General Sciences

Biodiversity

2nd Term

1st year Science - General Sciences I (Botany)

Prepared by: Dr. Azza Misk

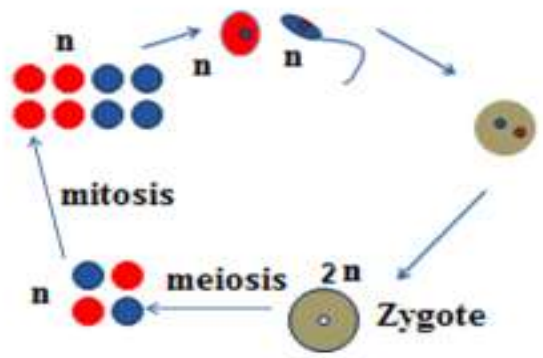
Part 1: Biodiversity II

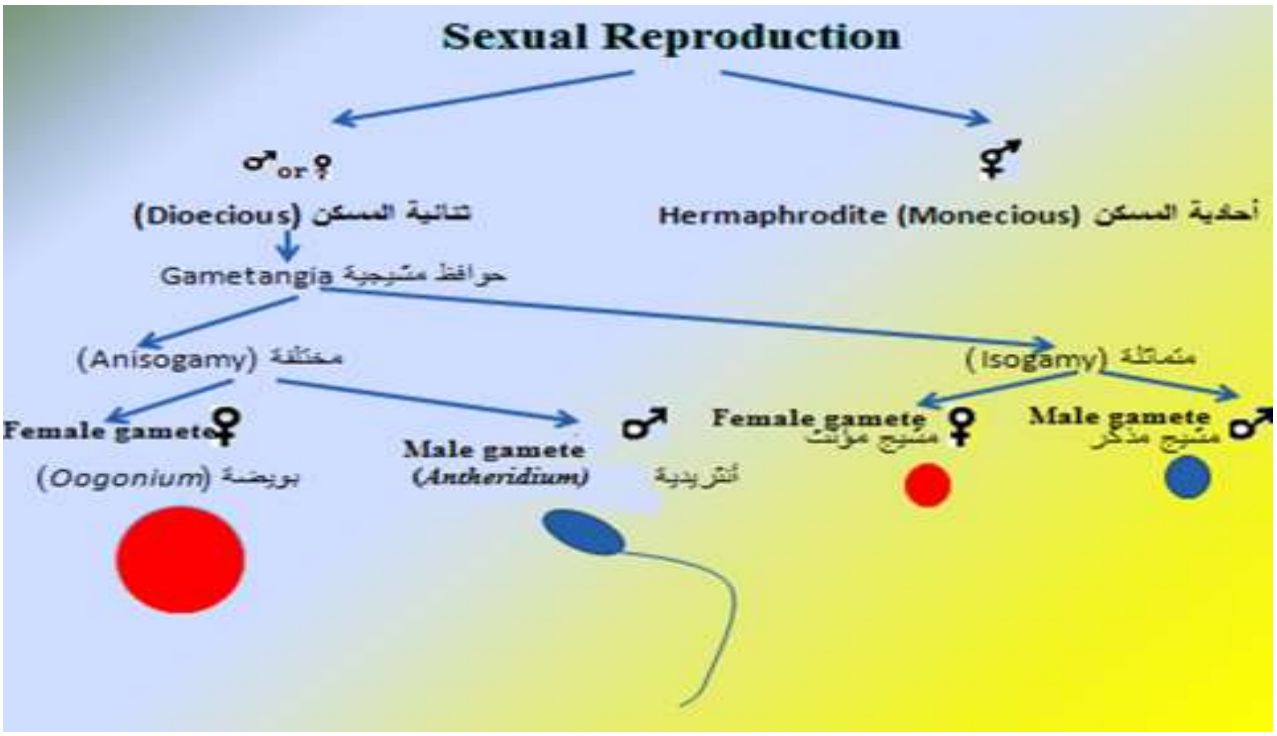
Kingdom: *Fungi*

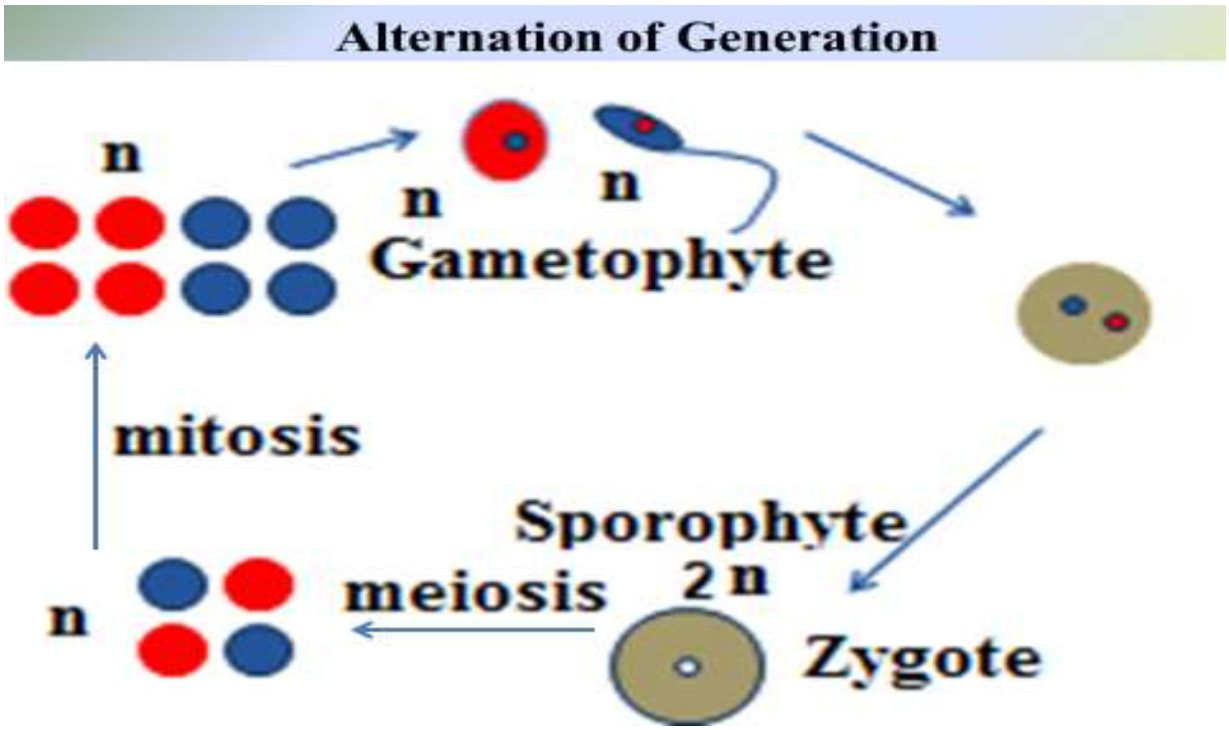
General Characteristics:

