SARDAR PATEL UNIVERSITY

Programme: B. Sc. (BOTANY)

Semester: III Paper Code: US03CBOT21 (T)

Title of Paper: PHYCOLOGY, MYCOLOGY AND PHYTOPATHOLOGY

Total Credit: 4 (Four Lectures per week)

(Total Marks 100, Internal-30 marks, External 70-marks)

Syllabus with effect from: June 2019

UNIT-2 Mycology:

*General Characteristic features of Chytridiomycota, Oomycota, Zygomycota, Ascomycota, Basidiomycota.

*Type study: Synchytrium, Phytophthora, Albugo, Aspergillus, Neurospora, Agaricus, Alternaria. (Classification (classification as per G. C. Ainsworth, 1973),

*Occurrence, Morphology, thallus organization, Cell structure, Reproduction and life-cycle).

*Bioluminescence, Fairy Rings and Mushroom Cultivation.

UNIT-4 Phytopathology:

*Major Plant Diseases: Differentiation between bacterial, viral and fungal diseases using morphological symptoms.

•Study of the following diseases (symptoms, causal organism, disease cycle and disease control).

•* Bacterial diseases – Citrus Canker, Angular leaf spot of cotton.

•* Viral diseases -Leaf curl of papaya, Yellow vein mosaic in bhindi.

•*Fungal diseases- White rust of crucifers, Red rot of sugarcane, Tikka disease of groundnut, and Stripe rust of wheat. Phytoplasma diseases: Little leaf brinjal.

UNIT-2 Mycology:

*General Characteristic features of :

(1)Chytridiomycota

(2)Oomycota

(3)Zygomycota

(4)Ascomycota

()Basidiomycota

General Characteristics of Fungi

- The study of fungi is called: **Mycology.**

1. All fungi are **Eukaryotic** organisms living everywhere on earth.
2. Fungi are **Heterotrophic** **i.e.** depend on other organism for food and are different from plants which are *"Autotrophic".*

➢ **Heterotrophic organisms are 3 kinds:**

A) Saprophytic: the fungus is living on dead organic matter.

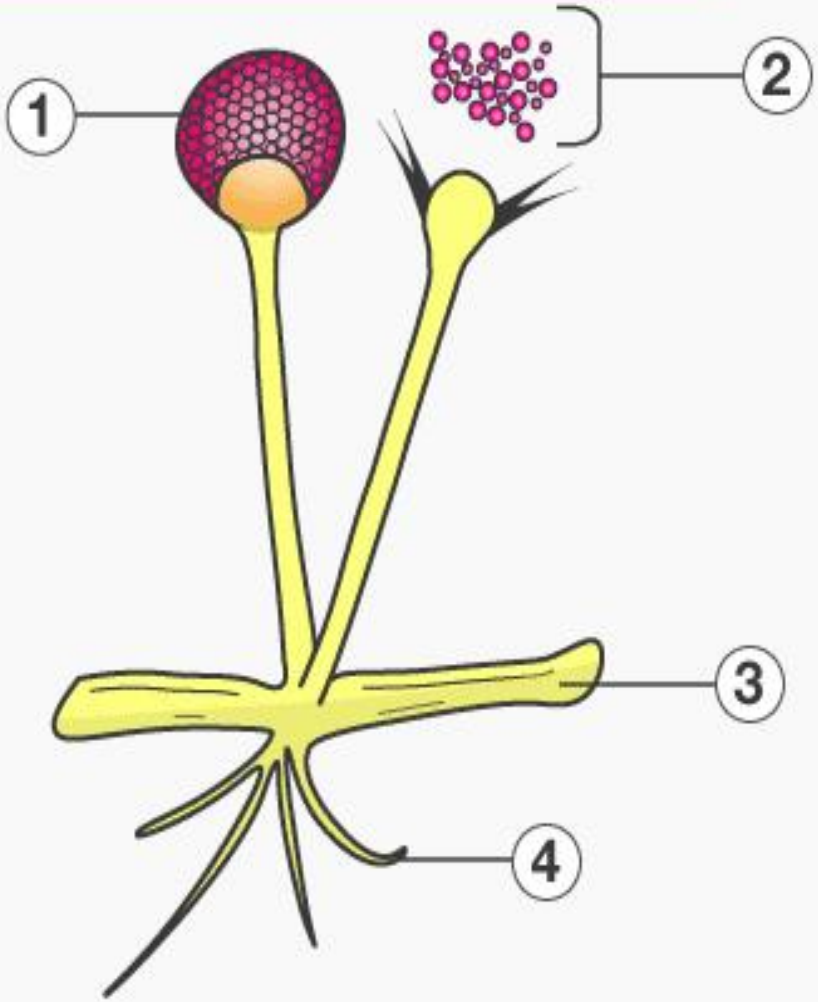
B) Symbiotic: the fungus is living together with other organism.

C) Parasitic: the fungus is living in an organism and it is harmful to it **e.g.** *Candida albican.*

3. Beneficial fungi are important in the production of cheeses and antibiotics **e.g.** Penicillin.

STRUCTURE OF KINGDOM FUNGI

BYJU'S The Learning App



1 Sporangium | 2 Spores | 3 Food Source | 4 Hyphae

General Characteristics of Fungi:

- Eukaryotic cell.
- Decomposers – the best recyclers around
- No chlorophyll – non photosynthetic
- Most multicellular (hyphae) – some unicellular (yeast)
- Non-motile
- Cell walls made of **chitin** *(kite-in)* instead of cellulose like that of a plant are **more related to animals** than plant kingdom
- Lack true roots, leaves and stems
- Absorptive heterotrophs
- Digest food externally and then absorb it
- *Lack of chlorophyll affects the lifestyle of fungi…*
- Not dependent on light
- Can occupy dark habitats
- Can grow in any direction
- Can invade the interior of a substrate with absorptive filaments

Structures

*Body of fungus made of tiny filaments or tubes called **hyphae** .

*It contain cytoplasm and nuclei (more than 1).

*Each hyphae is one continuous cell.

*Cell wall made of chitin.

*A tangled mess of hyphae is called **mycelium.**

***Rhizoids** are root-like parts of fungi that anchor them to the substrate *(whatever they are bonding to)*

***Mycelium increase the surface area of the fungi to absorb more nutrients.**

CLASSIFICATION OF FUNGI:

Fungi can be classified into 5 groups

Fungi evolved from an aquatic, flagellated ancestor

Chytrids

Glomeromycetes (Mycorrhizae fungi); **Mycorrhizae** are mutually beneficial associations of **plant roots and fungi**

- Common and may have enabled plants to colonize land
- Help create an extending network for the plant to absorb more nutrients and water

Ascomycetes (Sac fungi)

- Truffles and yeast

Basidiomycetes (Club fungi)

- Puff ball mushroom

Zygomycetes (Zygote fungi)

Fungus Reproduction:

*Fungi produce spores in both asexual and sexual life cycles.

*Mushrooms let out spores from their pores that are carried by the wind to meet other spores and become a new fungi.

*Yeast are unicellular and divide into new fungal cells **(mitosis).**

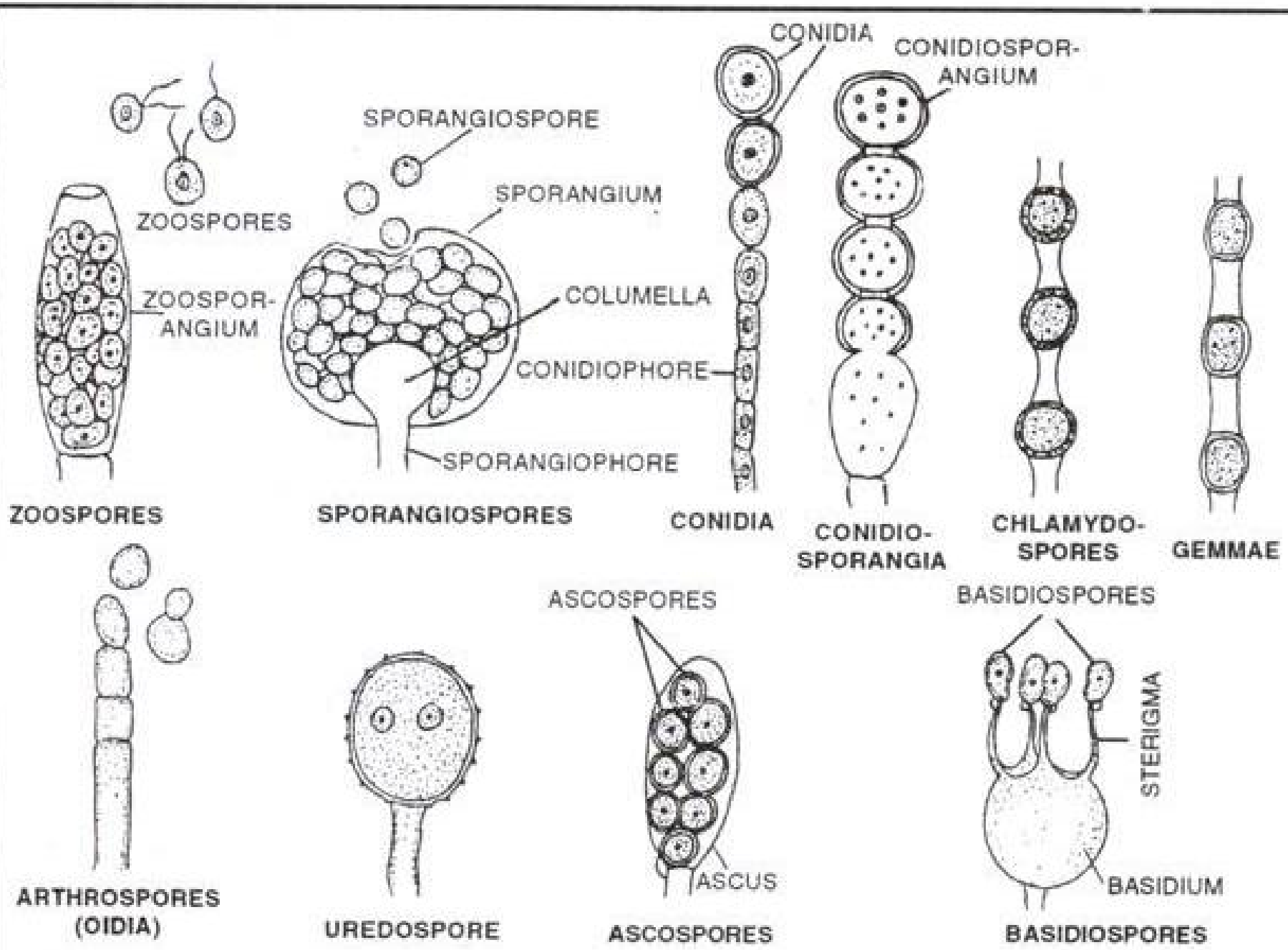


Figure 6.5 Various types of fungal spores.

1. Cell Type: eukaryotic

2. Type of Reproduction: asexual and sexual life cycle

Sex cell = spores

– made by the sporangium

– spores are spread by wind

– spores germinate (grow)

Asexual fragmentation may also occur

3. Characteristics

- nonmotile
- mycelium – vegetative part, under ground
- wide variety of shapes, sizes and colours

4. Ecological Role

1. Decomposers – transforms dead material to new material for plants
2. Human uses – yeast to make bread, wine and beer
3. Bioremediation – decomposes harmful pollutants and hazardous chemicals
4. Helps other organisms (symbiotic relationship) eg: helps roots of plants absorb nutrients

LICHEN : a combo of green algae and fungus growing together to help plant growth (act like soil for plants to grow on rocks)

Lichens are also indicators of air pollution since they absorb water from the air to provide for the plants

5. CONNECTION to HUMAN HEALTH

– skin infections such as athlete's food and ringworm

– poisonous mushrooms (*Amanita)* can cause death by producing neurotoxins if ingested

- In some fungi, **fusion of haploid hypha** produces a **heterokaryotic stage** containing nuclei from two parents *(fusion of cytoplasm)*
- After the nuclei fuse, meiosis produces **haploid spores** *(can grow in fungi and are the asexual part of the life cycle)*

General Fungi Reproduction Cycles:

But fungal groups do ***differ*** in their life cycles and reproductive structures

Reproduction in Basidiomycetes:

Basidiomycota *(typical mushroom)*

ASCOMYCOTA

FUNGI NUTRITION:

Fungi absorb food after digesting it outside their bodies

- Fungi are **heterotrophic eukaryotes**

•Fungi use digestive enzymes to break down their food then absorb the liquid. ***(acquire nutrients such as nitrogen)***

•**<u>Examples:</u>**

- •trap nematodes *(little worms who feed on fungi)* and paralyze them with special juices then absorbs and digests the nitrogen out of them.

3 Modes of Nutrition in Fungi:

•Saprophytes

•Parasites

•Mutualists (symbionts)

Saprophytes

•Use **<u>non-living organic material</u>**

•Important scavengers in ecosystems

•Important in recycling carbon, nitrogen and essential mineral nutrients

Parasites

Use organic **material from living organisms,** harming them in some way

Range of hosts from single-celled diatoms to fungi, to plants to animals to humans

Mutualists (symbionts)

Fungi that have a **mutually beneficial relationship with other living organisms**

Mycorrhizae – beneficial relationship with fungi with plant root

- More than 90% of plants in nature have a mycorrhizal in roots

(***example: Truffles- expensive delicacy!)***

Lichens – associations of fungi with algae or cyanobacteria

- Food source for animals, breaking down rocks into soil

Parasitic fungi harm plants and animals

- Parasitic fungi cause 80% of plant diseases
- Can kill plants and affect crops

Many fungi are harmful to humans

Can cause human diseases – *allergies, athletes foot, ringworm, yeast infection*

More Useful Fungi:

Yeasts – baking and brewing beer

Antibiotics – penicillin & cephalosporin

Production of organic acids – citric acid in Coke

Steroids and medicines – birth control pills

- Fungi also form mutualistic relationships with animals
- Some animals benefit from the digestive abilities of lichens
- **Lichens** consist of fungi living **mutually** with photosynthetic organisms

- Fungi have enormous **ecological, economic and practical uses.**
  - **Ecological=** fungi are essential **decomposers;** mycorrhizae increase plant growth.

Some of the most important characters of fungi are as follows:

1. Occurrence 2. Thallus organization
2. 3. Different forms of mycelium
   4.Cellstructure 5. Nutrition
   6.Heterothallism and Homothallism
3. 7. Reproduction 8. Classification of Fungi.

1. Occurrence:
Fungi are cosmopolitan and occur in air, water soil and on plants and animals. They prefer to grow in warm and humid places. Hence, we keep food in the refrigerator to prevent bacterial and fungal infestation.

2. Thallus organization:
Except some unicellular forms (e.g. yeasts, Synchytrium), the fungal body is a thallus called mycelium. The mycelium is an interwoven mass of thread-like hyphae (Sing, hypha). Hyphae may be septate (with cross wall) and aseptate (without cross wall). Some fungi are dimorphic that found as both unicellular and mycelial forms e.g. Candida albicans.

