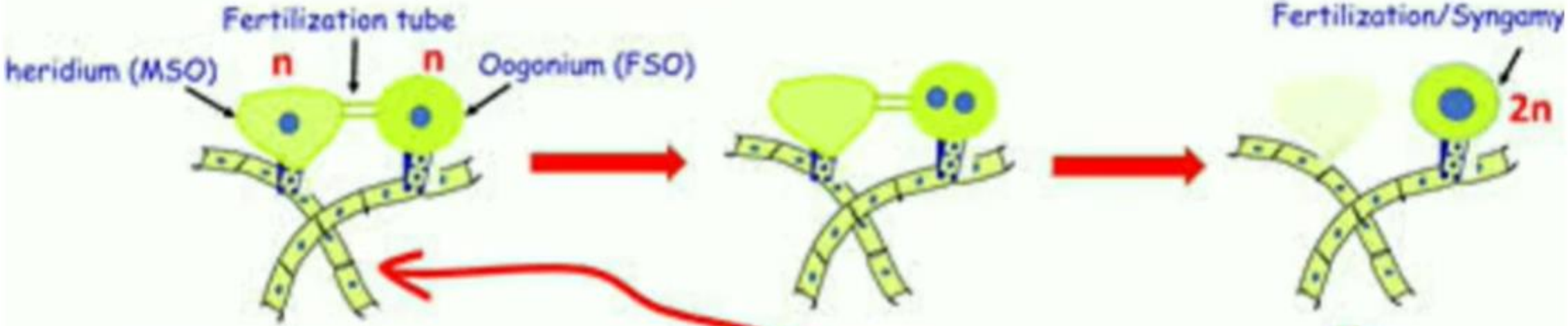






Sexual Reproduction in Fungi

1. Gametangial contact: Takes place between two hyphae of same mycelium



Steps

- Formation of Fertilization tube in between two opposite sex organ.
- Dikaryotic stage in FSO.
- Fertilization/Syngamy.
- Formation of Oospore (Cell wall thickening).
- Formation of haploid spore.
- Haploid spore are capable to form mycelium