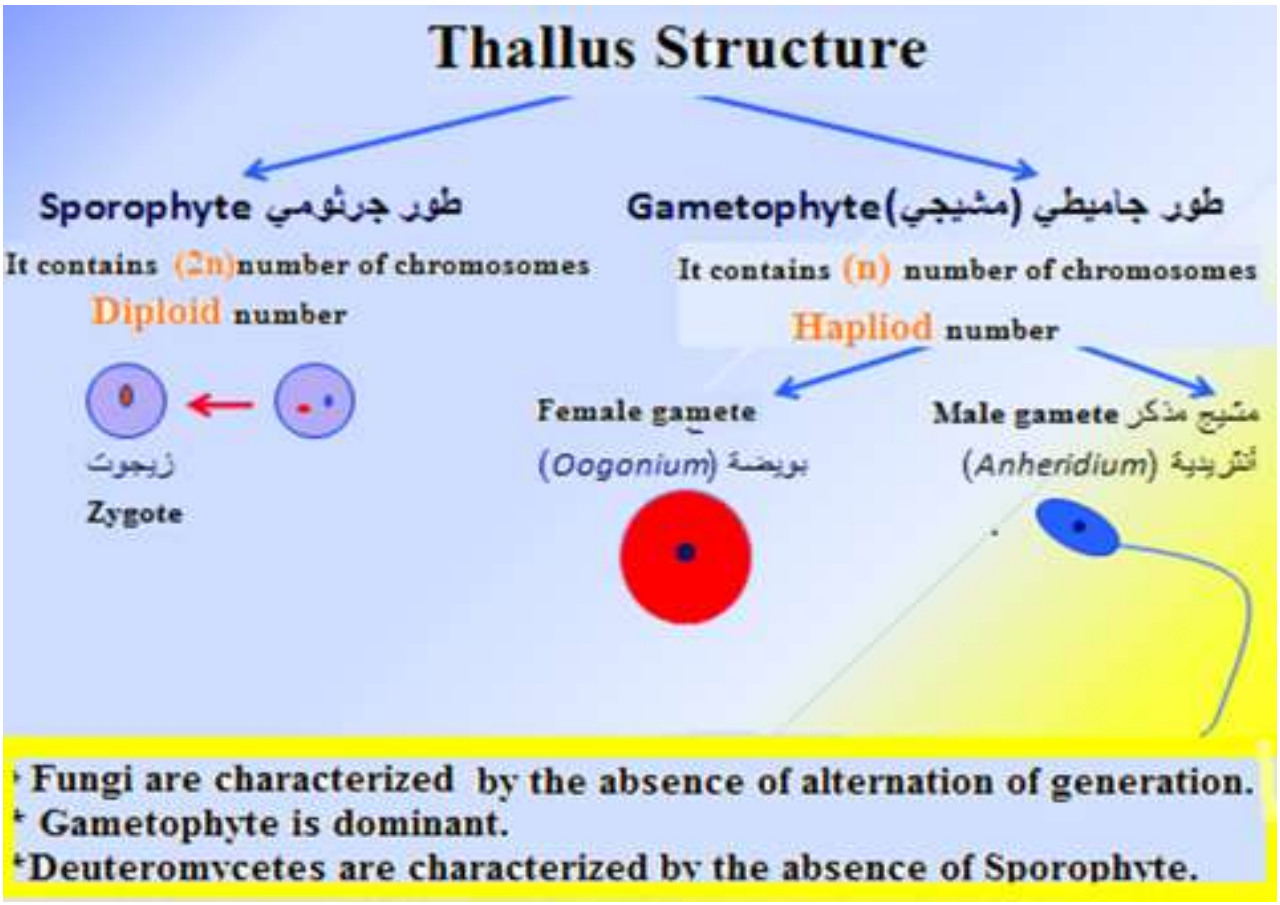
- They belong to *Eukaryota*. They are multicellular with no vascular system.
- ***Mycology***: is the science of studying *Fungi*. (***Mykes***: *Fungi*, ***logos***: science).
- They reproduce by binary fission, asexually by spores or sexually.
- They don't have chlorophyll thus they can't make their own food like plants do, but they can make most of their nutrients from carbohydrates. They have the ability to synthesis vitamins *i.e.* yeast.
- They live saprophytically, parasitically or symbiotically with Cyanogreens *i.e. Lichens*.
- They consist of mycelia, mostly branched filaments, where their cell walls are made up of cellulose, cutin or both.
- They can be cultivated on synthesized media in the lab.
- They are non-motile although some sex organs are motile.
- Their reserve food materials are glycogen and oils.
- They can grow under 0 to 35 □C. Their optimum temperature varies from 20 - 30□ C.
- They grow under slightly acidic habitat
- **Light** is necessary for spore germination. Sporangiophores are positively phototropic.
- The *Thallus* is made of *Hyphae*, where a group of *hyphae* are know as *Mycelia.*
- *Hyphae* are either septated or non-septated. Each cell has one or more nuclei. Cytoplasm contains vacuoles and oil droplets.