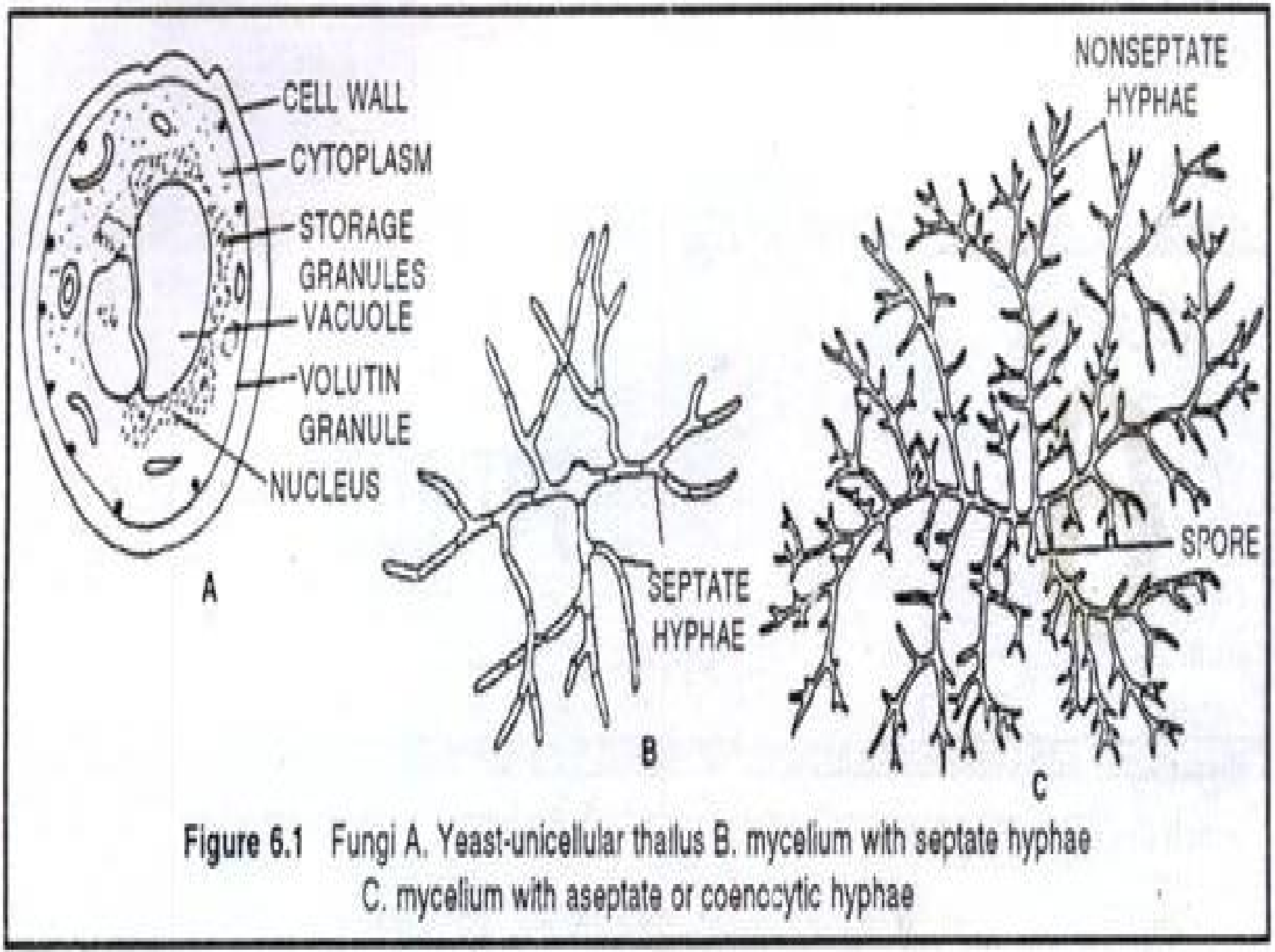


Figure 6.1 Fungi A. Yeast-unicellular thallus B. mycelium with septate hyphae C. mycelium with aseptate or coenocytic hyphae

3. Different forms of mycelium:

(a) Plectenchyma (fungal tissue):

In a fungal mycelium, hyphae organized loosely or compactly woven to form a tissue called plectenchyma.

It is two types:

i. Prosenchyma or Prosoplectenchyma:

In these fungal tissue hyphae are loosely interwoven lying more or less parallel to each other.

ii. Pseudoparenchyma or paraplectenchyma:

In these fungal tissue hyphae are compactly interwoven looking like a parenchyma in cross-section.

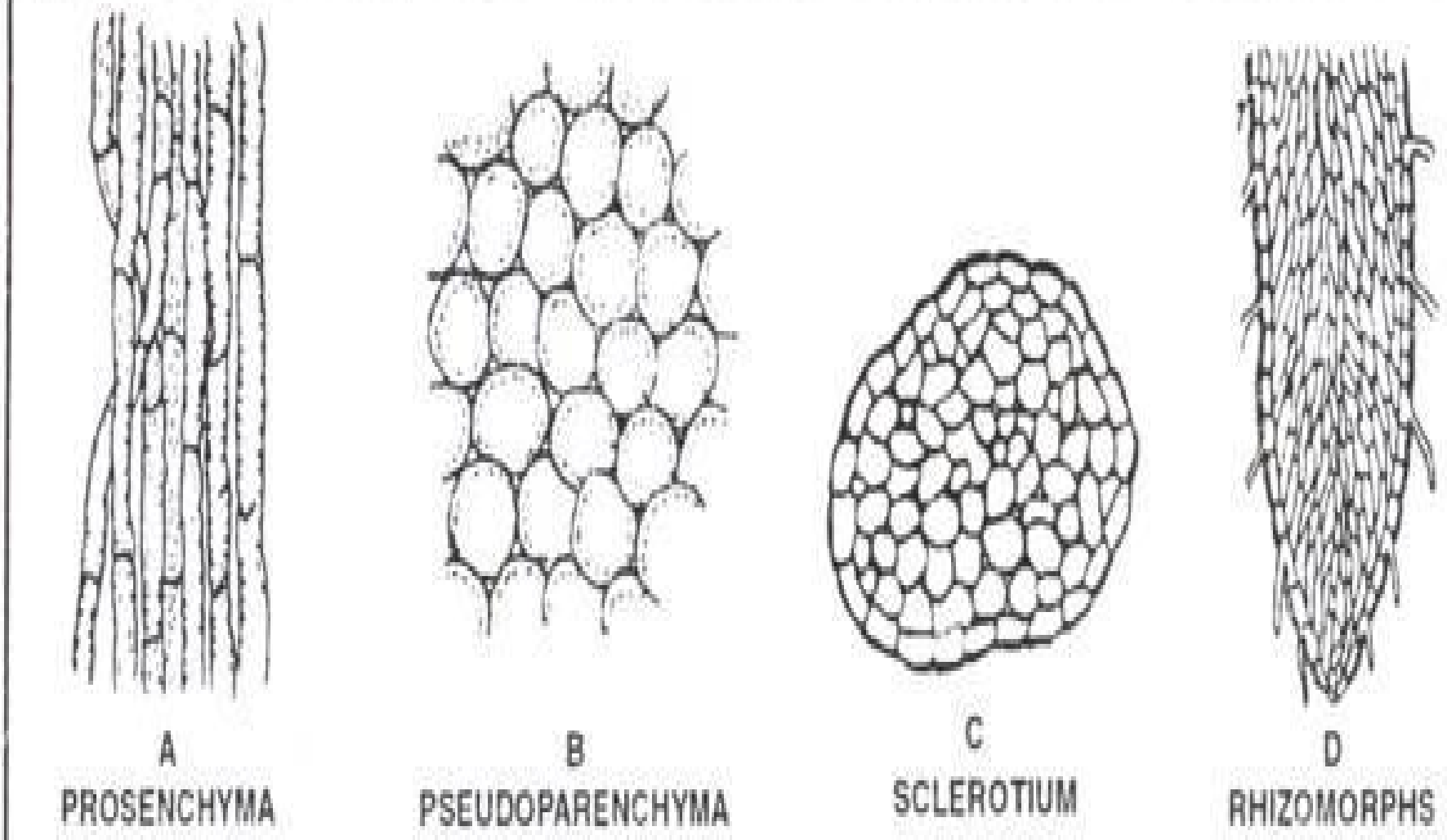


Figure 6.2 Different forms of fungal mycelium

(b) Sclerotia (Gr. Skleros=haid):

These are hard dormant bodies consist of compact hyphae protected by external thickened hyphae. Each Sclerotium germinates into a mycelium, on return of favourable condition, e.g., Penicillium.

(c) Rhizomorphs:

They are root-like compactly interwoven hyphae with distinct growing tip. They help in absorption and perennation (to tide over the unfavourable periods), e.g., Armillaria mellea.

4. Cell structure:

Fungal cell wall composed of chitin (fungal cellulose, $C_{22}H_{54}N_4O_{21}$). In primitive fungi true cellulose with or without chitin found. Plasma-lemma bears occasional coiled ingrowths called lomasomes which lie below cell wall. Cytoplasm contains organelles (Endoplasmic reticulum, mitochondria, ribosome, Golgi bodies etc.) and inclusions (stored foods, pigments and secretory granules).

The cytoplasm at hyphal tip contains Golgi vesicles called chitosomes which filled with cell wall materials. Nucleus and mitochondria are found to connect with ER. Nucleus divides by intracellular mitosis called karyochoresis where nuclear envelop remain intact during nuclear division and internal spindle develop. Reserve food is glycogen and oil.

Reproduction:

Like most other thallophytes, fungi also reproduce by vegetative, asexual and sexual means. However, asexual reproduction is generally predominant Depending upon the involvement of the entire thallus or a part of it, the fungi may be holocarpic or eucarpic.

(i) Holocarpic:

In this category of fungi the entire thallus gets converted into one or more reproductive bodies. Hence, the vegetative and reproductive phase can never occur at the same time.

(ii) Eucarpic:

Most of the fungi are eucarpic. Here only a part of the thallus is involved in the development of reproductive organs and remaining thallus remains vegetative. In eucarpic fungi, vegetative and reproductive phases exist at the same time.

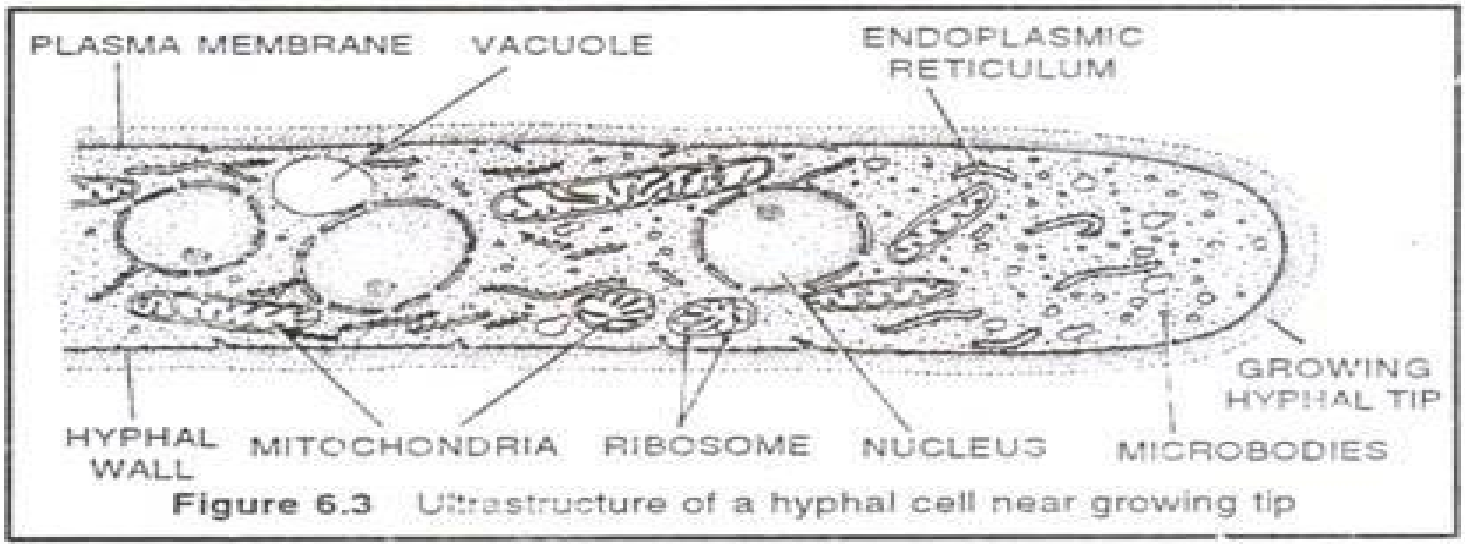


Figure 6.3 Ultrastructure of a hyphal cell near growing tip

A. Vegetative Reproduction:

In this type of reproduction, a part of mycelium separate and forms a new individual. The various methods of vegetative reproduction are— fragmentation, budding, fission, sclerotia, rhizomorphs and oidia formation. In case of Rhizopus and Coprinus the hyphae break up into numerous fragments called oidia, each of which give rise to a new mycelium.

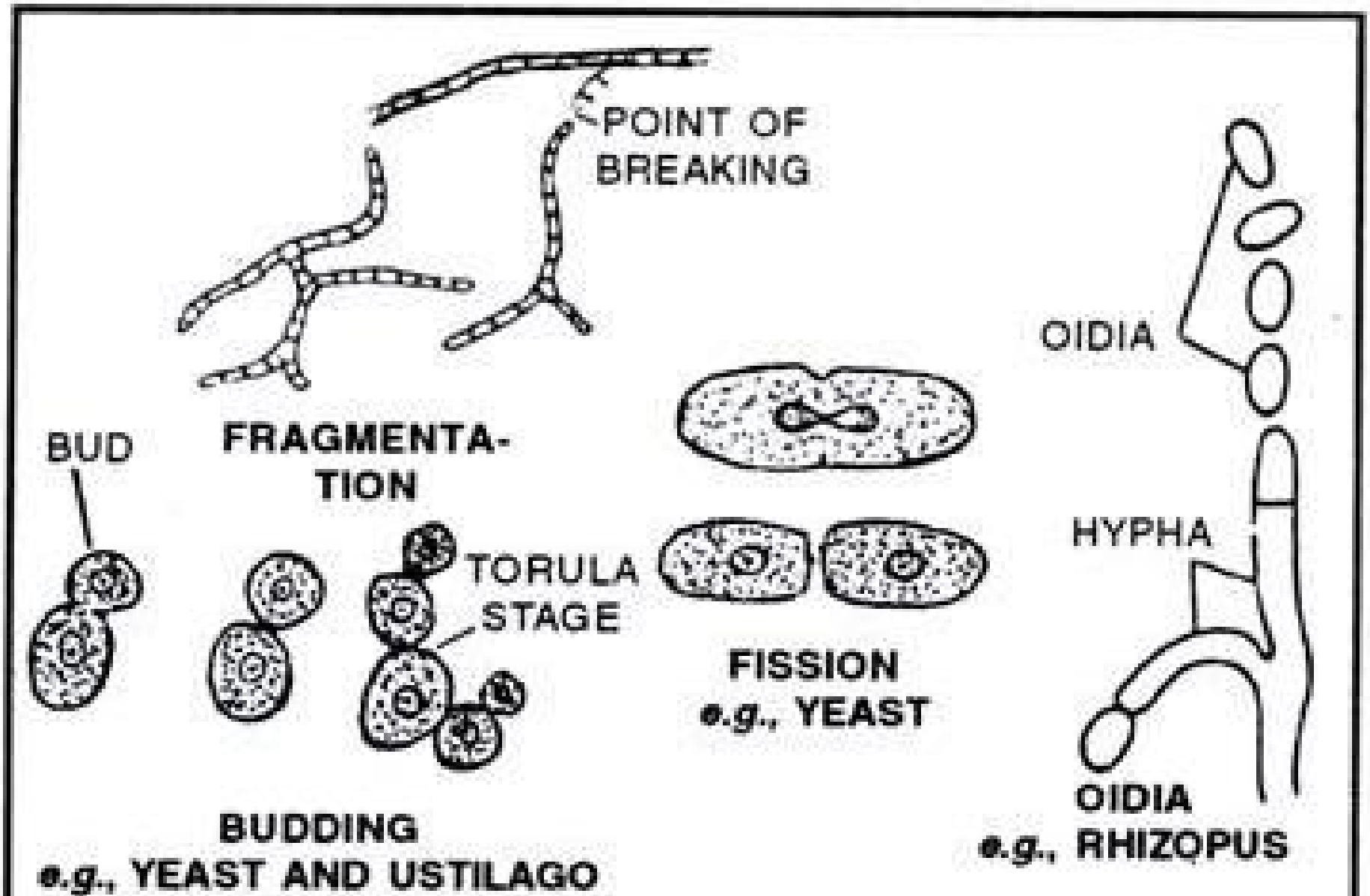


Figure 6.4 Different types of vegetative reproduction in

B. Asexual Reproduction:

It commonly occurs through spores, either motile or non-motile and form in a specialized part of mycelium. The various types of spores are: zoospores, sporangiospores (=aplanospores), conidia, oidia (arthrospores), chlamydospores, gemmae, ascospores, uredospores, basidiospores etc.