E.g. Oomycetes

I like this

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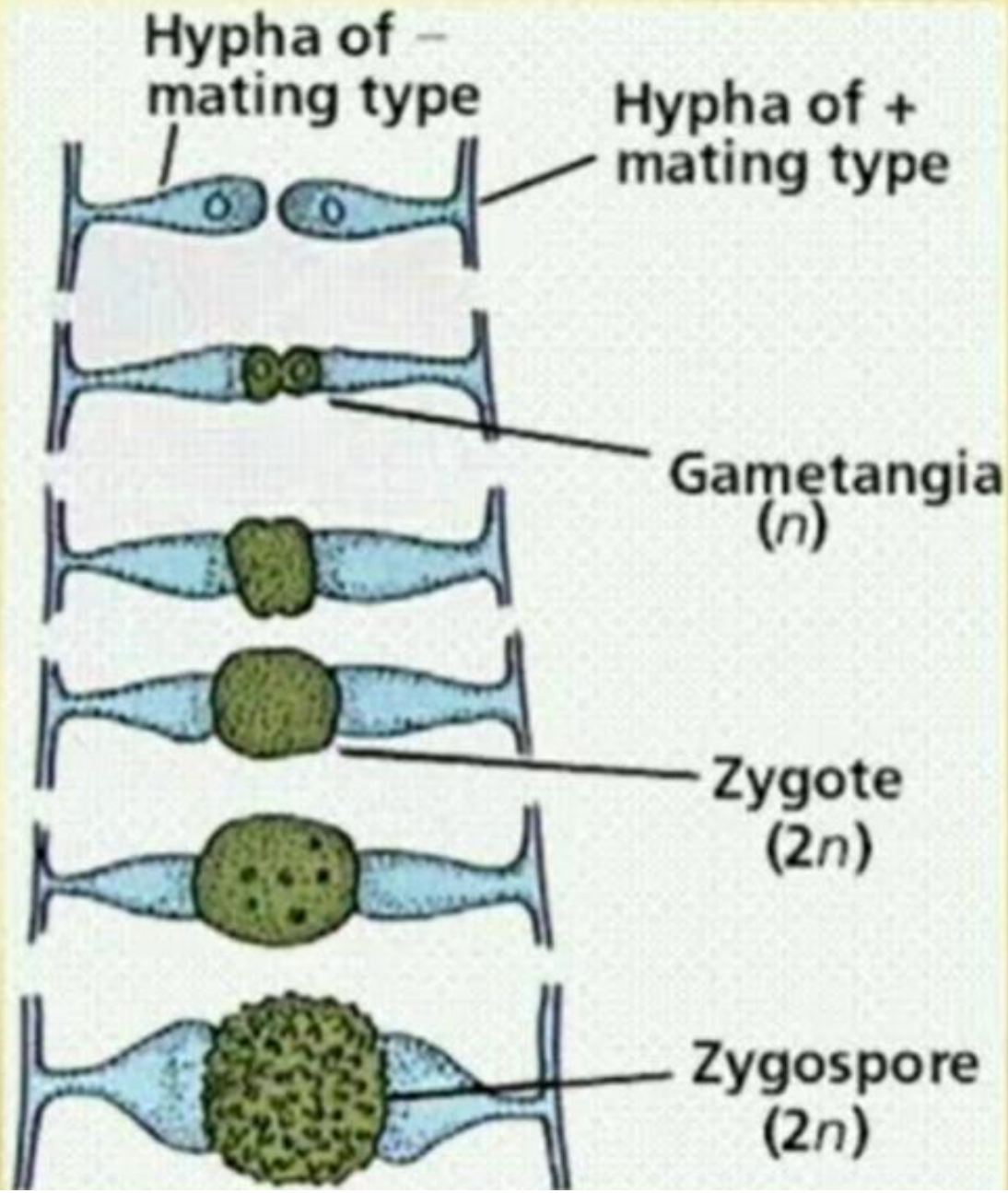
(iii) Gametangial Copulation:

This method involves the fusion of the entire contents of the two connecting gametangia. This takes place by the dissolution of the connecting walls of the two gametangia e.g., Rhizopus, Saccharomyces, Sporodinia. (Fig. 22 A, B).