Reproduction Of *Fungi:*

Sexually	Asexually
• It occurs every year	• It reproduce several times during the season
• **Steps of reproduction:** 1. Cytoplasmic conjugation 2. Nuclear conjugation *3. Meiosis* *4. Mitosis*	• Fragmentation • Binary fission • Budding • Spores - conidia
	  


Sexual Reproduction
♂ or ♀
(Dioecious) ثنائية المسكن
Hermaphrodite (Monecious) أحادية المسكن
Gametangia حوافظ منوجية
(Anisogamy) مختلفة
(Isogamy) متماثلة
Female gamete
(Oogonium) بويضة
Male gamete
(Antheridium) أنثريدية
Female gamete مشيج مؤنث
Male gamete مشيج مذكر


Alternation of Generation
n
n
n
Gametophyte
mitosis
Sporophyte
2n
n
meiosis
Zygote


Thallus Structure
Sporophyte طور جرثومي
It contains (2n)number of chromosomes
Diploid number
زيجوت
Zygote
Gametophyte(مشيجي) طور جاميطي
It contains (n) number of chromosomes
Hapliod number
Female gamete
(Oogonium) بويضة
Male gamete مشيج مذكر
(Anheridium) أنثريدية
Fungi are characterized by the absence of alternation of generation.
Gametophyte is dominant.
Deuteromycetes are characterized by the absence of Sporophyte.

Kingdom: *Fungi* (Mycota)

Division: *Myxomycota*

1. There is no defined cell walls.
2. The body is of a multinucleated protoplasmic mass -resembling *Amoeba*- called *"Plasmodium"*, consumed during the formation of the fruit body and is surrounded by a sac called the *"Peridium"*.
3. Cells are flagellated

Division: *Eumycota*

1. They have cell walls.
2. Filamentous
3. Reproduce Sexually and Asexually
4. Uni- or multi-cellular

Class 1 : *Chytridiomycetes*

Class 2 :*Hyphochytridiomycetes*

Class 3: *Oomycetes*

Class 4: *Plasmodiophoromcyetes*

Class 5: *Zygomycetes*

Class 6: *Trichomycetes*

Class 7: Ascomycetes

Class 8: Basidiomycetes

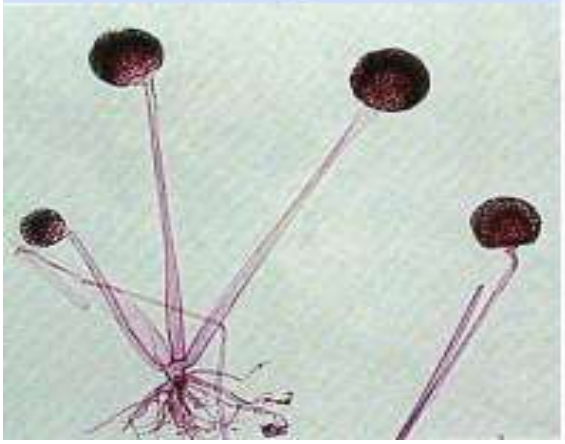
Class 9: *Deuteromycetes*

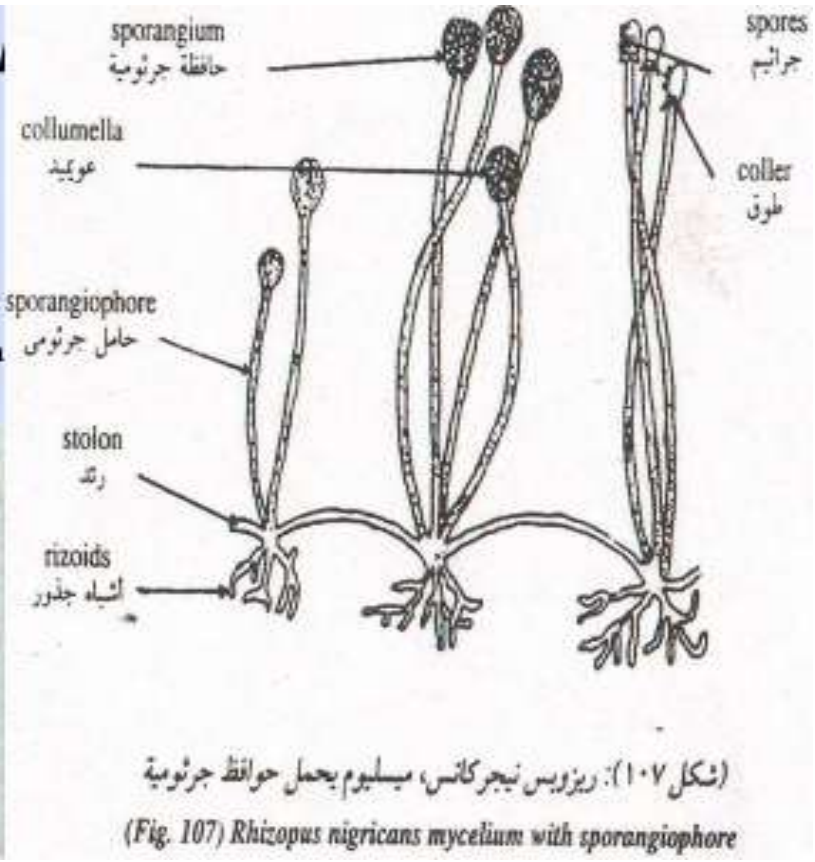
Phylla	Motility	Reproduction	Other Characters
Chytridiomycetes	By one back flagella	Sexually & Asexually	Of variable *Thallus*
Hyphochytridiomycetes	By one front flagella	Sexually & Asexually	Aquatic *Fungi*
Oomycetes	Amphitrichous	Sexually & Asexually ,Producing a fertile non motile Oogonium	Unseptated *Fungi*
Plasmodiophoromcyetes	By two front flagella	Sexually & Asexually	Acellular thallus, multinumcleated, with non-motile spores, no fruit bodies are produced, live inside the tissues of their hosts.
Zygomycetes	Non - motile	Produce a non motile spore from the conjugation of two similar gametes	Septated or unseptated mycelia *i.e. Rhizopus*
Trichomycetes	Motile	Sexually & Asexually	Unseptated branched or unbranched mycelia, parasitize on *Arthropoda*
Ascomycetes	Motile	Sexually & Asexually by *Ascospores*	Each *Asci* has 8 *Ascospores*. *i.e. Aspergillus, Penicillium, yeast, Peziza*
Basidiomycetes	Motile	Sexually & Asexually by *Basidiospores*	Each *Basidium* has 4 *Basidiospores*. *i.e. Agaricus, Puccinia graminis.*
Deuteromycetes	Motile	Only Asexually	There is no Gametophyte