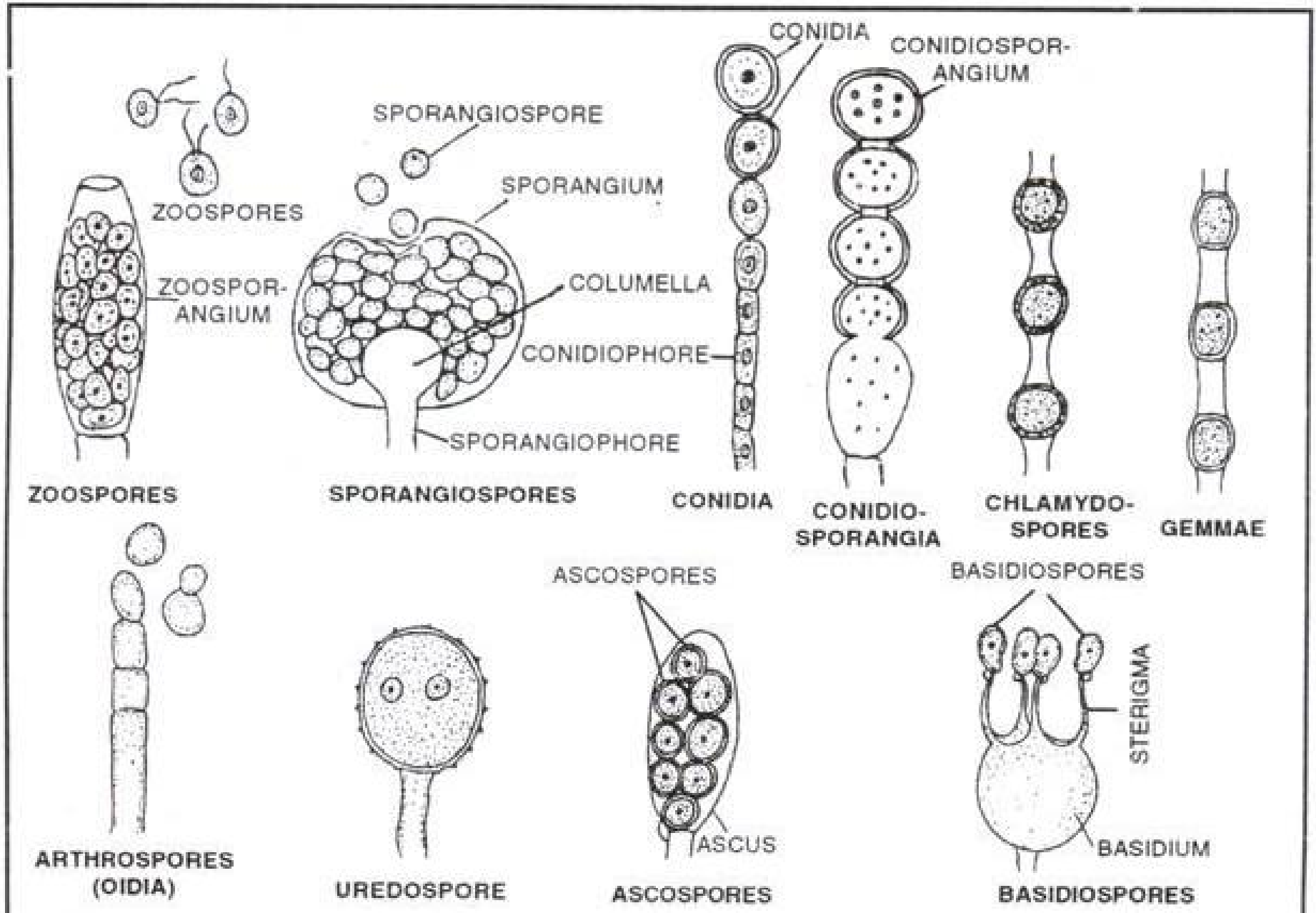


Figure 6.5 Various types of fungal spores.

C. Sexual Reproduction:

- It involves the formation and fusion of gametes. Sexual reproduction found in all groups of fungi except deuteromycetes or fungi imperfecti.
- Sexual reproduction has three distinct phases i.e. plasmogamy (protoplasmic fusion), karyogamy (fusion of nuclei) and meiosis (reduction division of zygote).

The various methods of sexual reproduction in fungi are as follows:

(i) Planogametic copulation:

This is simplest type of sexual reproduction. In this process fusion of two gametes of opposite sex or strains takes place where one or both of the fusing gametes are motile (flagellated). It results in the formation of a diploid zygote.

This process is usually of three types:

(a) Isogamy:

In this process fusing gametes are morphologically similar and motile but physiologically dissimilar. These gametes are produced by different parents e.g. Synchytrium.

(b) Heterogamy:

*When the fusing gametes are morphologically as well as physiologically different, the process is known as heterogamy.

*Heterogamous reproduction is of two types: anisogamy and oogamy.

*Anisogamy consists of the fusion of two motile gametes where the male gamete is small and more active than the female gamete, e.g., Allomyces.

*In oogamy the motile male gamete (antherozooid) fuses with the large, non-motile female gamete (egg or ovum), Synchytrium etc.

(ii) Gametangial contact:

In this process two gametangia of opposite sex come in contact with one another. The male gametangium (antheridium) transfer male nucleus or gamete into the female gametangium (oogonium) either through a pore at the point of contact or through a fertilization tube, e.g., Phytophthora, Sphaerothera, Alb. go, Pythium etc.

(iii) Gametangial copulation:

In involves the fusion of entire contents of two gametangia to form a common cell called zygote or zygospore, e.g., Mucor, Rhizopus.

(iv) Spermatization:

Some fungi produce many minute, spore-like, single-celled structures called spermatia (nonmotile gametes). These structures are transferred through agencies like water, wind and insects to either special receptive hyphae or trichogyne of ascogonium. The contents migrate into receptive structure. Thus dikaryotic condition is established, e.g. Puccinia.

(v) Somatogamy:

This takes place in fungi where formation of gametes is absent. In such fungi, anastomoses takes place between hyphae and their somatic cells fuse to produce dikaryotic cells, e.g, Agaricus, Peniophora etc.

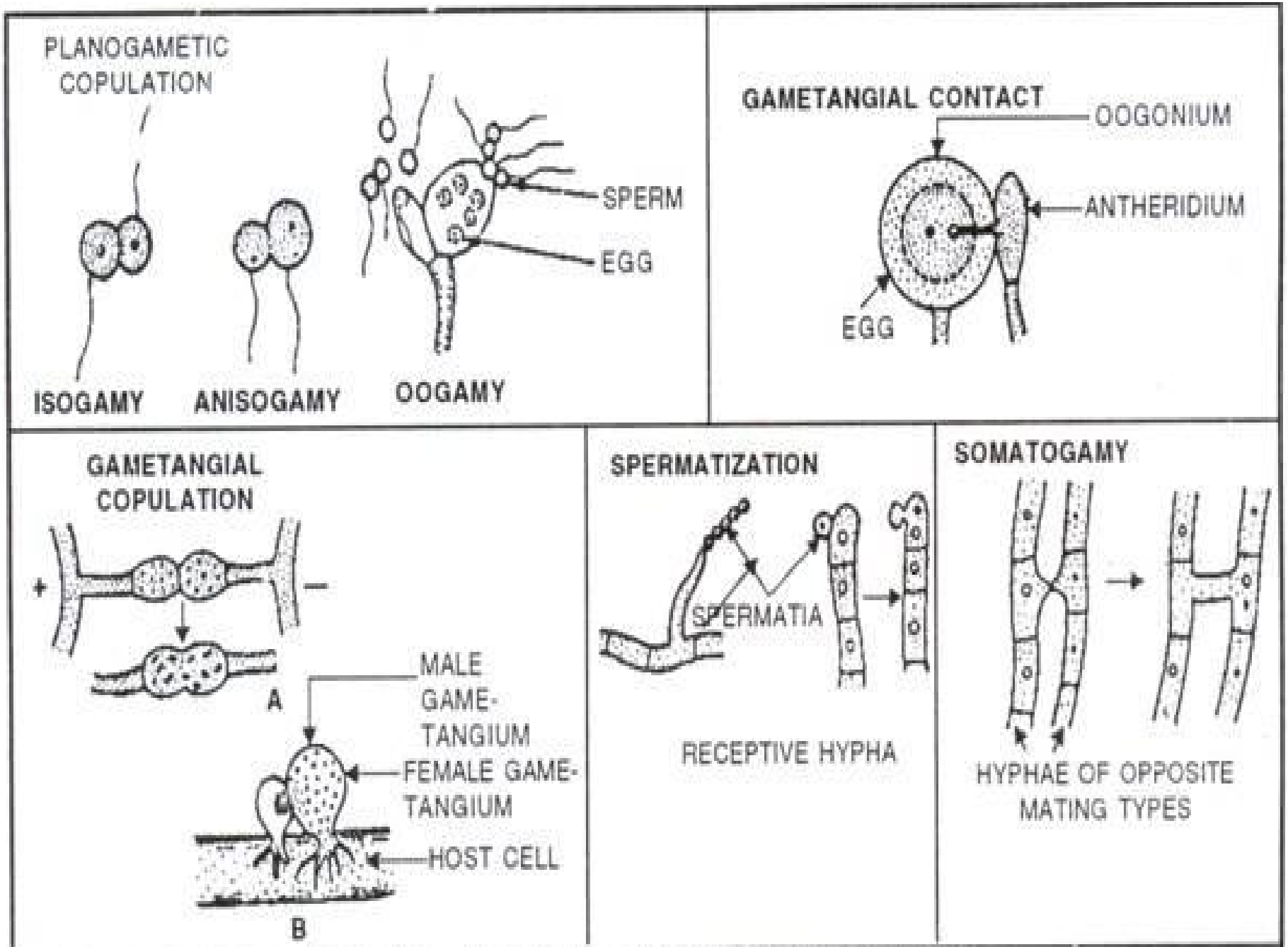


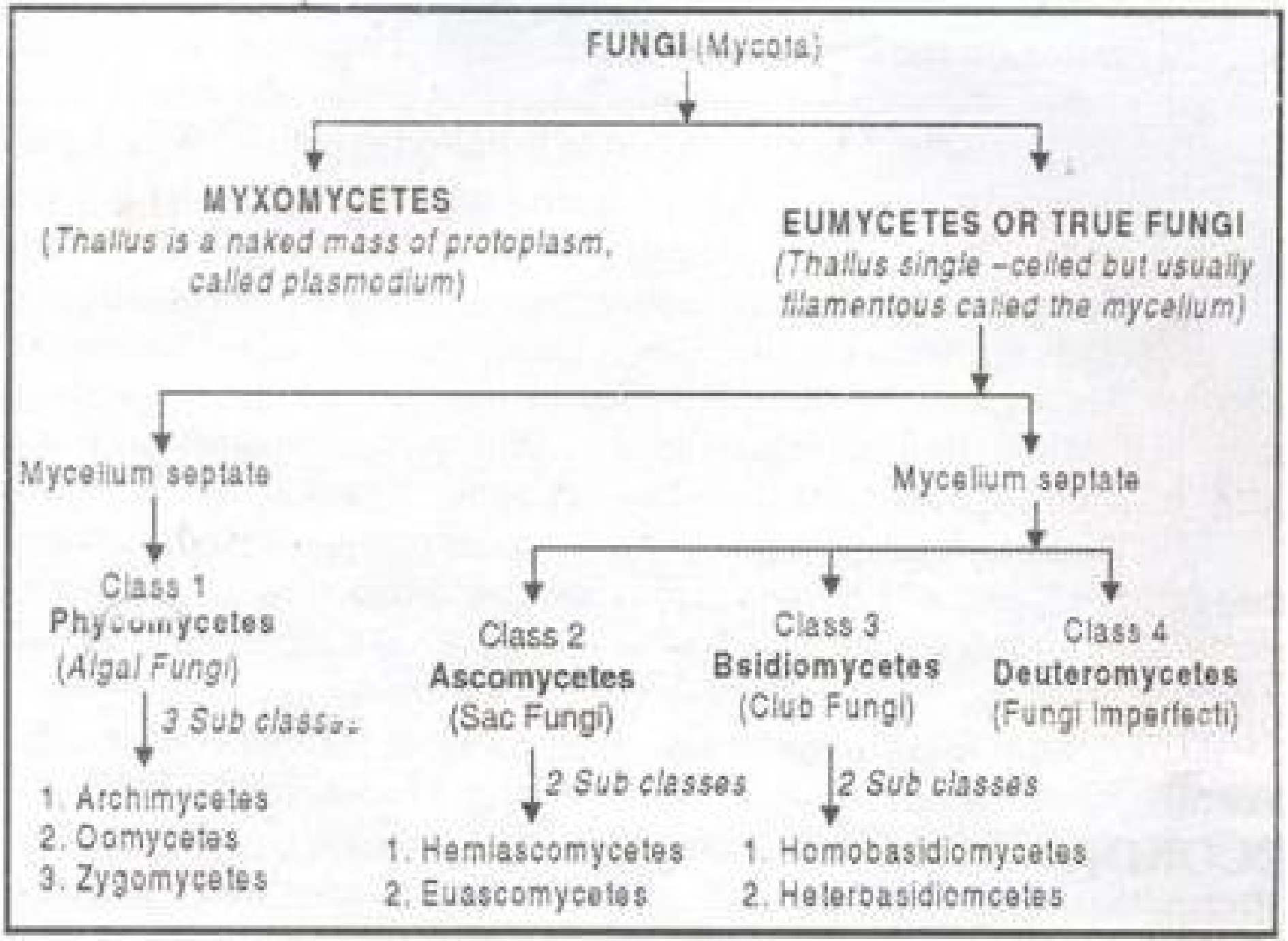
Figure 6.6 Different types of sexual reproduction in fungi.

Classification of Fungi:

Fungi are classified on the basis of morphology of the mycelium spore formation, fruiting bodies and mode of life cycles. Martin's (1995) classification of fungi is the most prevalent one.

He classified fungi into 3 subdivisions:

1. Schizomycetes (Bacteria)
2. Myxomycetes (Slime moulds)
3. Eumycetes(True fungi)


FUNGI (Mycota)
MYXOMYCETES
(Thallus is a naked mass of protoplasm, called plasmodium)
EUMYCETES OR TRUE FUNGI
(Thallus single -celled but usually filamentous called the mycelium)
Mycelium septate
Mycelium septate
Class 1
Phycomycetes
(Algal Fungi)
3 Sub classes
1. Archimycetes
2. Oomycetes
3. Zygomycetes
Class 2
Ascomycetes
(Sac Fungi)
2 Sub classes
1. Hemiascomycetes
2. Euascomycetes
Class 3
Bsidiomycetes
(Club Fungi)
2 Sub classes
1. Homobasidiomycetes
2. Heterobasidiomcetes
Class 4
Deuteromycetes
(Fungi Imperfecti)

Myxomycetes:

- These include about 600 species of free living slime moulds which are now considered as consume r-decomposer protists or protistan fungi.
- They grow in damp places. The thallus resembles amoeba, hence these fungi is also myxamoeba.
- They are holocarpic i.e. the entire thallus gets converted into reproductive body. They reproduce asexually by fission or cysts and sexually by zoospores.

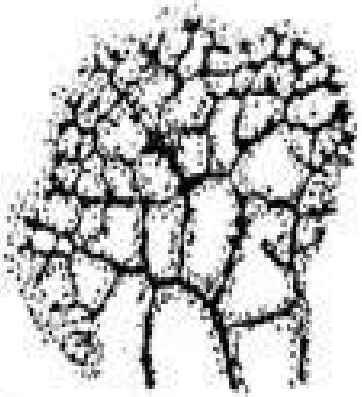
•The thallus of slime moulds exists in two forms – acellular slime mould (plasmodium) and cellular slime mould (pseudoplasmodium).
•Plasmodium is a wall-less mass of multinucleate protoplasm, e.g. Physarum, Didymium, Fuligo etc.
•At maturity plasmodium develops stalked sporangia tilled with spores and a network of protoplasmic threads called capillitium.
• A pseudo plasmodium is an aggregate of individual amoeboid cells, e.g. Dictyostelium.

Phycomycetes (Algal fungi):

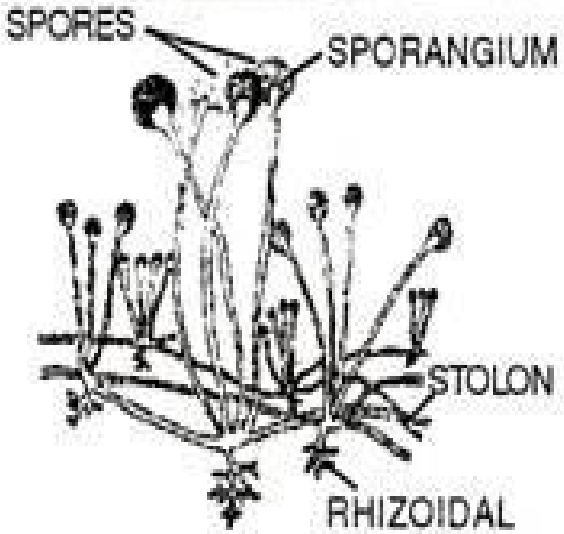
- The members are considered as lower fungi (over 1700 species), found in aquatic and semi-aquatic forms.

They include both unicellular and mycelial forms. Mycelium is aseptate and coenocytic. Sporangia produce asexual spores i.e. zoospores (ciliated) and aplanospores (non-ciliated).

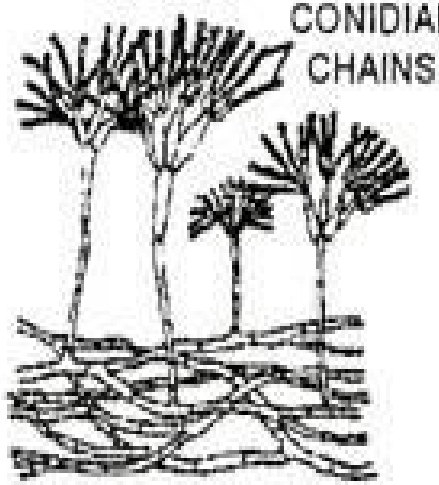
- In sexual reproduction, zygospores form by fusion of similar (isogamy) or dissimilar (anisogamy or oogamy) gametes. Examples: Mucor, Rhizopus, (bread mould), Albugo (cause white rust of crucifers) etc.