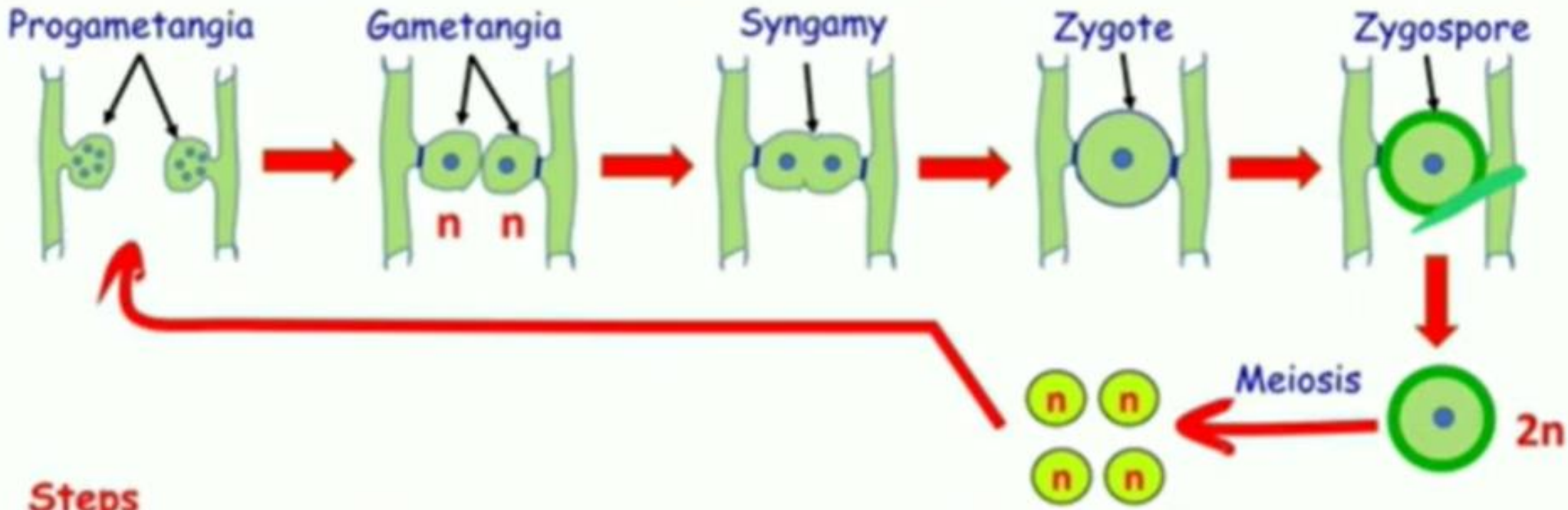
There are no male and female fungi

The two mating types are called **PLUS** mating type and **MINUS** mating type.

Fertilization occurs when the hyphae from a plus and minus fuse



2. Gametangial copulation: Takes place between two hyphae of two different mycelium



Steps

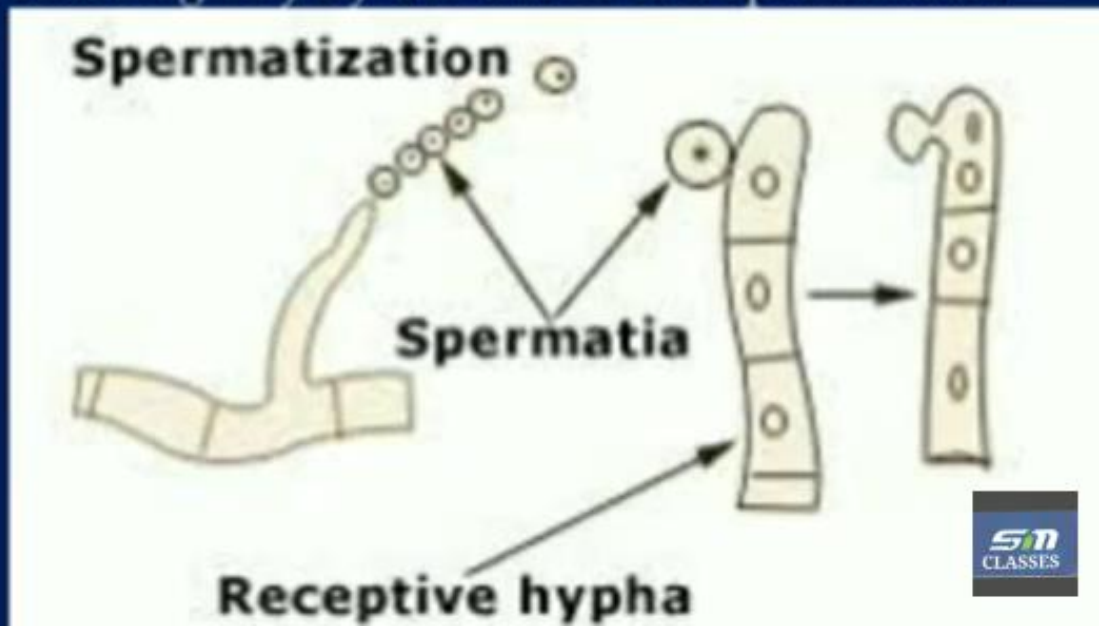
- Progametangia (Immature gametangia, aseptate, multinucleated).
- Mature gametangia (Septate and uninucleated) come in contact.
- Fertilization/Syngamy.
- Formation of Zygote
- Formation of Zygospore (Wall thickening)
- After meiosis haploid spore are capable to form mycelium

E.g. Zygomycetes

(iv) Spermatization (Gr. sperma = seed):

Some higher fungi (sub-division : Ascomycotina and Basidiomycotina) reproduce sexually by this method. Here the male structures are minute uninucleate cells known as spermatia (sing, spermatium; Gr. spermation = little seed). They are carried away by insects, wind or water to a reduced female gametangium, which may be a specialized hypha called receptive hypha.