Rhizopus nigricans

Kingdom: *Fungi*
Division: *Eumycota*
Class : *Zygomycetes*
i.e.: Rhizopus nigricans

*They live saprophytically on bread and other organic substances

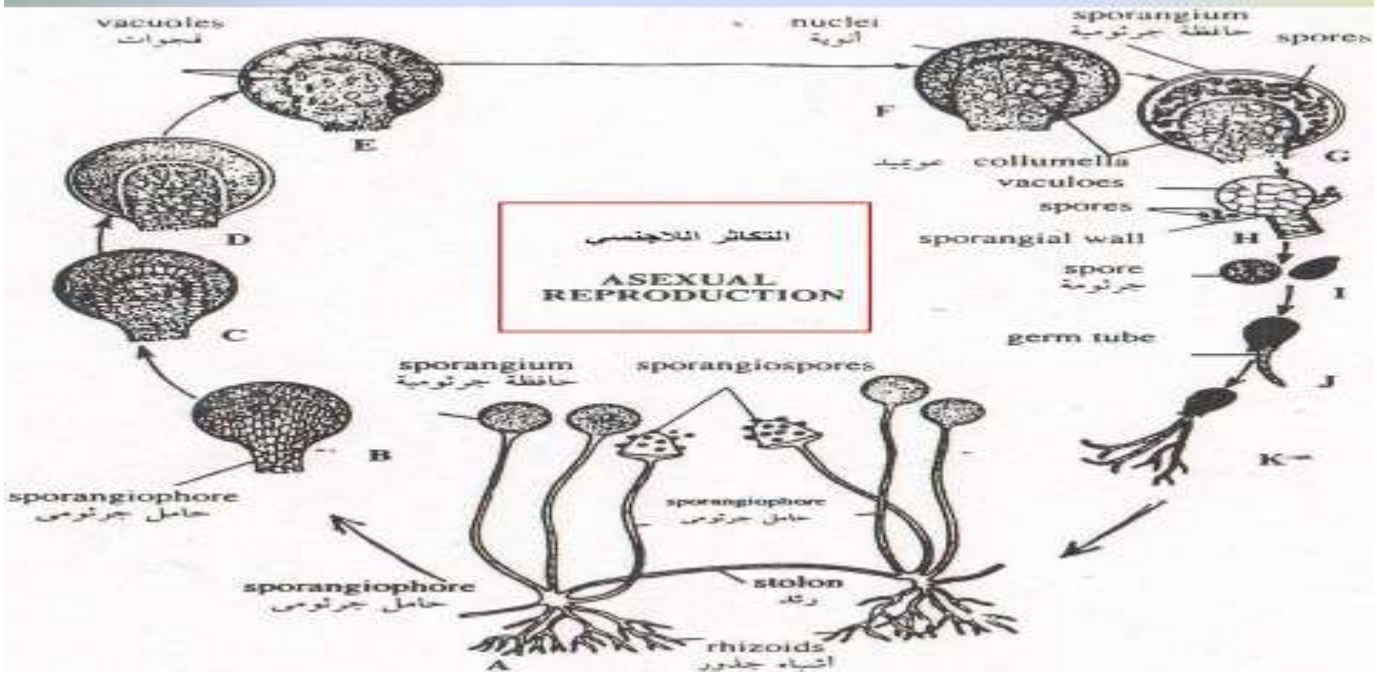




(شكل ١٠٧): ريزوبس نيجركانس، ميسليوم يحمل حوافظ جرثومية

(Fig. 107) Rhizopus nigricans mycelium with sporangiophore

Asexual reproduction in *Rhizopus sp.*



Asexual reproduction:

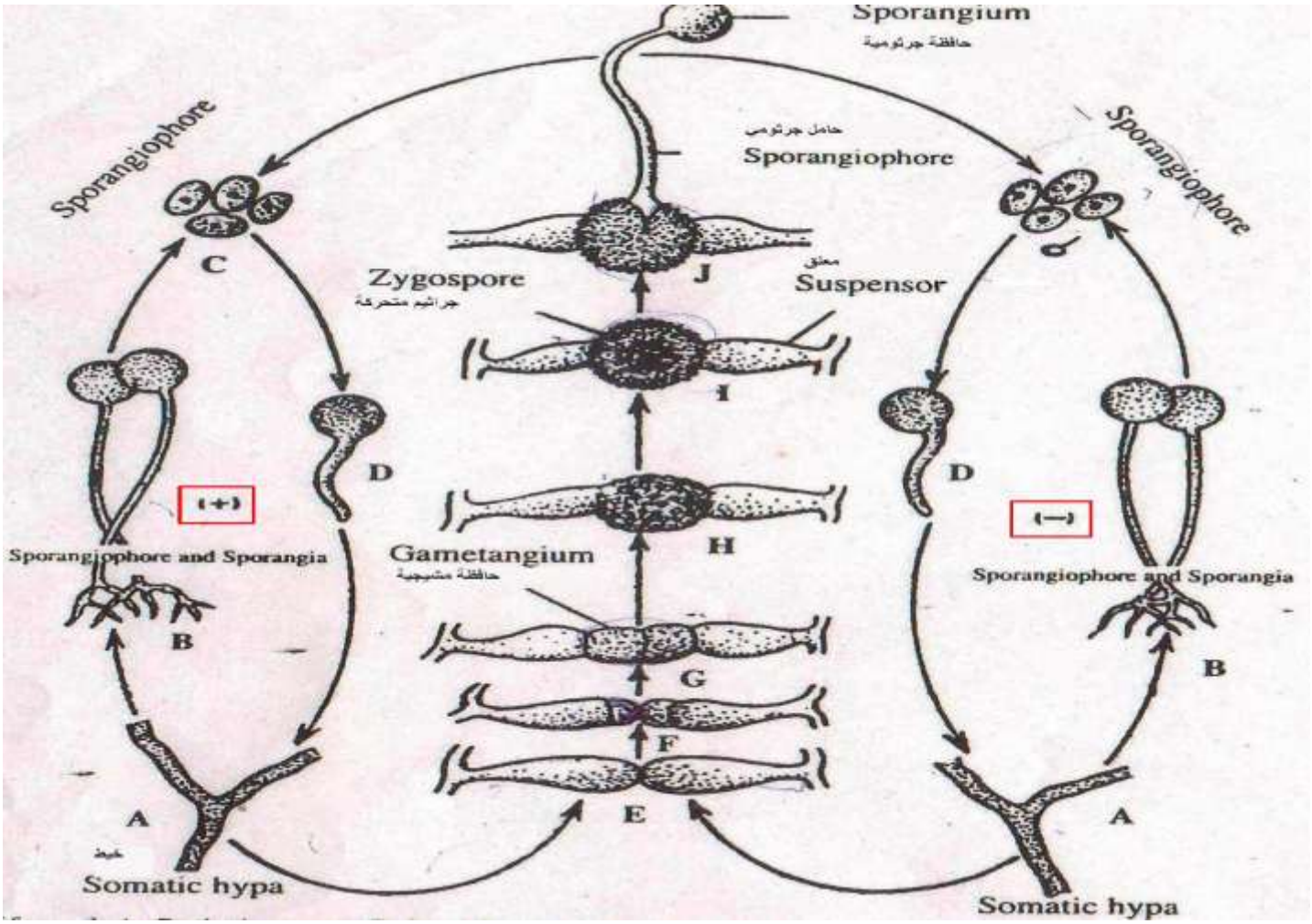
1- The tip of the sporangiophore becomes swollen, forming a sporangium in which a part of the protoplasm containing nuclei and food flows and accumulates at the periphery of the sporangium.
2- The inner area of the sporangium is poor in cytoplasm and nuclei.
3- A dome-shaped layer of vacuoles appears between the inner and outer zones.
4- Such vacuoles enlarge and fuse. A wall is then formed separating the outer fertile zone from the inner sterile materials known as the columella.
5- The many nuclei in the fertile zone forms collects a small mass of cytoplasm around each of them, form a wall and become transformed into uninucleated spores.
6- When the sporangia become mature, their walls rupture and the spores become free.
7- The remnant of the ruptured sporangial wall is known as the collar.
8- Each spore on germination gives rise to a new hypha.

1. **Sexual reproduction**:

It takes place either between the tips of two hyphae or between two neighbouring hyphae. The two fusing hyphae may be either originating from a single spore, *i.e.* from one and the same mycelium, or they originate from two sexually different spores. *Rhizopus* species belonging to the first type are called homothallic, while those performing the second type of reproduction are called heterothallic. As example of the heterothallic forms is *Rhizopus nigricans*.

In case of heterothallic forms, the two different spores give two sexually different mycelial strains, one of them is called a negative (-) strain and the other is a positive (+) one (some- times called-minus or plus strains). Fusion takes place between gametangia of different strains. When the mycelia of two opposite strains come near each other, lateral lobes are developed. These are the progametangia which are darker than the remaining mycelium due to the thickening of the protoplasm. The apical portion is separated by a cross-wall to form the gametangia.

These are equivalent in function to the antheridium and oogonium in other plants. Each gametangium contains a multinucleated gamete. When the gametangia come in contact with each other, the cell wall between them dissolves, and their nuclei fuse to gamete. form diploid nuclei. Unfused nuclei disintegrate. The multi-nucleated zygote enlarges to form a zygospore. This is fixed in its place by the remaining parts of the lateral lobes called suspensors. The zygospore attains a thick sculptured black wall and remains inactive for a period of time.