Physarum
(slime mold)



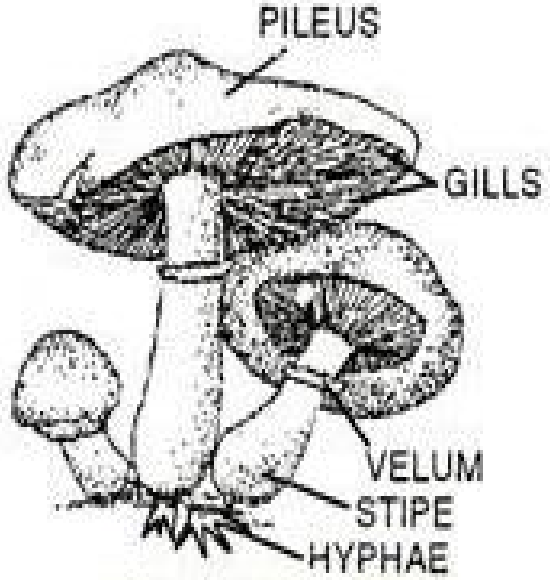
Rhizopus
(black mold)



Penicillium
(green mold)

Polyporus
(bracket fungi)

Peziza
(cyp fungi)



Agaricus
(Mushroom)

Figure 6.7 Different types of fungi.

Ascomycetes (Sac fungi):

*These include over 30,000 species unicellular and multi-cellular fungi.

*Asexual spores develop exogenously in form of chains called conidia.

*Sexual spores are endogenous ascospores that develop in a sac like ascus.

*The fruiting body containing asci is called ascocarp. Examples: yeasts, Penicillium, Aspergillus, Clavicep (ergot fungi), Neurospora, Peziza.

Basidiomycetes (Club fungi):

*These include over 25,000 species of mushrooms, puffballs, rusts, smuts, toad stools etc.

*The club-shaped end of reproductive hypha is called basidium which alter meiosis develops four exogenous asexual spores called basidiospores.

*The basidia arranged in a fruiting body are called basidiocarp. Examples: Agaricus (edible mushrooms), Puccinia (Rust fungi), Ustilago (Smut fungi), Polyporus (Bracket fungi), Candida etc.

Deuteromycetes (imperfect fungi):

*It includes about 17,000 species of fungi where sexual or perfect stage absent and only asexual or vegetative stages are known.

*Some asexual structures are synnema, pyenidia, accrvulii, sporodochium etc.

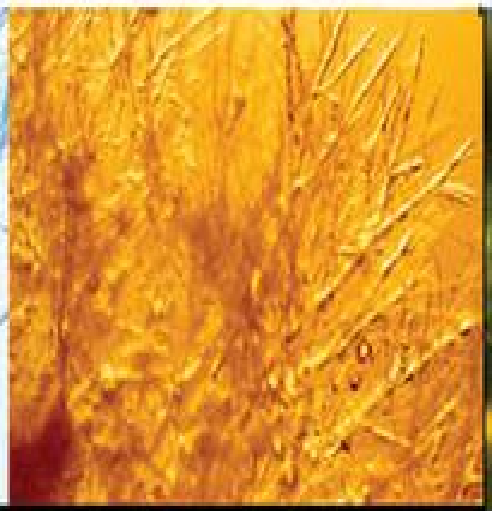
•Most of them are decomposers while some are saprophytes or parasites.

•*They reproduce only asexually by means of conidia which are very similar to conidia of ascomycetes.

Examples: Alternaria, Helminthosporium, Collectotrichum, Trichodenna etc.

Phycomycetes (Lower Fungi)	Ascomycetes (Sac Fungi)	Basidiomycetes (Club Fungi)	Deuteromycetes (Fungi imperfecti)
• Saprolegnia	• Yeast	• Agaricus	• Cercospora
• Rhizopus	• Aspergillus	• Polyporus	• Collectotrichum
• Mucor	• Pencillium	• Puccinia	• Trichoderma
• Albugo	• Neurospora	• Ustilago	• Pyricularia
• Pythium	• Peziza	• Lycoperdon	• Fusarium

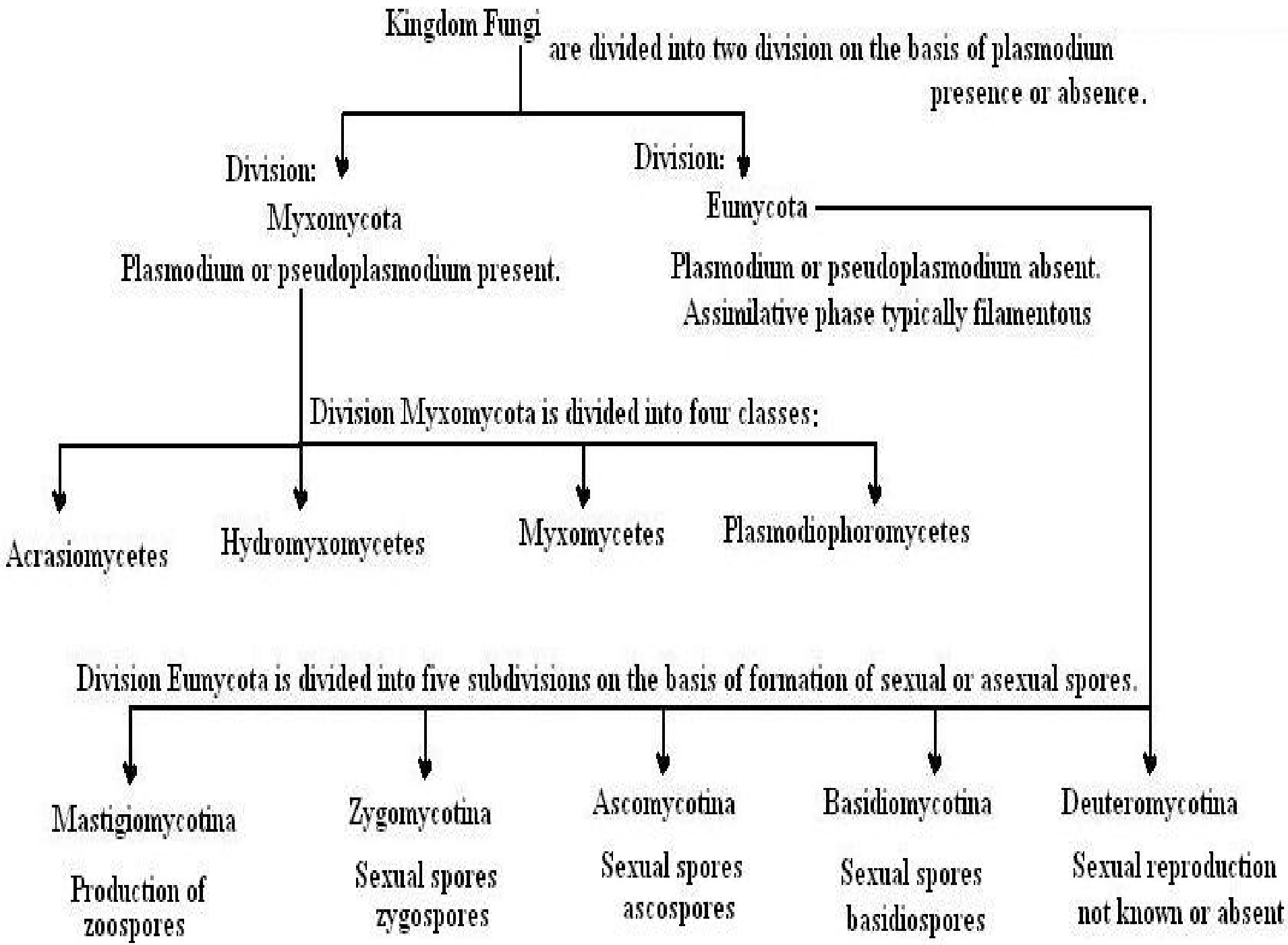
Rhizopus



Neurospora

Agaricus

Fusarium


Kingdom Fungi
are divided into two division on the basis of plasmodium presence or absence.
Division:
Myxomycota
Plasmodium or pseudoplasmodium present.
Division:
Eumycota
Plasmodium or pseudoplasmodium absent.
Assimilative phase typically filamentous
Division Myxomycota is divided into four classes:
Acrasiomycetes
Hydromyxomycetes
Myxomycetes
Plasmodiophoromycetes
Division Eumycota is divided into five subdivisions on the basis of formation of sexual or asexual spores.
Mastigiomycotina
Production of zoospores
Zygomycotina
Sexual spores zygospores
Ascomycotina
Sexual spores ascospores
Basidiomycotina
Sexual spores basidiospores
Deuteromycotina
Sexual reproduction not known or absent

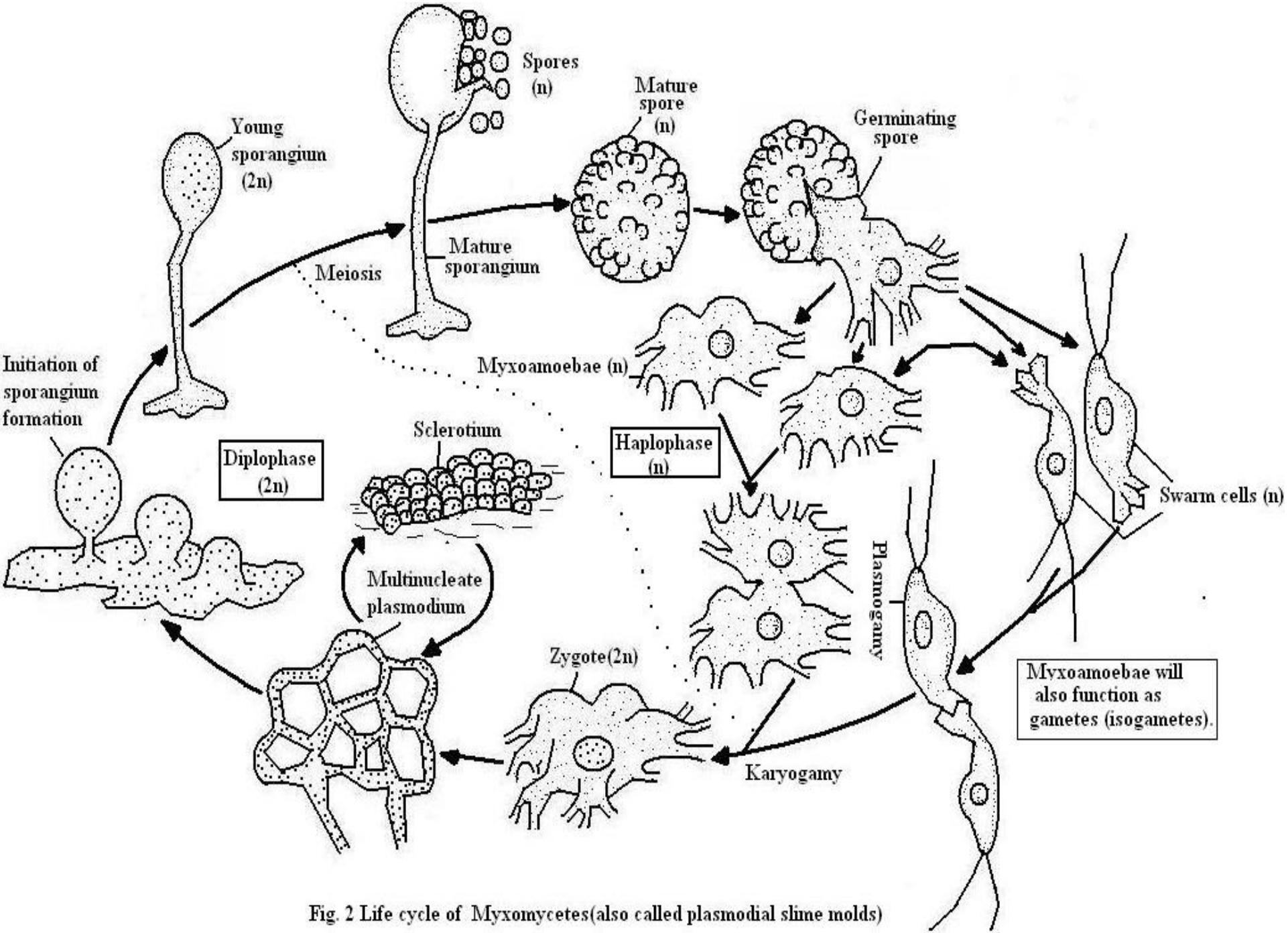
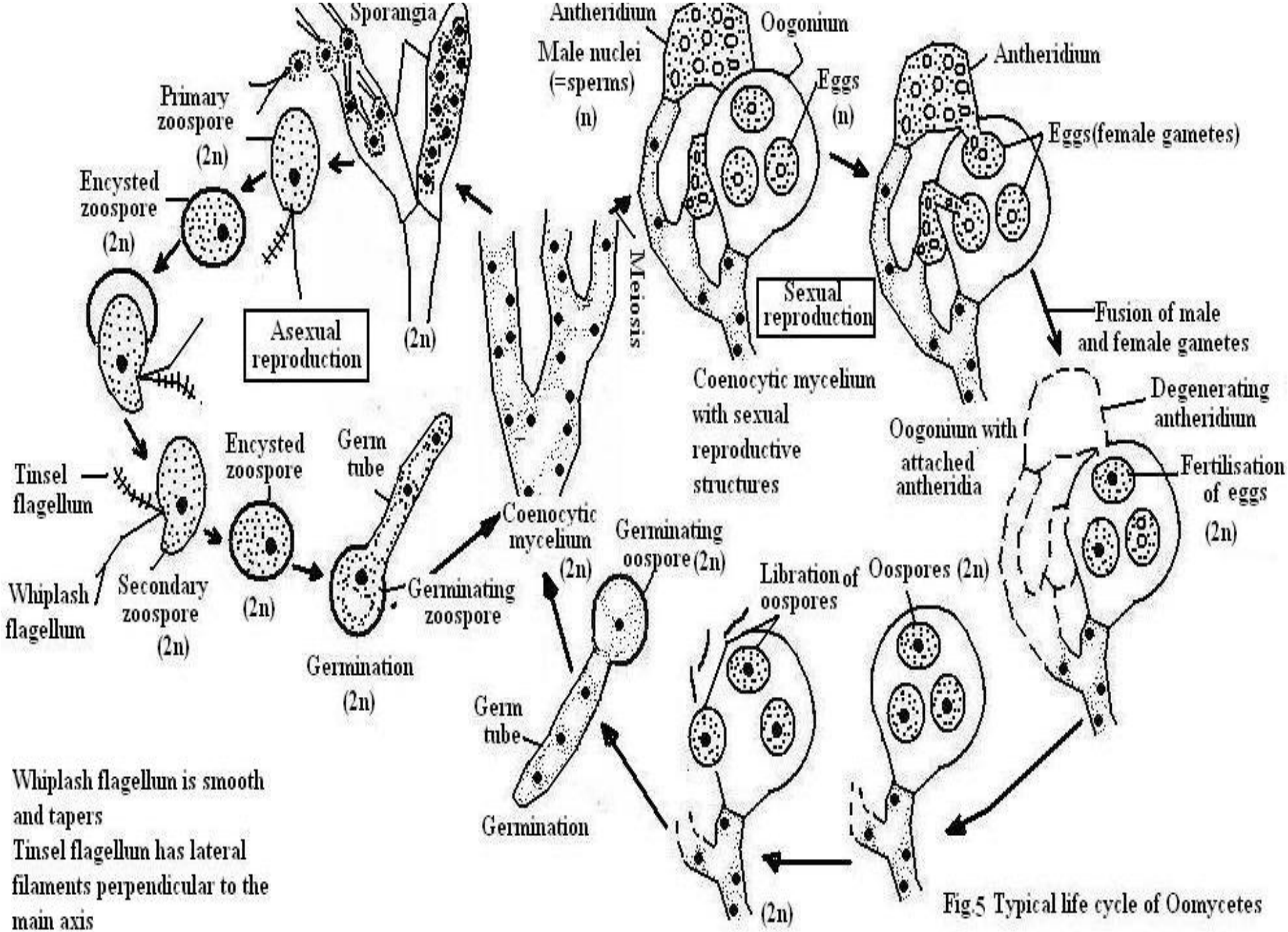
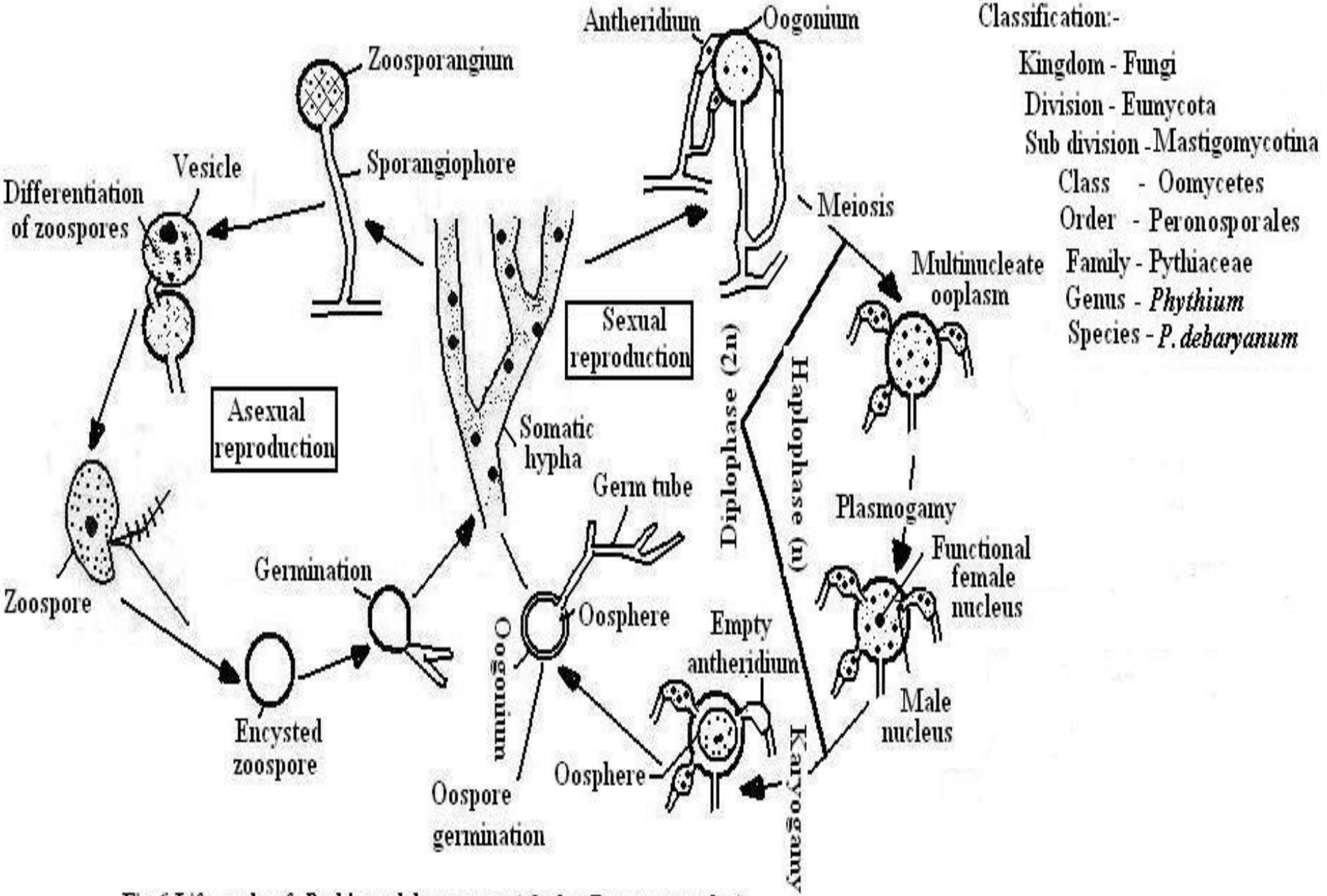