A pore develops at the point of contact and contents of the spermatium pass into the female organ e.g., Puccinia, Podospora, Neurospora. (Fig. 23 A-D). Plasmogamy by the union of a spermatium with a receptive structure is called spermatization.



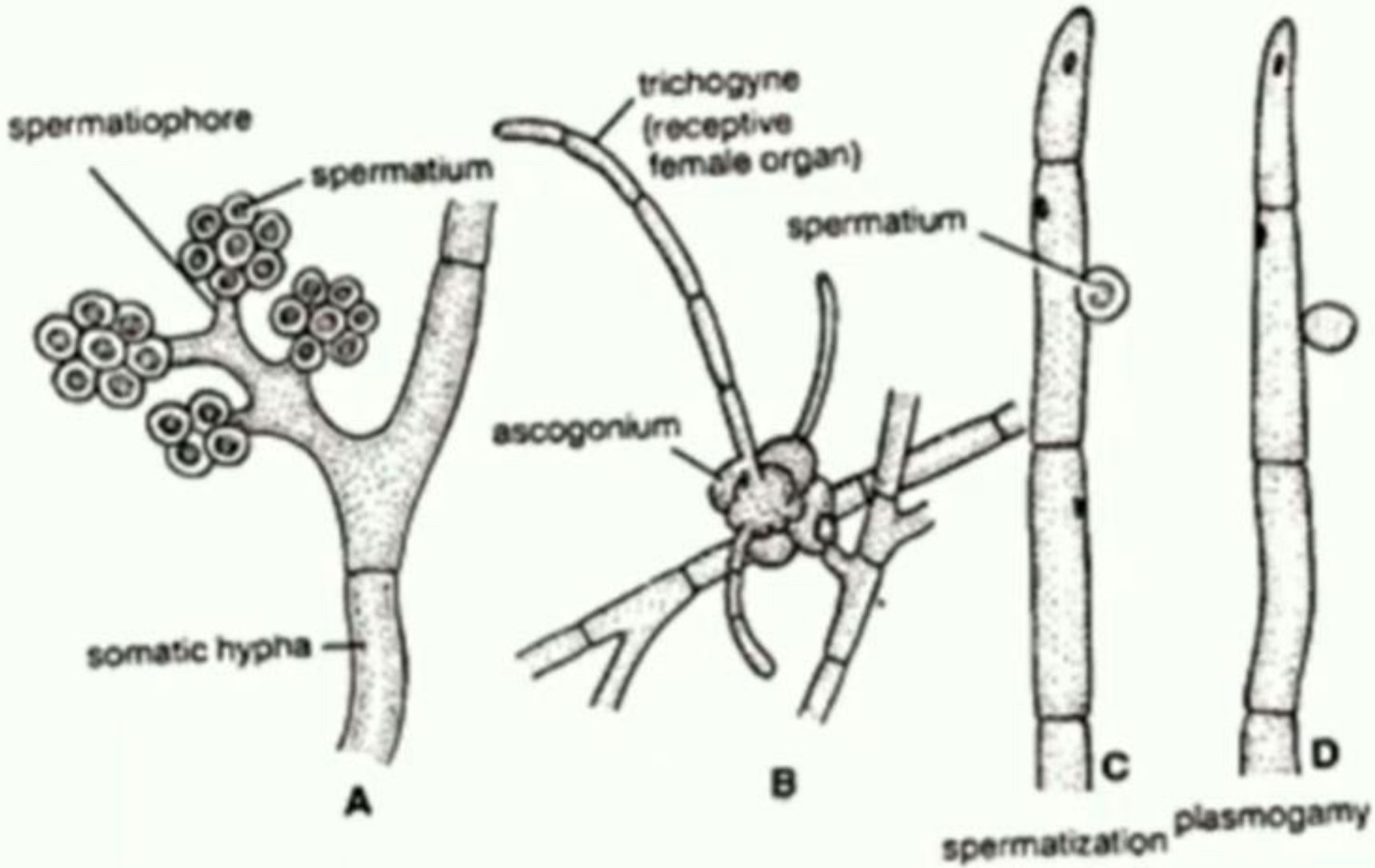
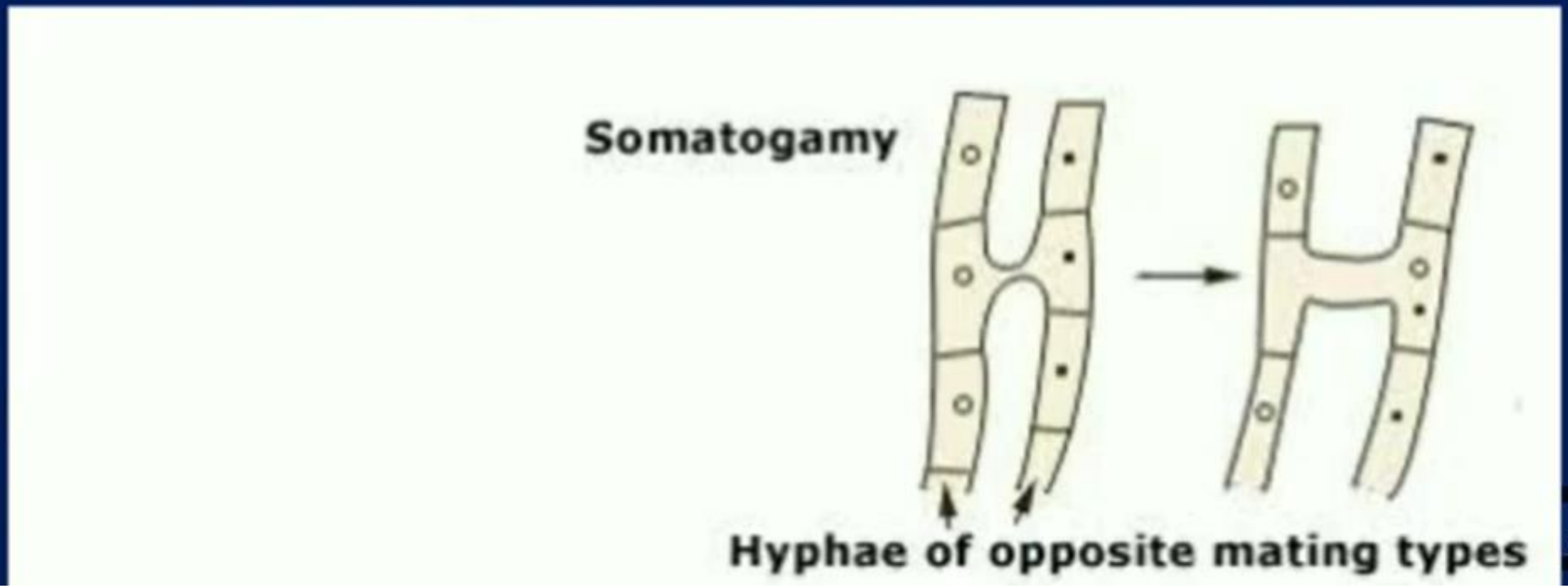