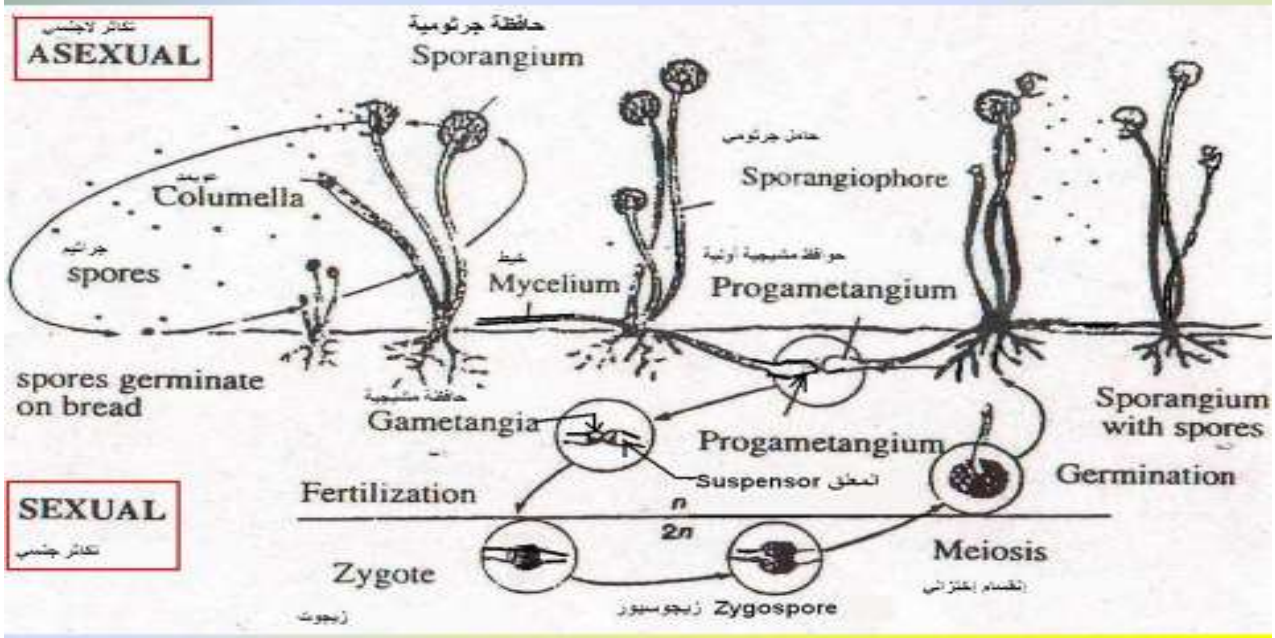


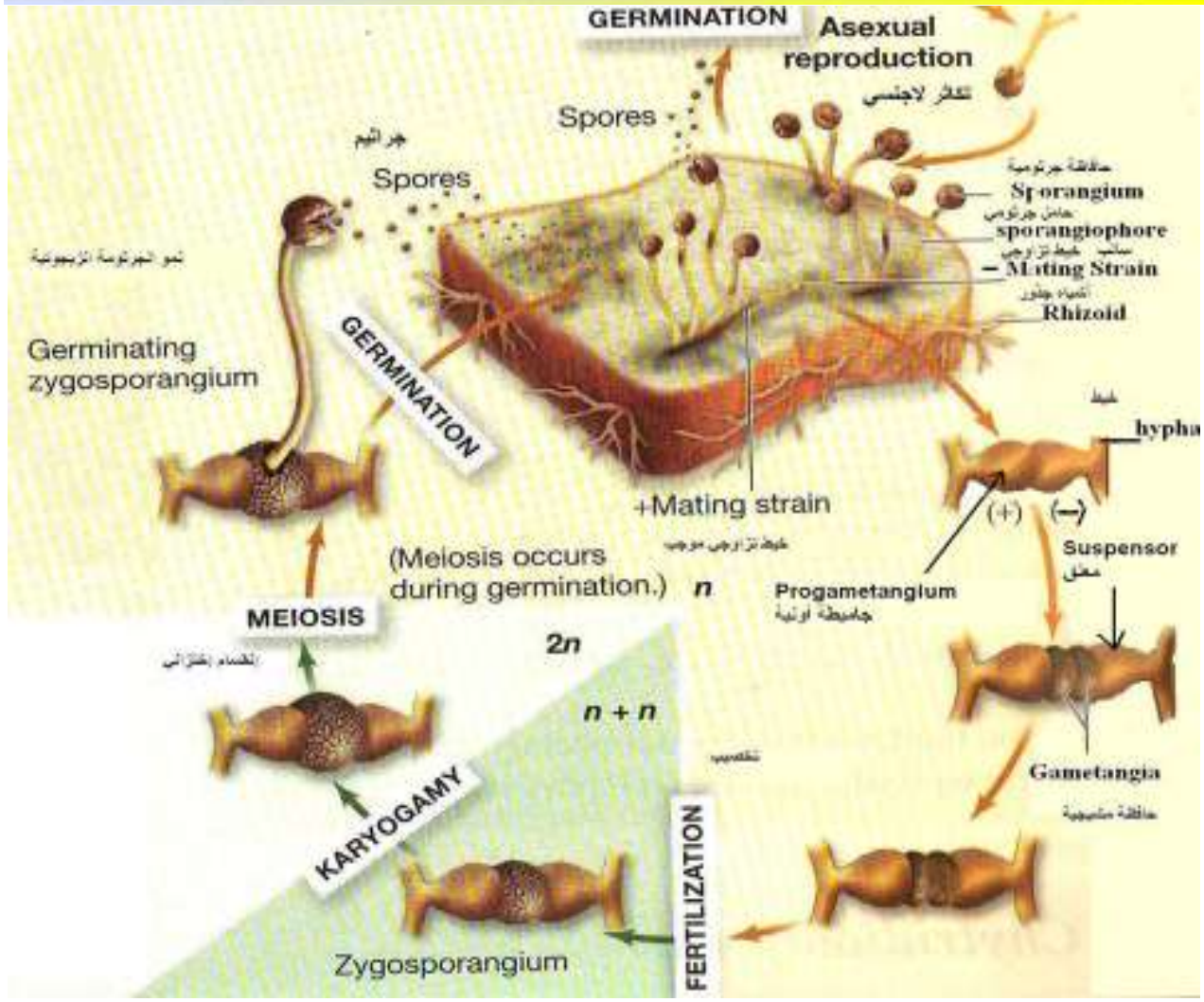
By the return of favourable conditions, the zygospore germinates to give a tube which ends with a sporangium. Meanwhile the diploid nuclei of the zygospore divide many divisions, the first of which is meiotic. This reduction division results in the segregation of genes for sex, and accordingly half of the produced nuclei carry the -ve sex character while the other half carry the + ve sex one.