Fig. 2 Life cycle of Myxomycetes(also called plasmodial slime molds)



Whiplash flagellum is smooth and tapers
Tinsel flagellum has lateral filaments perpendicular to the main axis

Fig.5 Typical life cycle of Oomycetes



Classification:-

Kingdom - Fungi
Division - Eumycota
Sub division - Mastigomycotina
Class - Oomycetes
Order - Peronosporales
Family - Pythiaceae
Genus - *Phythium*
Species - *P. debaryanum*

Fig.6 Life cycle of *Pythium debaryanum* (Order-Peronosporales)

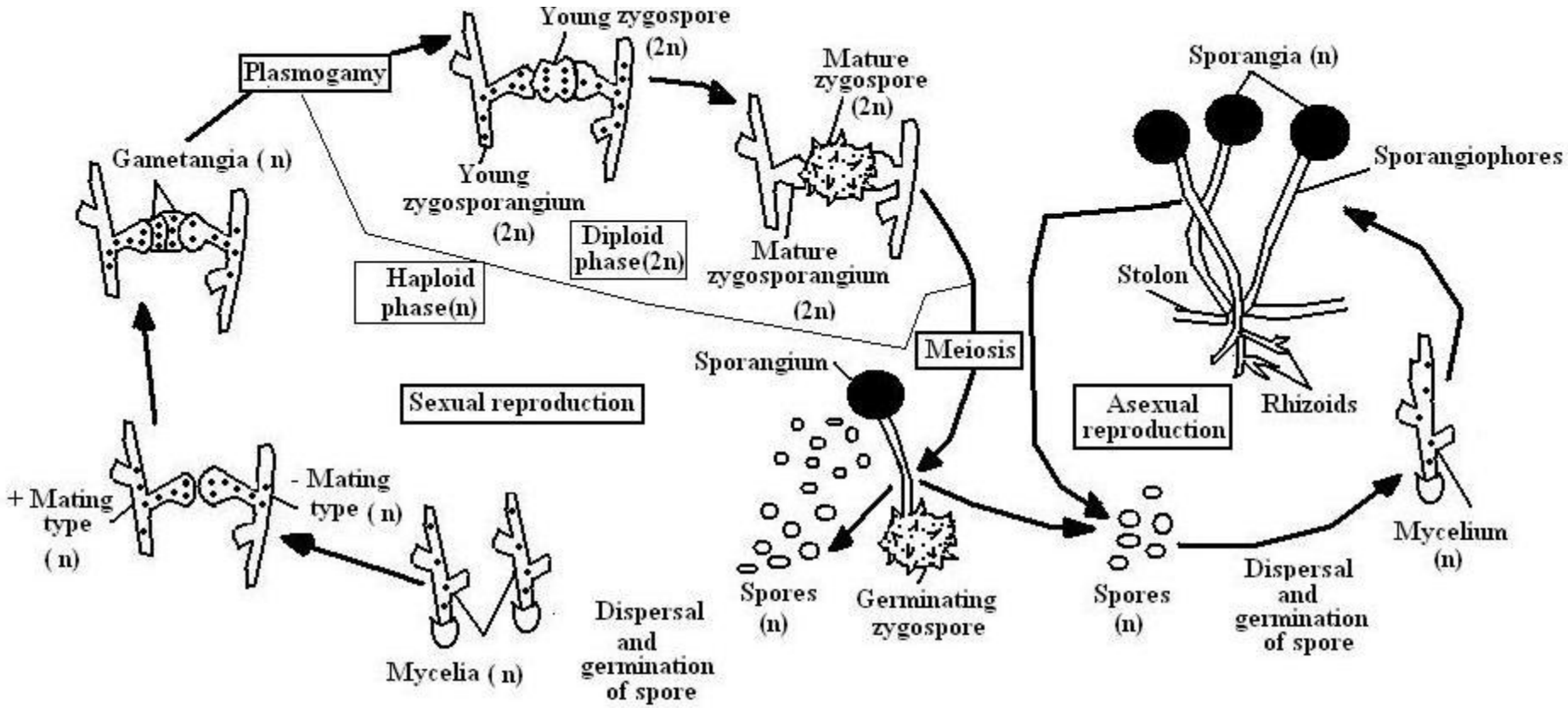


Fig.7 Life Cycle of Rhizopus stolonifera.

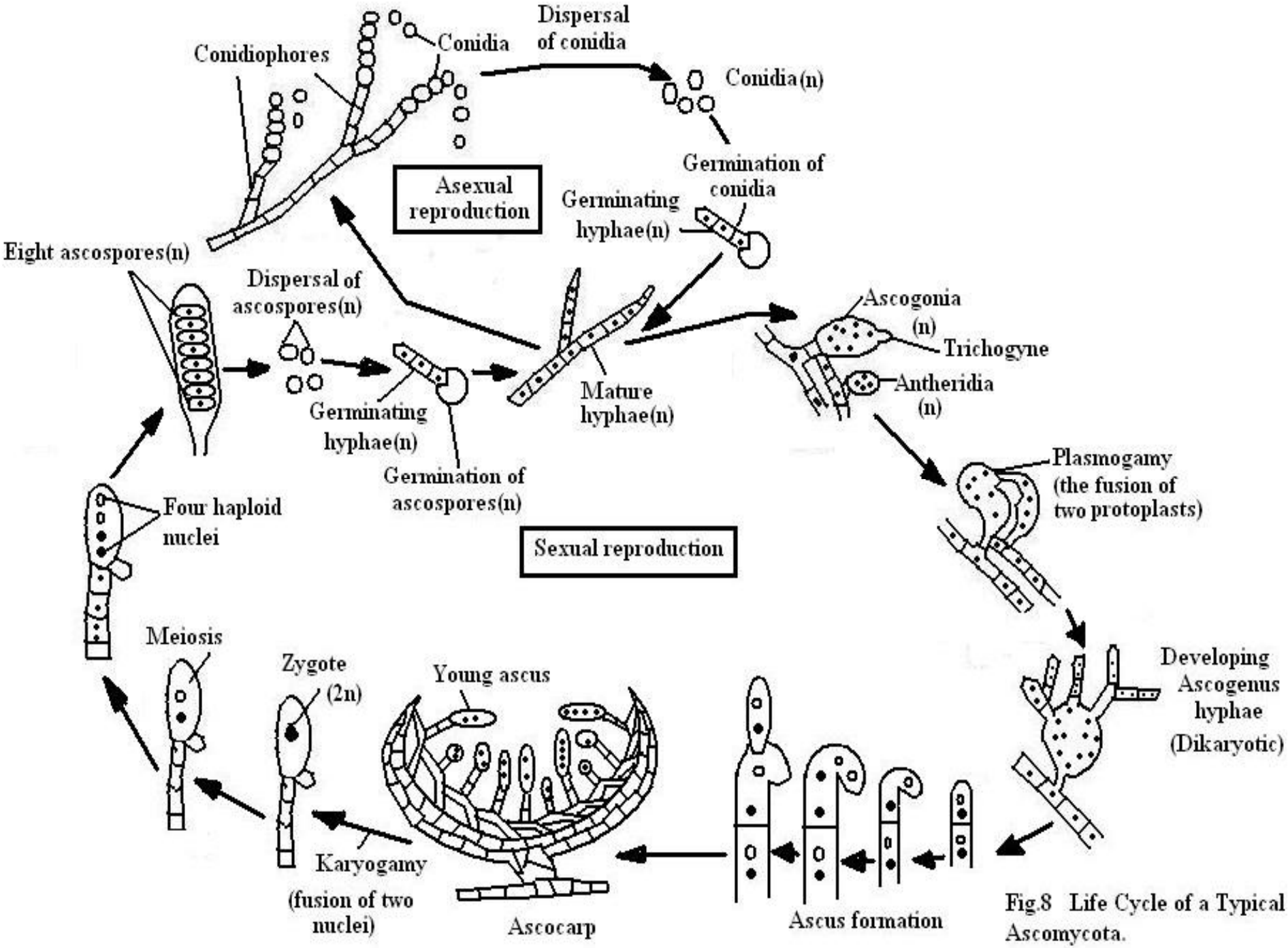
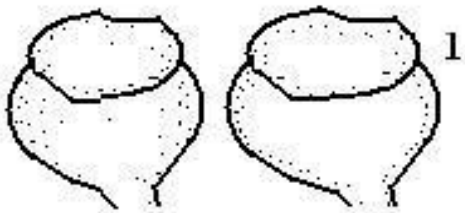
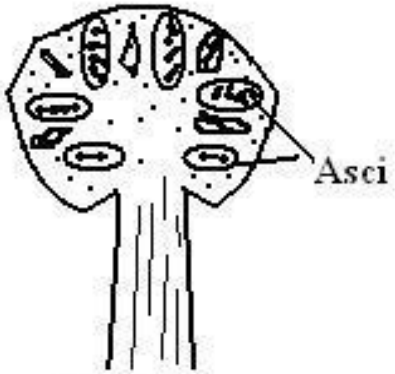


Fig.8 Life Cycle of a Typical Ascomycota.



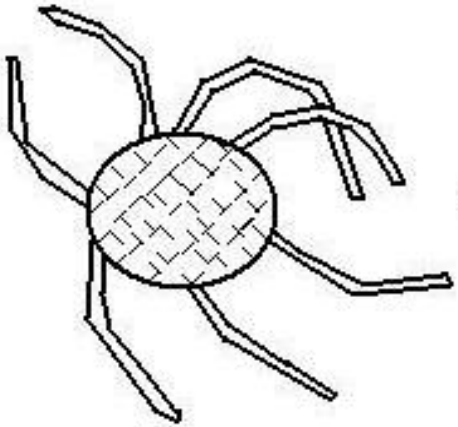
Apothecium

1. Apothecium - An ascocarp is a wide open and more or less cup-shaped structure, varying from quite flat to distinctly cup-like.Having an exposed hymeniun (layer of asci) e.g. Peziza



Perithecium

2. Perithecium - This is almost closed and flask shaped with a small ostiole or opening at the tip for release of the ascospores . e.g. Claviceps.

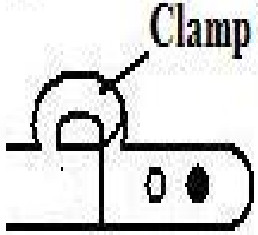


Cleistothecium

3. Cleistothecium - Closed and spherical in shape, with scattered asci, i.e. not in an hymenium and without sterile filaments, e.g paraphyses.
No special opening for the release of the ascospores. e.g. Microsphaera or Sphaerotheca.

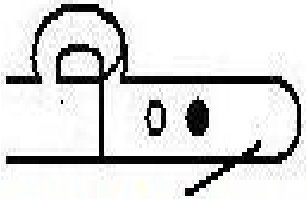
4. Pseudothecium (ascostroma) - Asci are produced in cavities without a distinct wall within a stroma of mycelium within host tissues.

Fig.9 Formation of Clamp Connections:—

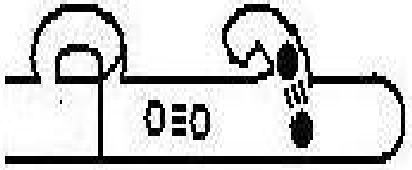


A. Terminal cell of hypha.

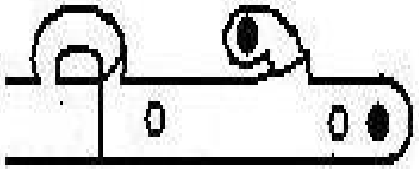
Growth only takes place at hyphal tips;



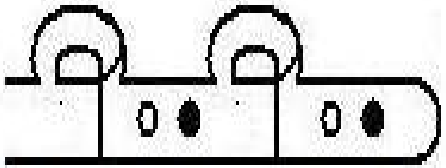
B. Hyphal tip elongating.



C. Synchronous division of nuclei and the beginning of hyphal branch that will become the clamp connection. One nucleus migrates into the new clamp.



D. Septum forms at base of the clamp trapping nucleus . Two nuclei of different strains migrate to the hyphal tip, while other nucleus migrates away from the tip.



E. Septum forms below clamp forming new cell at hyphal tip. Fusion of the clamp to the adjacent cell releases nucleus of different strain to the adjacent cell. Now both the terminal and subterminal are binucleate, each with a compatible pair of nuclei.