Fig. 23 (A–D). Fungi : (A) Spermatia, (B) Receptive hypha, (C) Spermatization, (D) Plasmogamy

(C) Somatogamy (Gr. soma = body + gamos – marriage, union):

In this method fusion takes place between two cells of somatic hypha. Sex organs are completely absent e.g., Peniophora sambuci and many other members of subdivision Ascomycotina and Basidiomycotina (Fig. 24).



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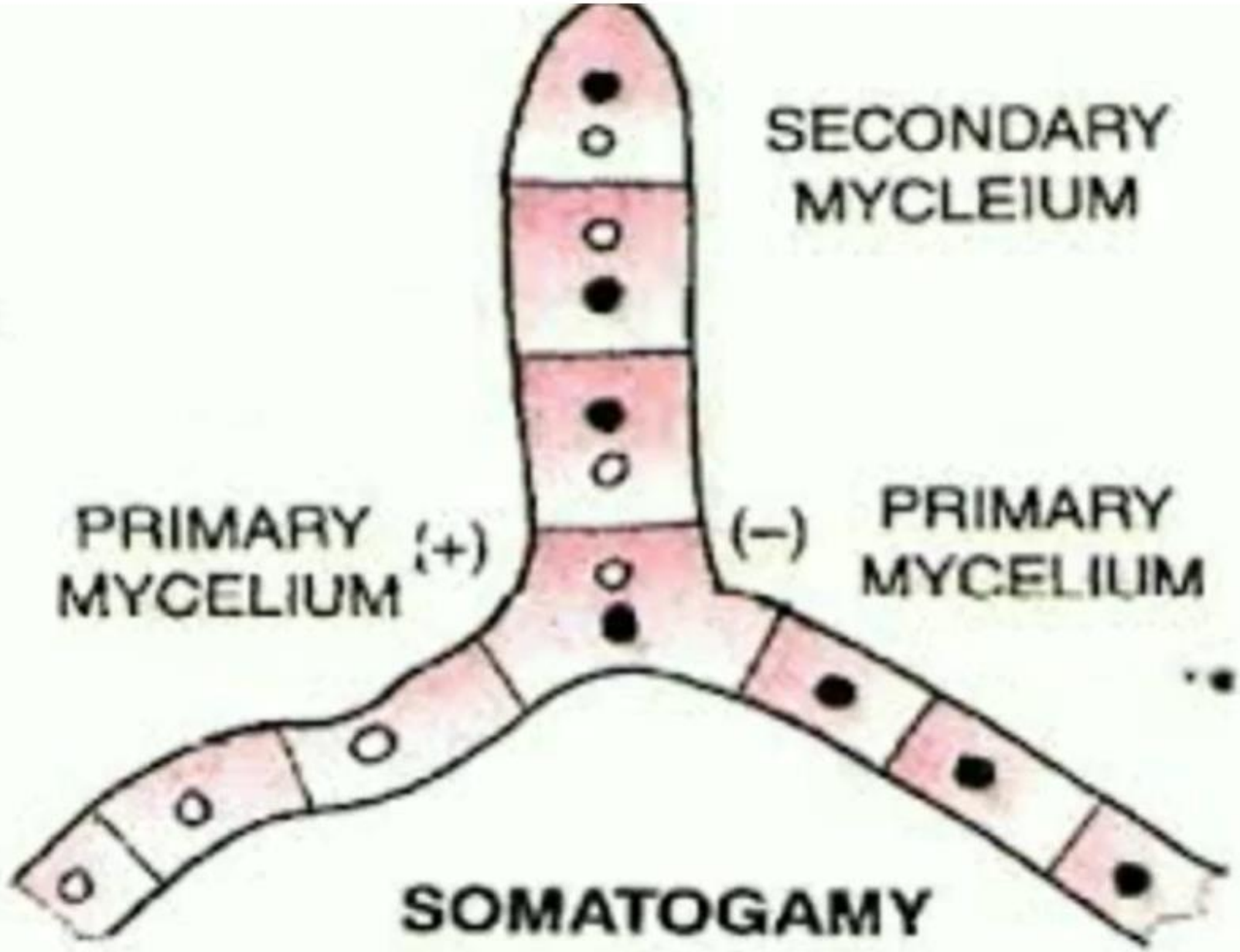

Important point :-

Ascomycetes

- Sex organ present
- Gametes absent

Basidiomycetes

- Sex organ absent
- Gametes absent
- Sexual reproduction present

Duteromycetes

- Sexual reproduction - Unidentified

THANK YOU

https://www.youtube.com/watch?v=tYpnzUcF2NI

https://www.youtube.com/watch?v=f0ESxjz5qDY

https://www.youtube.com/watch?v=GZxgCdKQIBU&t=1084s

https://www.youtube.com/watch?v=PsGZy11wdrQ

Life cycle of Rhizopus:
https://www.youtube.com/watch?v=jilPm_OaXr4