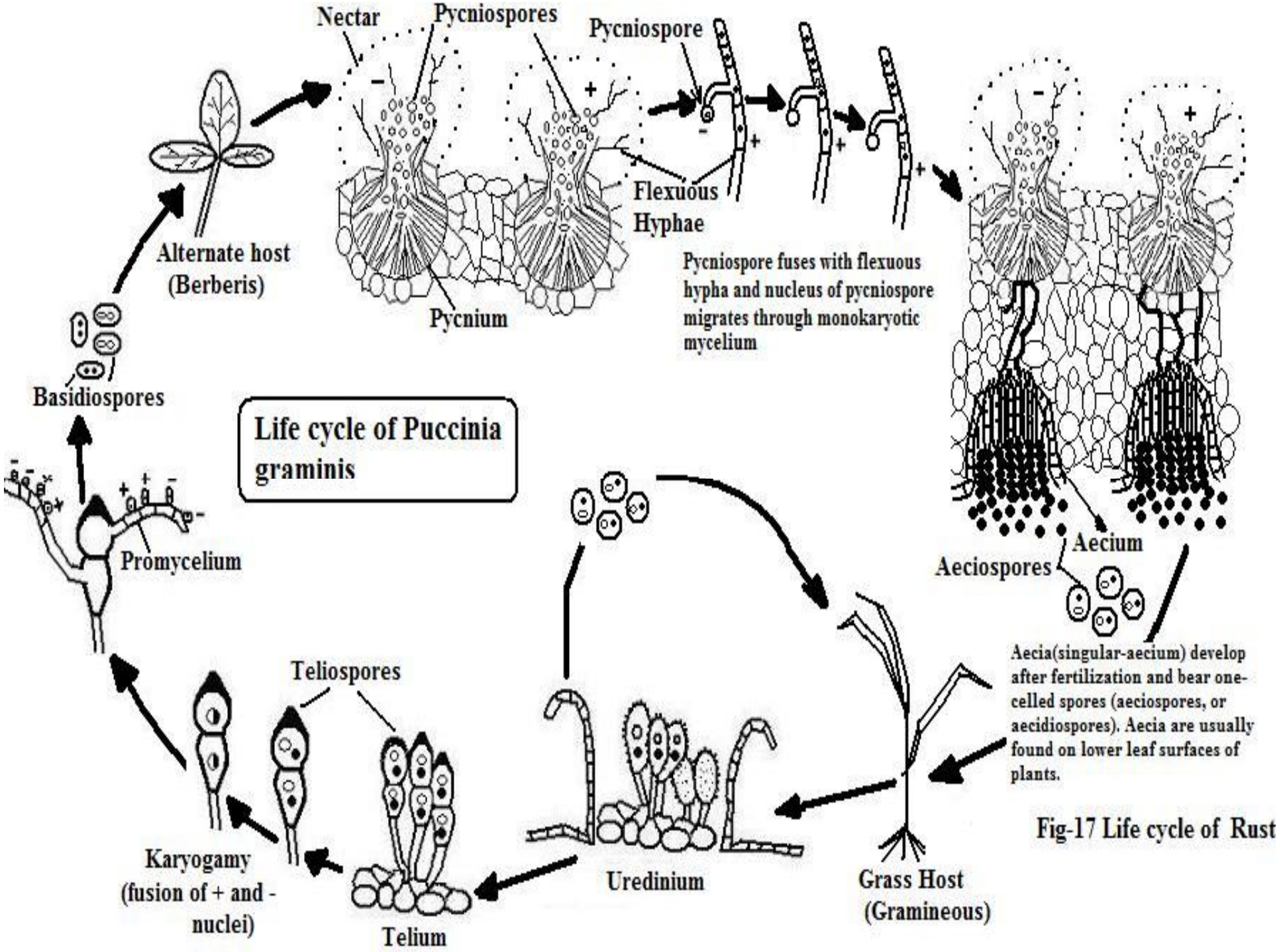
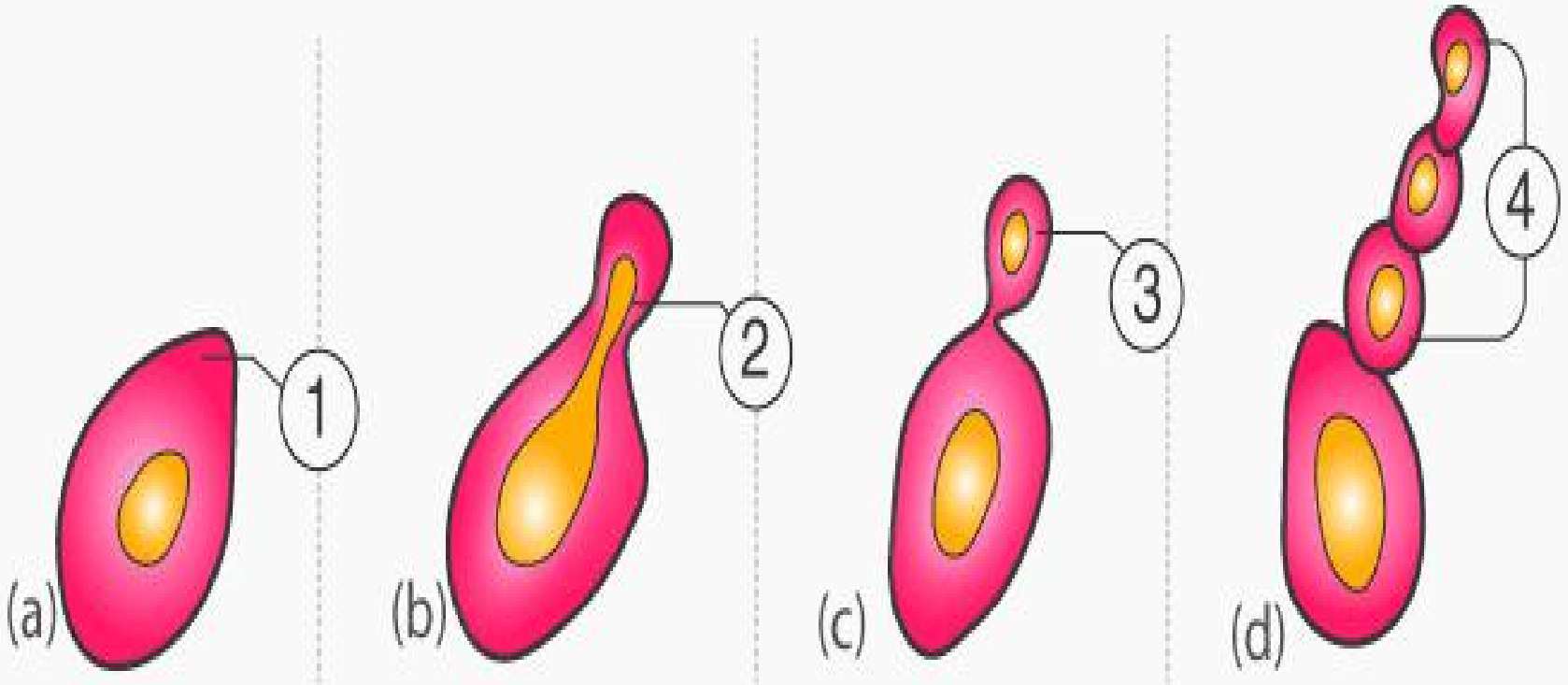


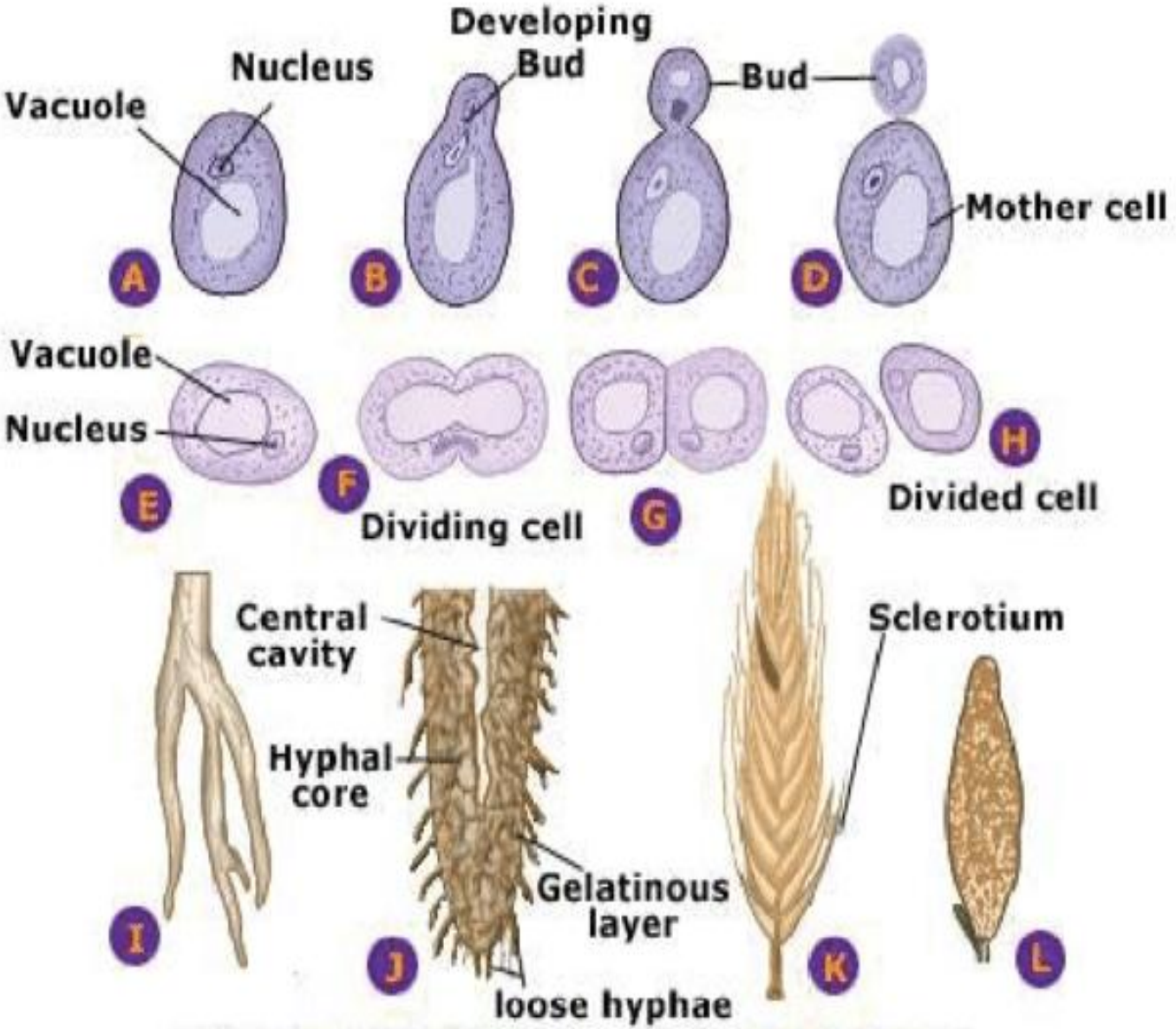
Fig-17 Life cycle of Rust

REPRODUCTION IN FUNGI : YEAST

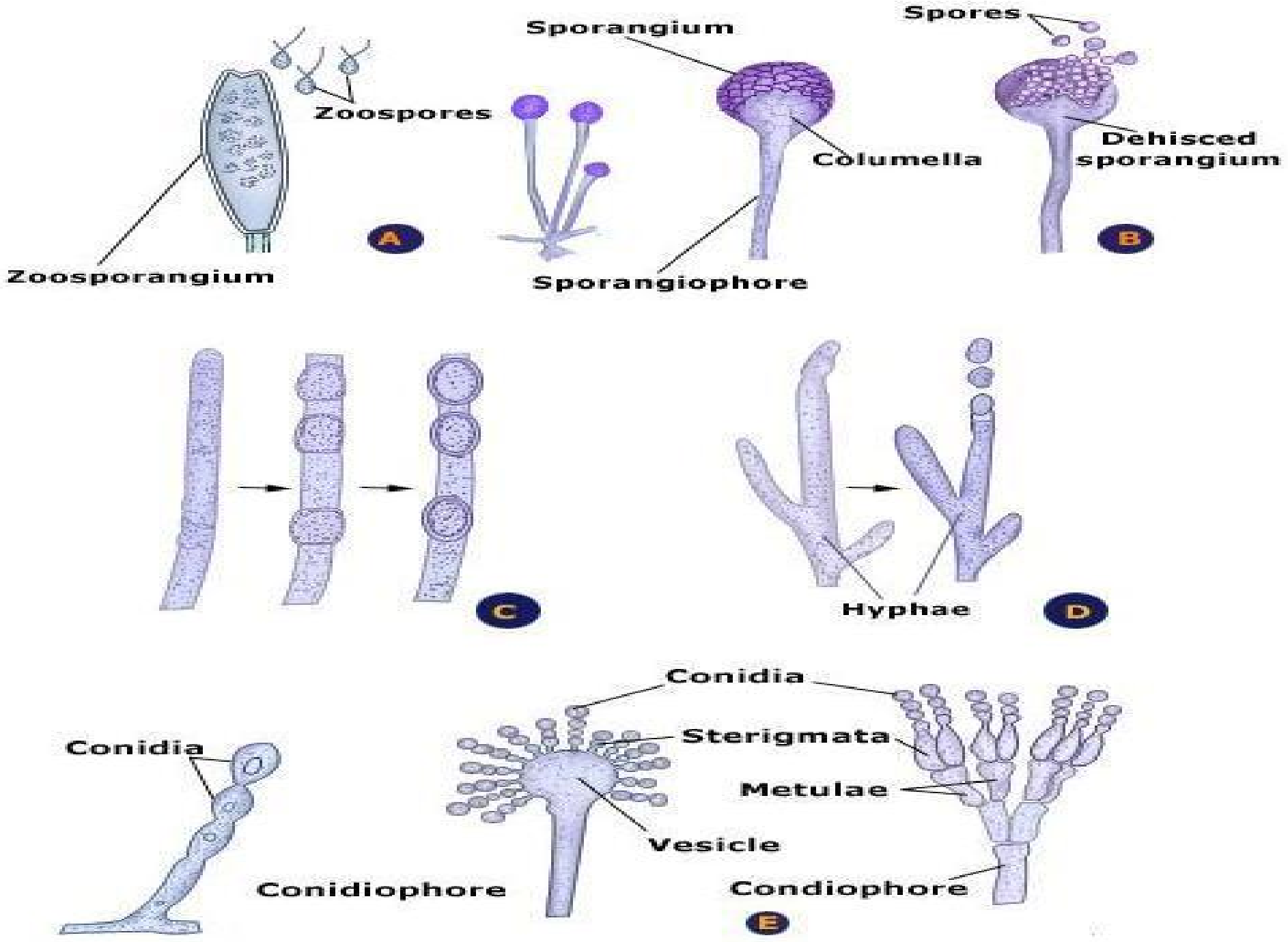
BYJU'S The Learning App

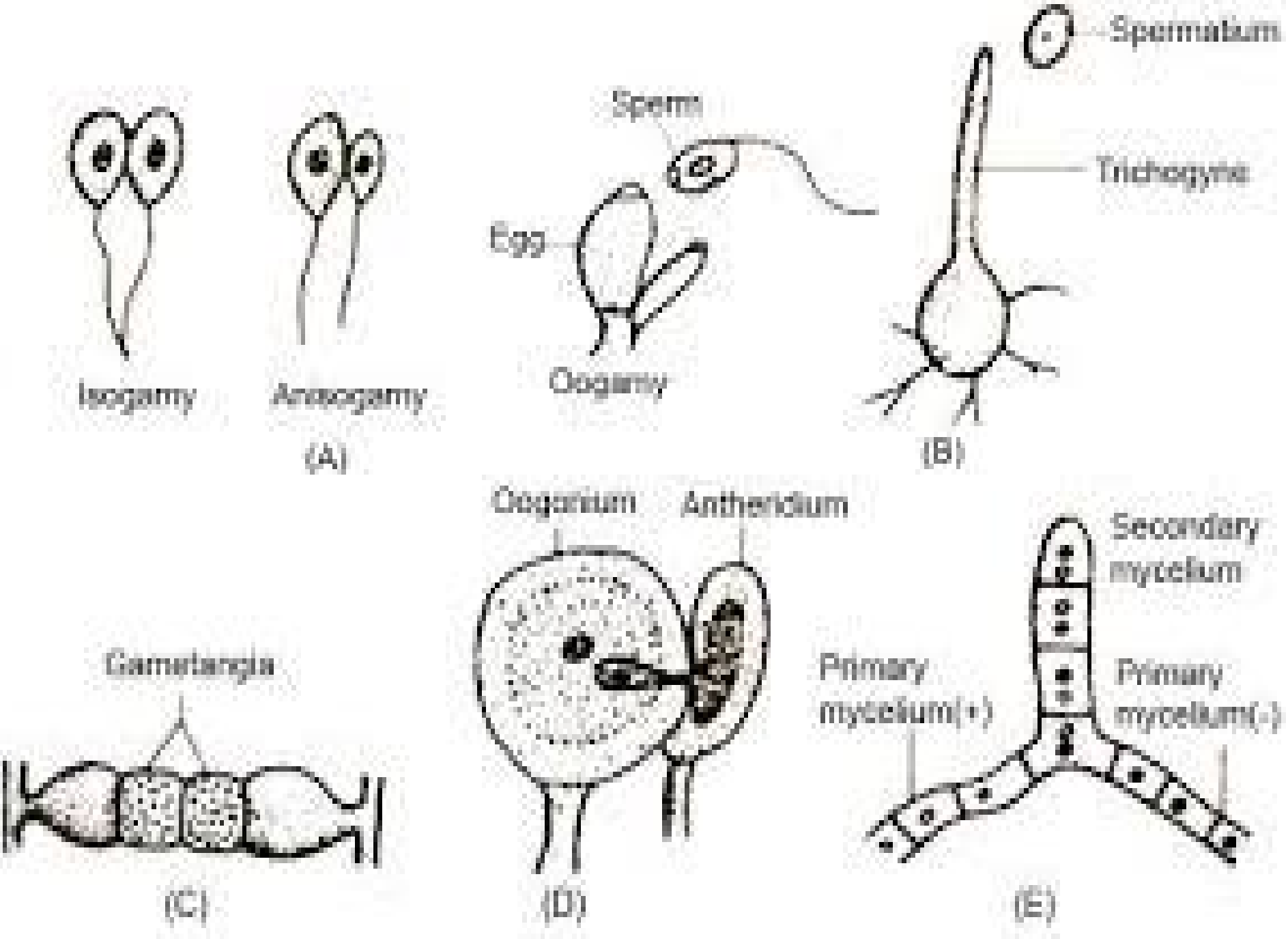


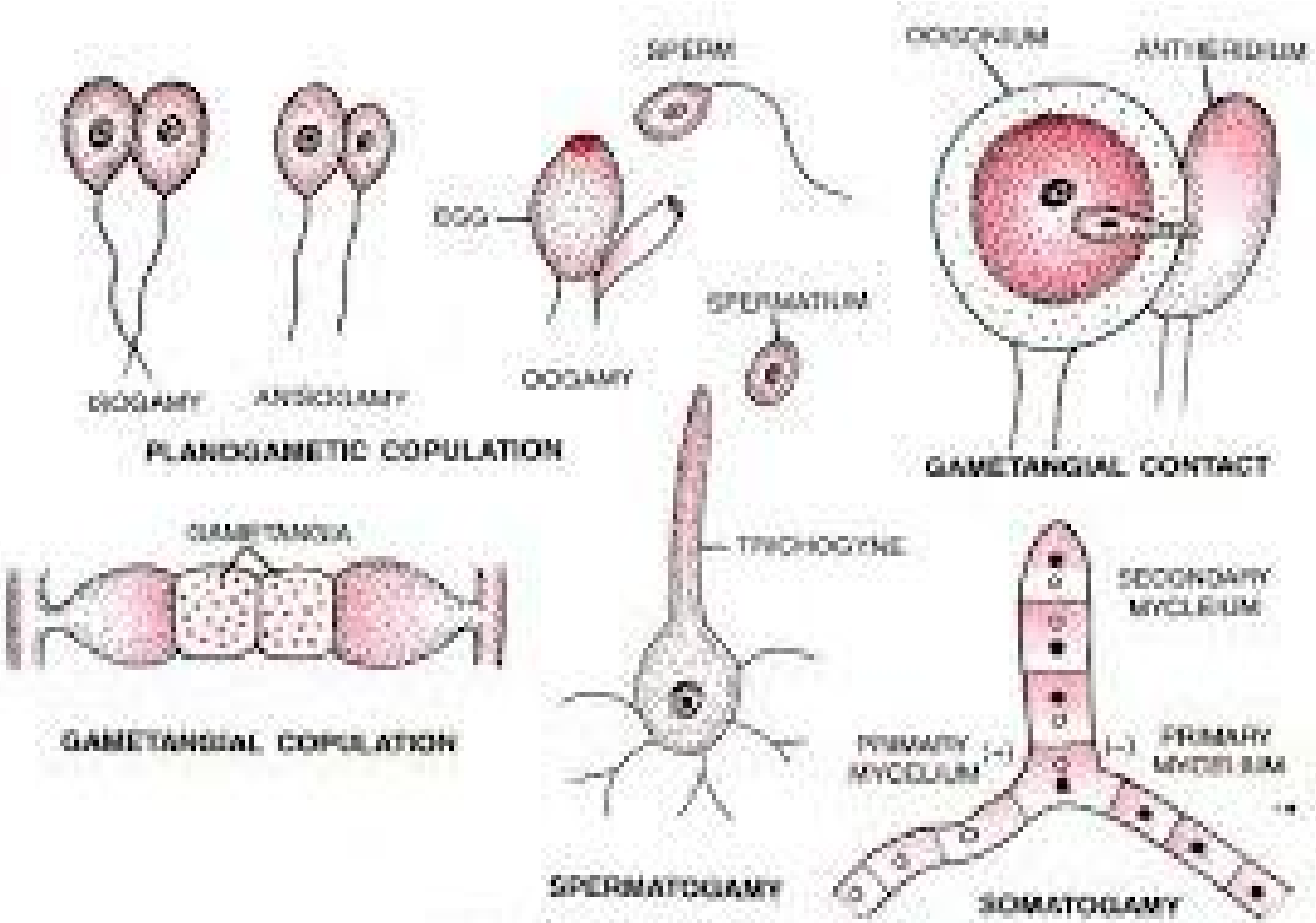
1 Yeast Cell | 2 Developing Bud | 3 New Bud | 4 Chain of buds



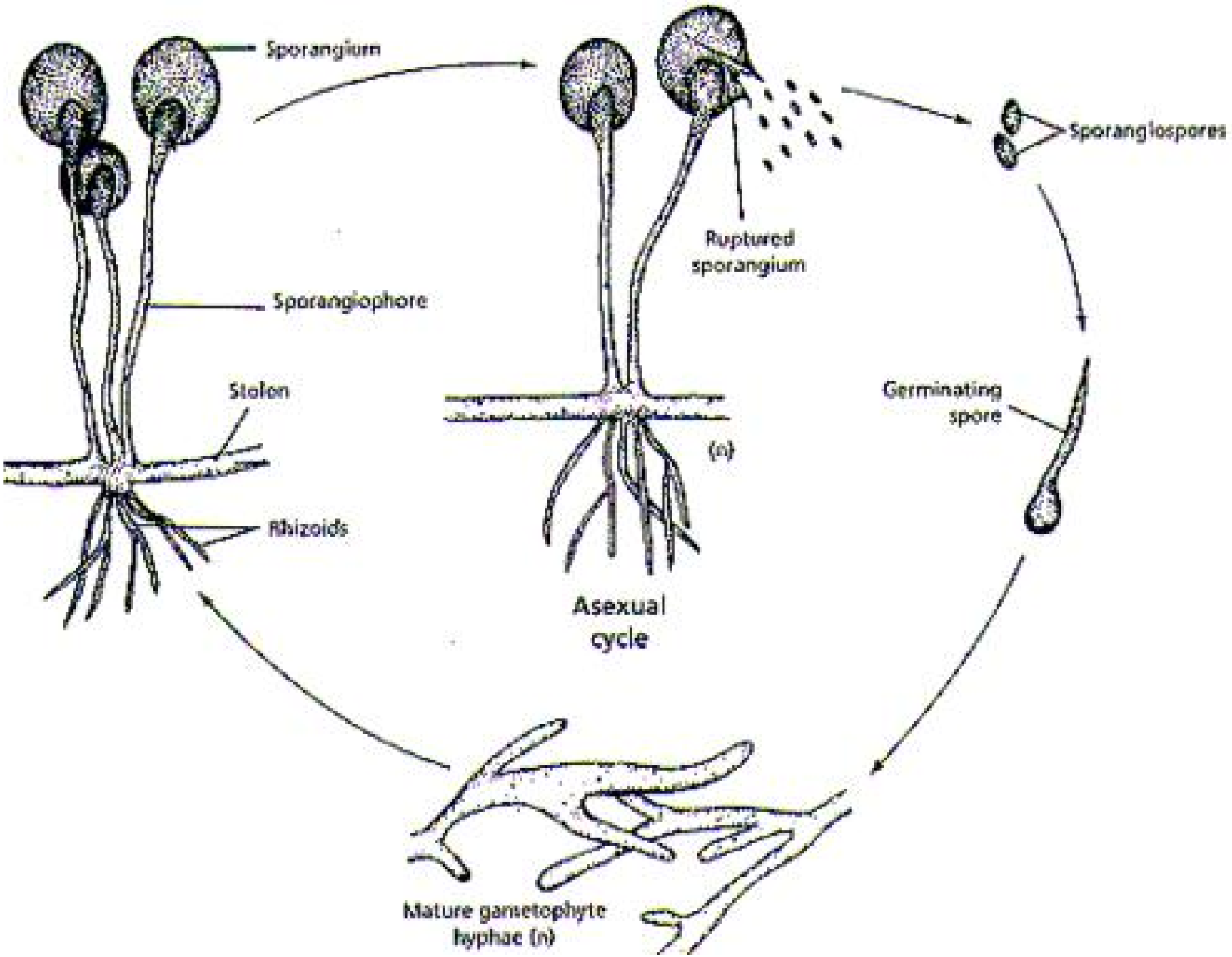
Modes of vegetative reproduction in fungi.
A-D. Budding. E-H. Fission. I-J. Rhizomorph; K-L. Sclerotia

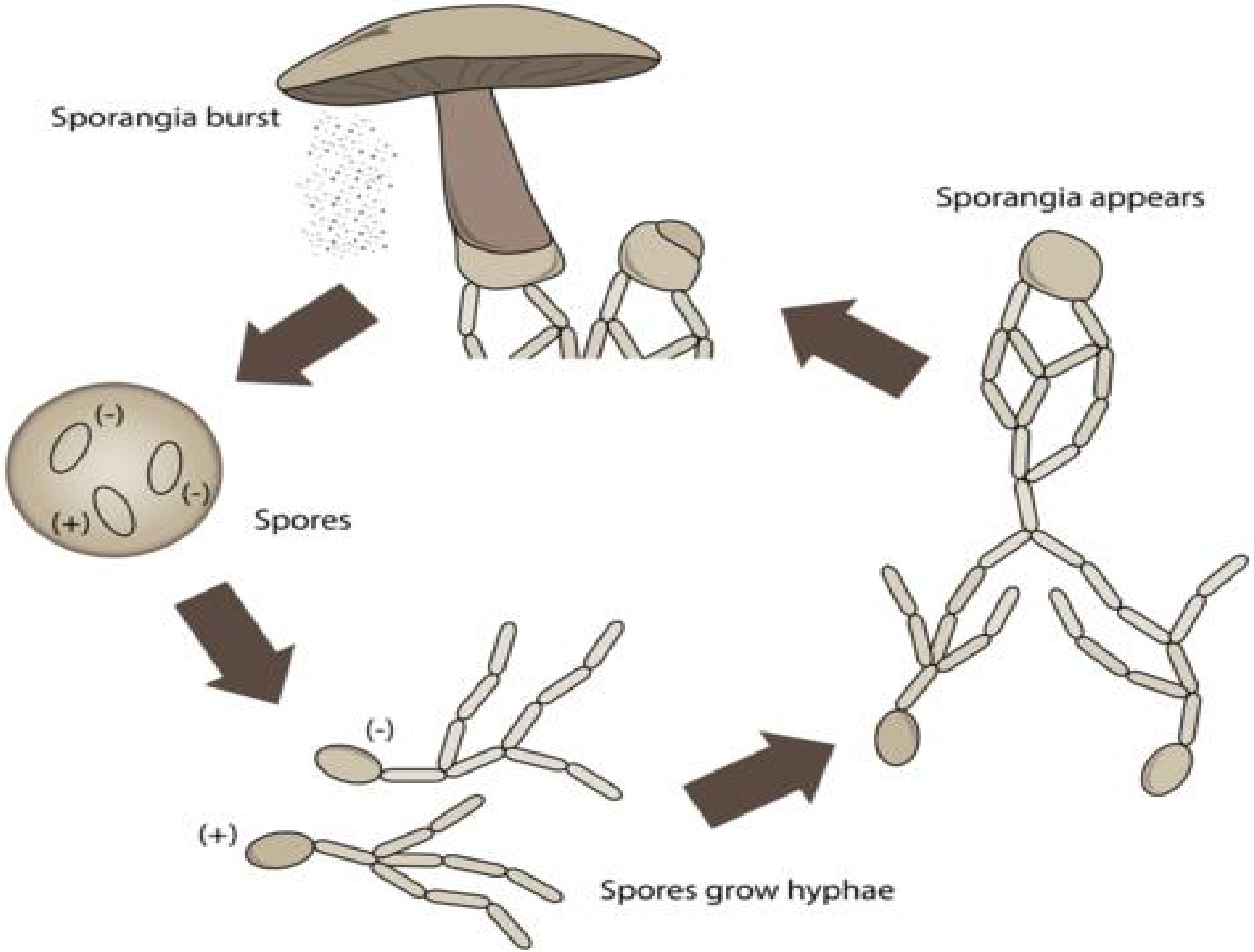

Zoosporangium
Zoospores
A
Sporangium
Columella
Sporangiophore
Spores
Dehisced sporangium
B
C
Hyphae
D
Conidia
Conidia
Sterigmata
Metulae
Vesicle
Conidiophore
Condiophore
E

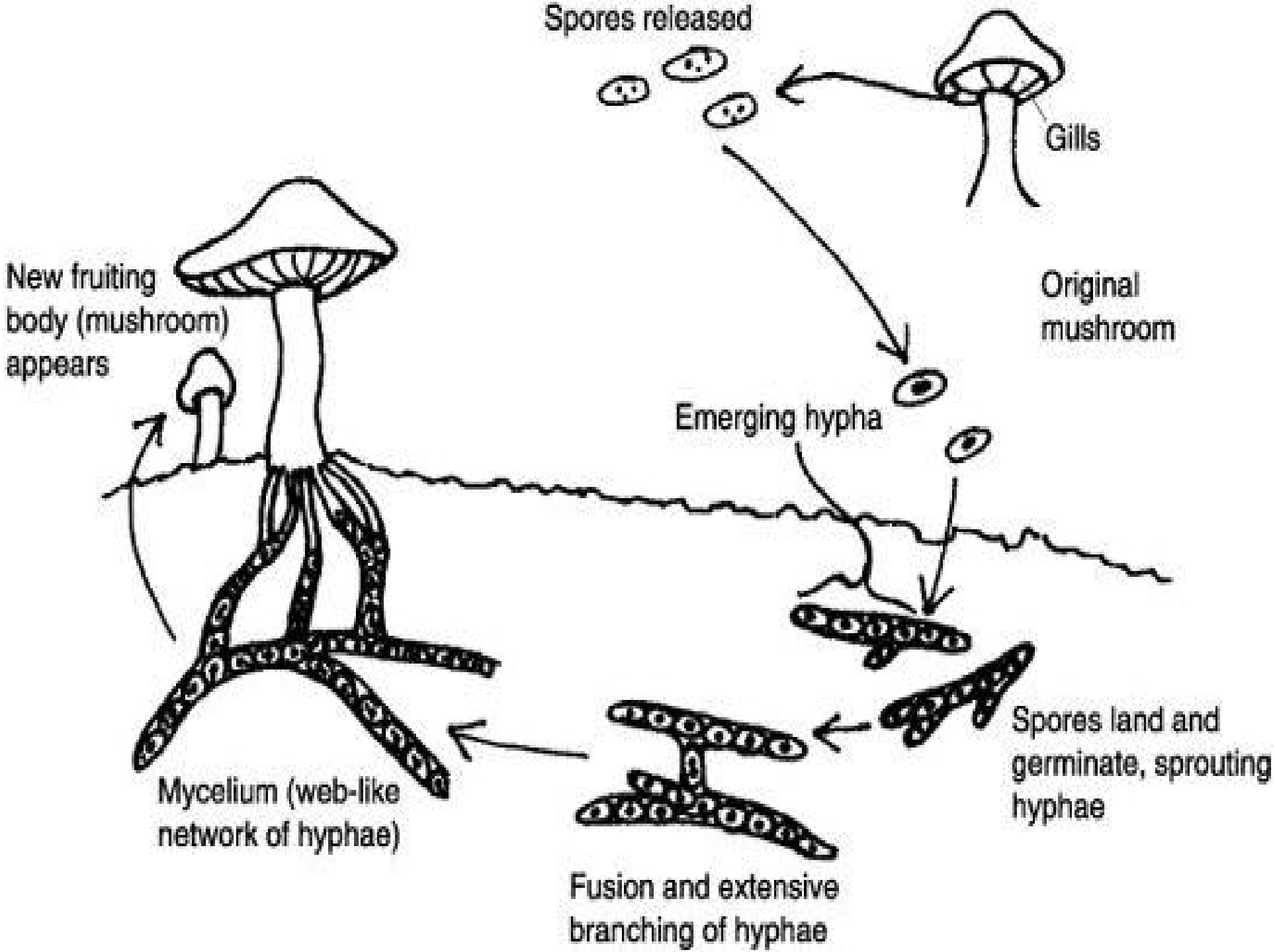

Isogamy
Anisogamy
(A)
Sperm
Egg
Oogamy
Spermatium
Trichogyne
(B)
Gametangia
(C)
Oogonium
Antheridium
(D)
Secondary mycelium
Primary mycelium(+)
Primary mycelium(-)
(E)

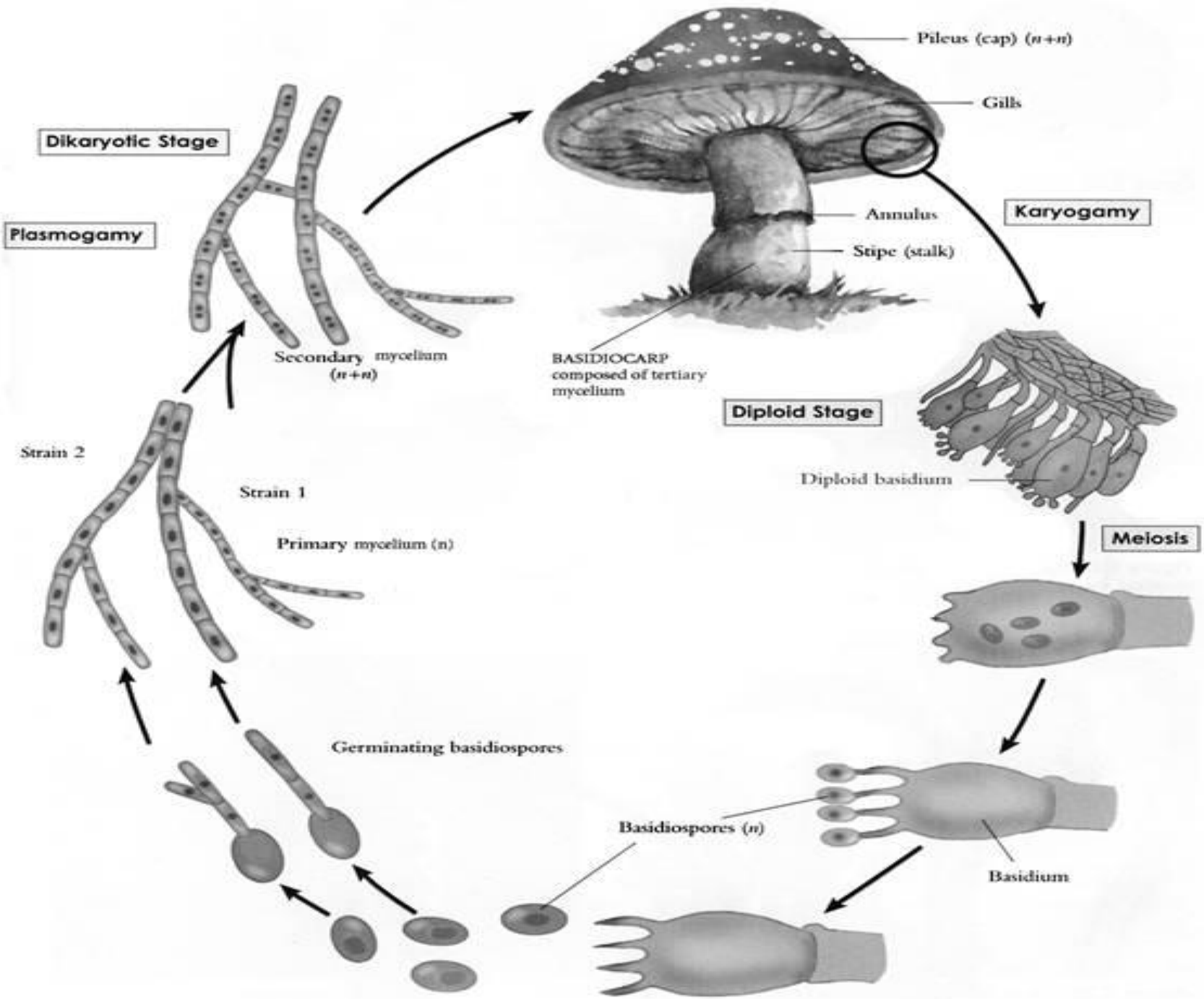


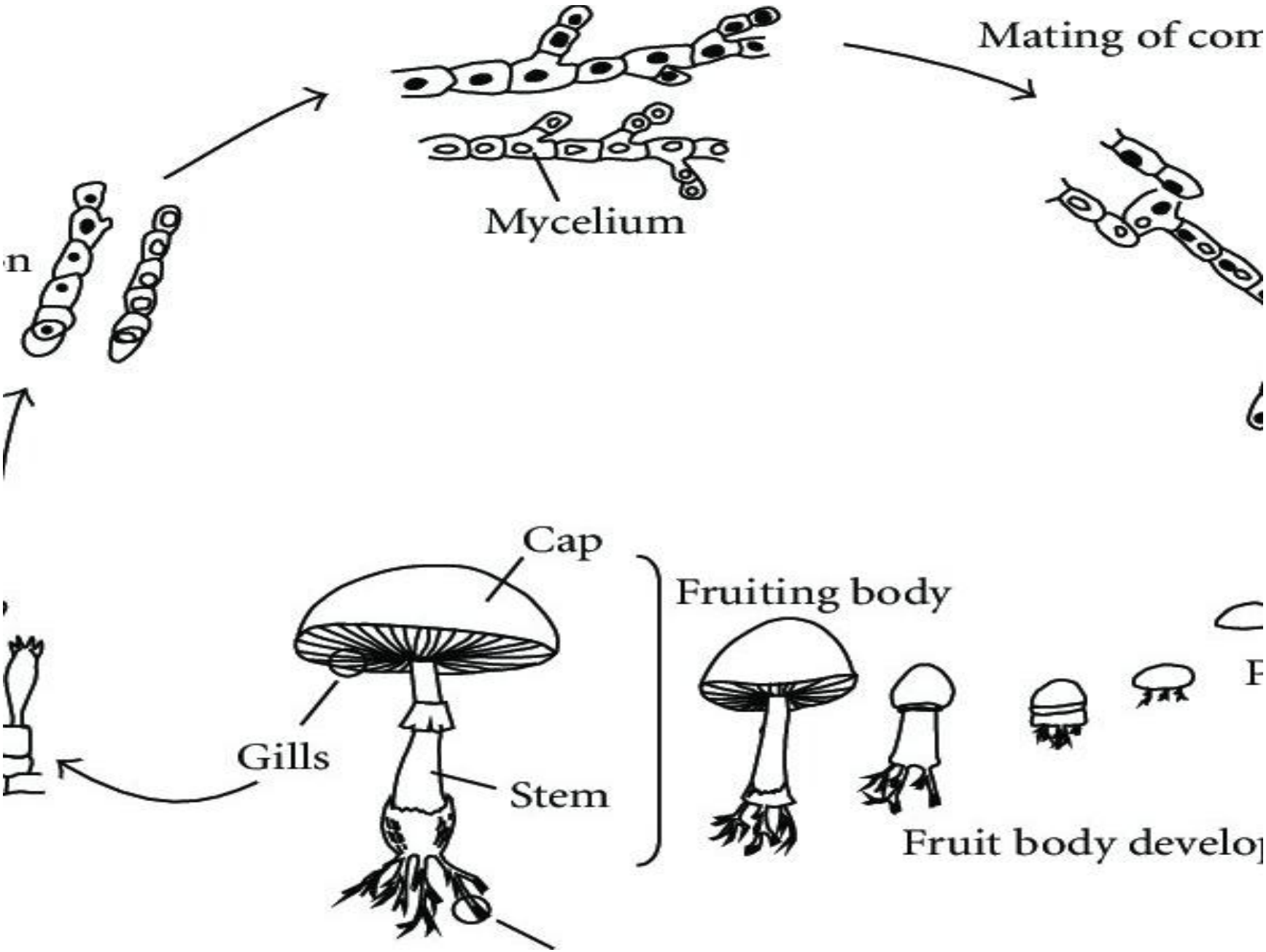
Types of sexual reproduction in fungi.

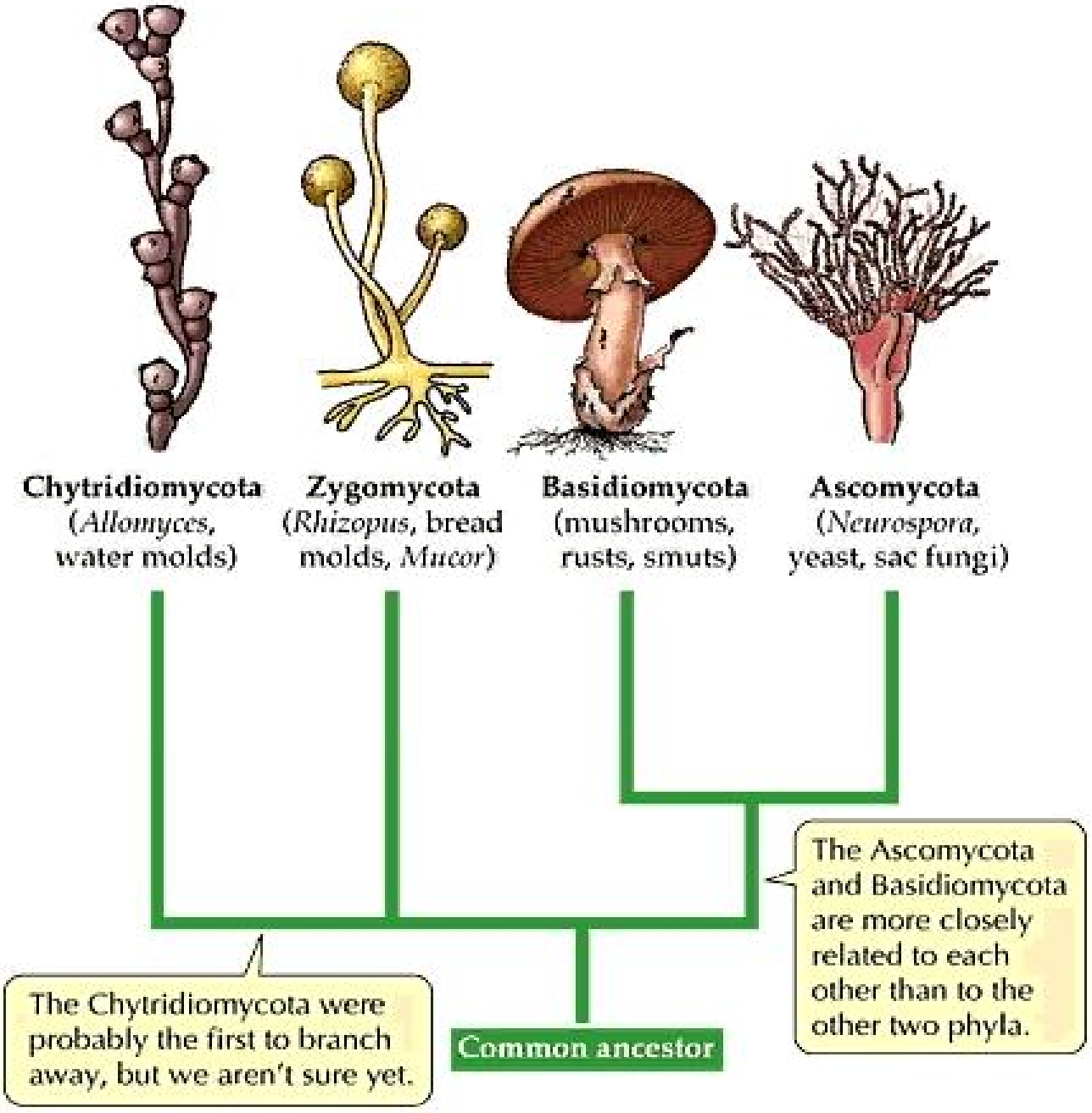

Sporangium
Sporangiophore
Stolon
Rhizoids
Ruptured sporangium
(n)
Asexual cycle
Sporangiospores
Germinating spore
Mature gametophyte hyphae (n)

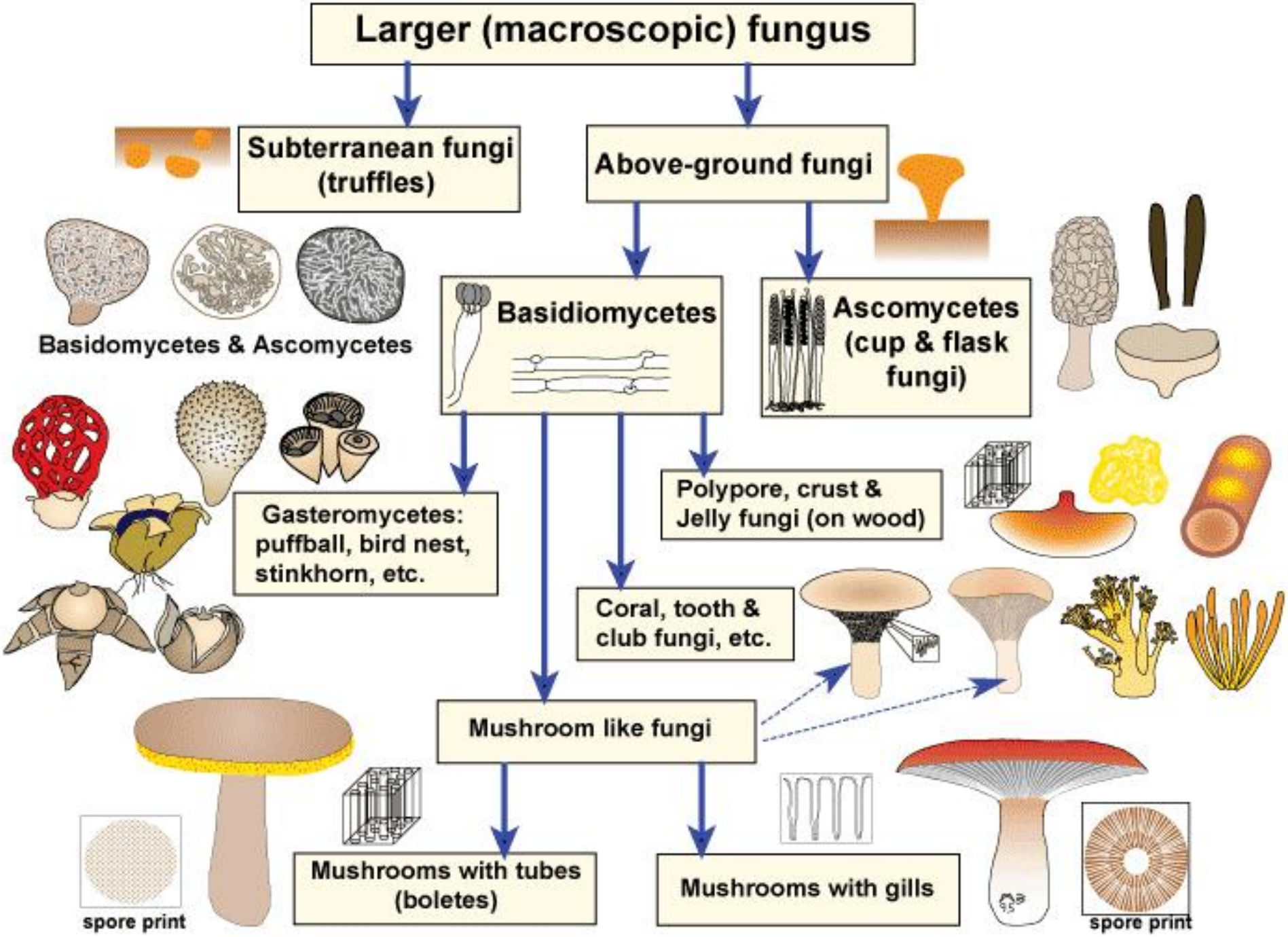

Sporangia burst
Sporangia appears
(-)
(+)
(-)
Spores
(-)
(+)
Spores grow hyphae


Spores released
Gills
New fruiting body (mushroom) appears
Original mushroom
Emerging hypha
Spores land and germinate, sprouting hyphae
Mycelium (web-like network of hyphae)
Fusion and extensive branching of hyphae


Pileus (cap) (n+n)
Gills
Annulus
Stipe (stalk)
Karyogamy
Dikaryotic Stage
Plasmogamy
Secondary mycelium (n+n)
BASIDIOCARP composed of tertiary mycelium
Diploid Stage
Diploid basidium
Meiosis
Strain 2
Strain 1
Primary mycelium (n)
Germinating basidiospores
Basidiospores (n)
Basidium


Mating of com
Mycelium
n
Cap
Fruiting body
Gills
Stem
Fruit body develo


Chytridiomycota (*Allomyces*, water molds)
Zygomycota (*Rhizopus*, bread molds, *Mucor*)
Basidiomycota (mushrooms, rusts, smuts)
Ascomycota (*Neurospora*, yeast, sac fungi)
The Chytridiomycota were probably the first to branch away, but we aren't sure yet.
Common ancestor
The Ascomycota and Basidiomycota are more closely related to each other than to the other two phyla.


Larger (macroscopic) fungus
Subterranean fungi (truffles)
Above-ground fungi
Basidomycetes & Ascomycetes
Basidiomycetes
Ascomycetes (cup & flask fungi)
Gasteromycetes: puffball, bird nest, stinkhorn, etc.
Polypore, crust & Jelly fungi (on wood)
Coral, tooth & club fungi, etc.
Mushroom like fungi
spore print
Mushrooms with tubes (boletes)
Mushrooms with gills
spore print

Zygomycota
Chytridiomycota
} 'Lower Fungi'

Ascomycota
Basidiomycota
} 'Higher Fungi'