Since these nuclei are the units which form the spores, then it is expected that 50% of the produced spores, give on growth, a mycelium of the -ve strain and the other 50% give a mycelium of the + ve strain.

In case of homothallic species of *Rhizopus (R. sexualis)*, the same steps of fertilization occur except that the fusing hyphae are not sexually differentiated and the zygospore gives on germination, a sporangium containing one type of spores.

Reproduction in *Rhizopus sp.*

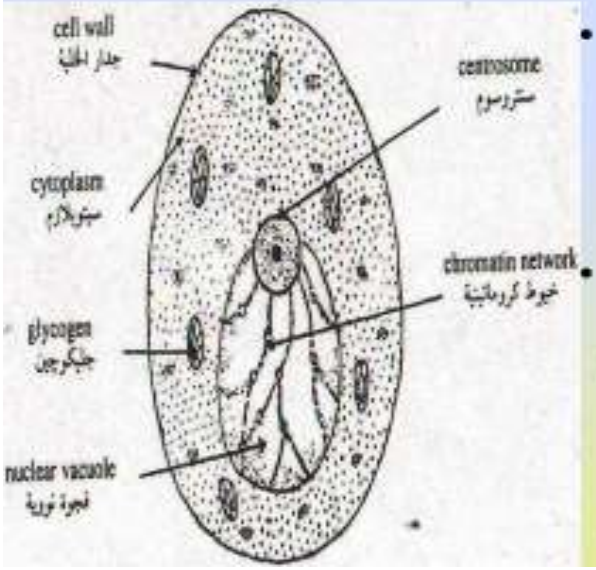




Saccharomyces cerevisiae

Kingdom: ***Fungi***
Division: ***Eumycota***
Class : ***Ascomycetes***
i.e.: Saccharomyces cerevisiae

- Unicellular oval cells, growing on sugary substances.
- Yeast cells can live saprophytically, symbiotically or even parasitically.



- **Reproduction:**

1. **Vegetatively**:
   - Budding - Fission -Budding fission
2. **Sexually**

- **Economic Importance:**

1. In baking: due to fermentation.
2. It is used as tablets as it is rich in many enzymes and vitamins *i.e.* vitamin B complex.
3. It is used in alcoholic industry.

Vegetative Reproduction

- Budding
- Fission
- Budding fission

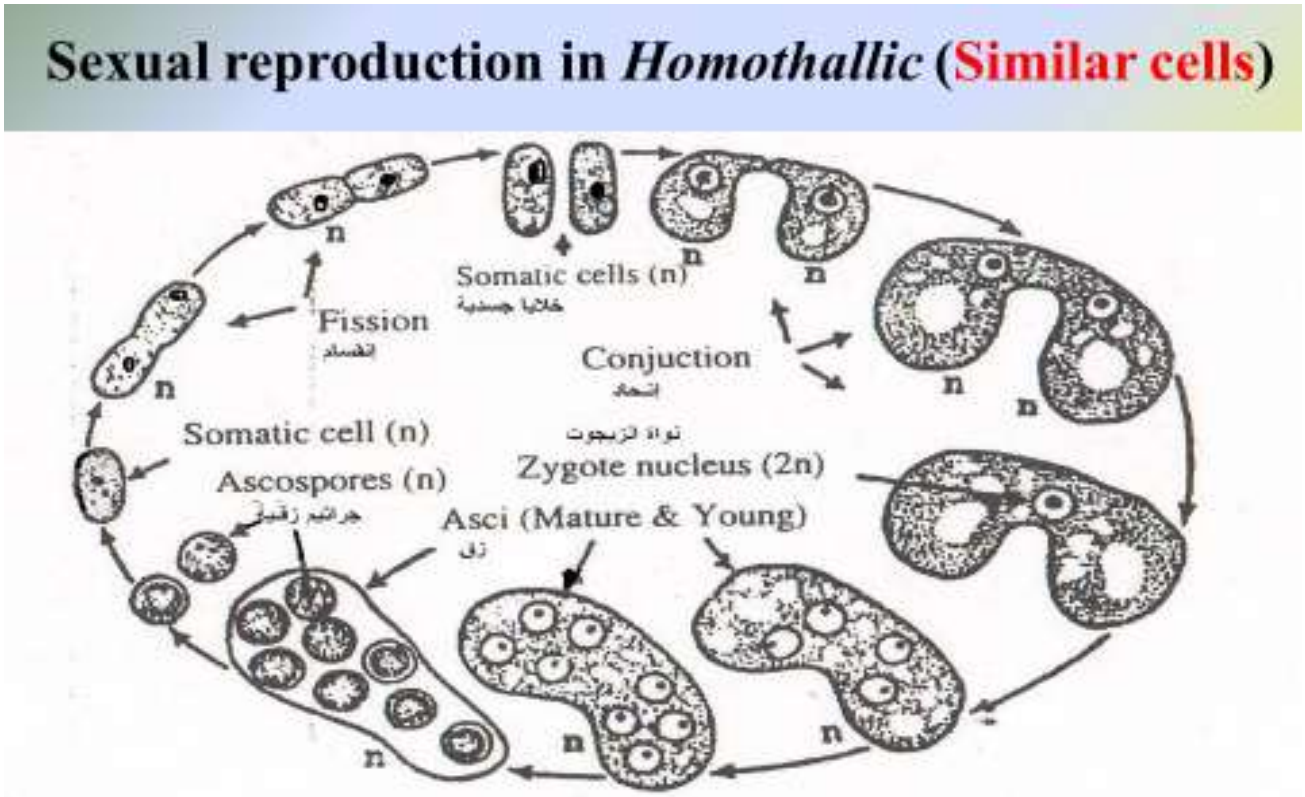
1. Vegetative reproduction:

From the vegetative point of view yeasts are divided into 3 types according to the method of division namely, budding, fission, and budding-fission yeasts.

A. Budding: A lateral outgrowth or a bud is formed. The mother nucleus divides mitotically into two and the new bud receives one of them. The bud enlarges and becomes separated from the mother cell by a constriction at its base. Re-budding may occur either from the mother cell or the bud, resulting in chains or clusters of buds producing what is known as *Pseudomycelium*.

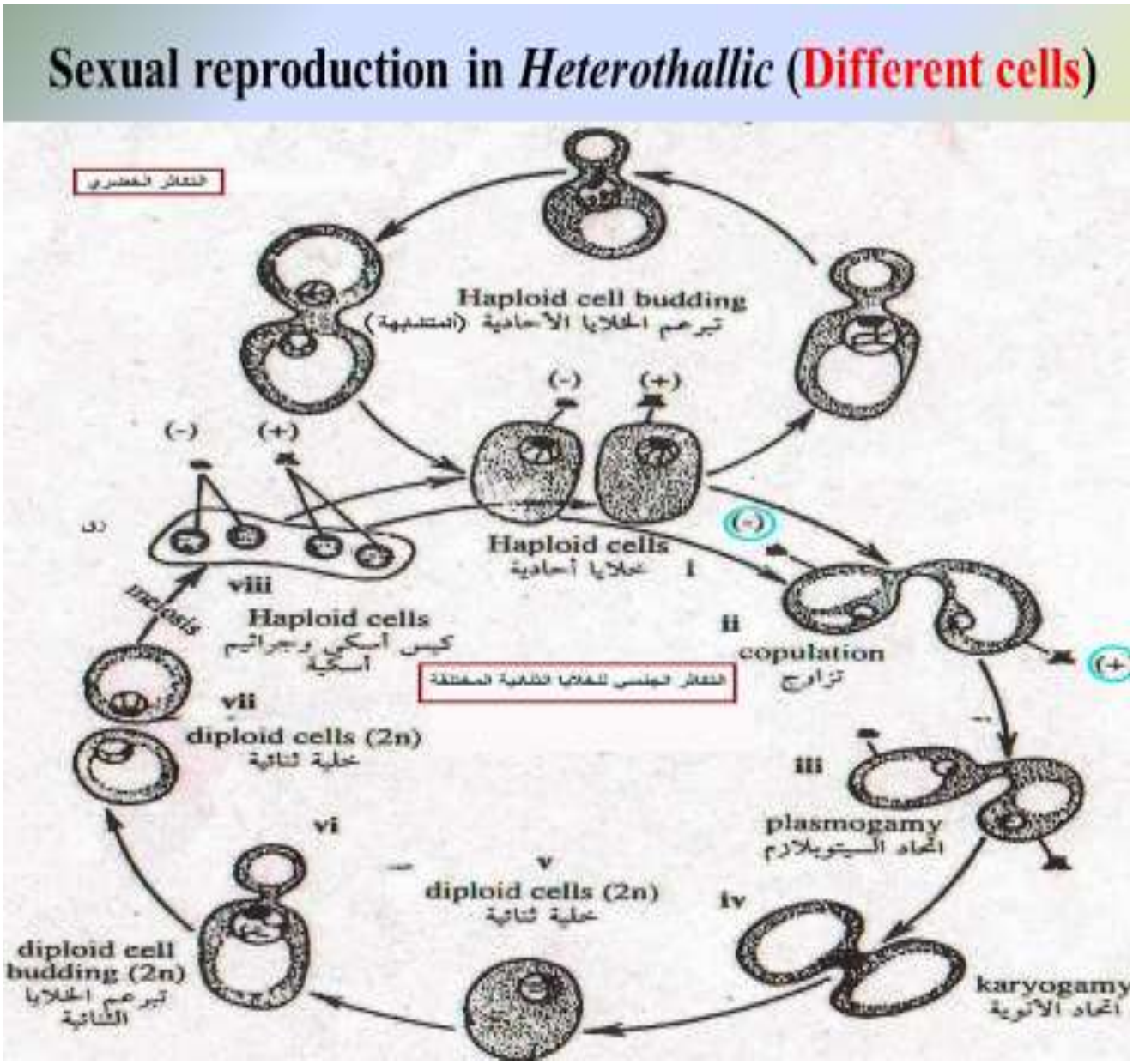
B. Fission: It occurs in a way similar to that found in bacteria. The cell elongates, the nucleus divides mitotically into two and a transverse wall or septum is formed in the middle, dividing the mother cell into two unincleated daughter cells which become separated. *Schizosccharomyces octosporus* reproduces by this method.

C. Budding-fission : A bud is produced in the usual way, but it becomes separated by fission instead of constriction (e.g. *Saccharomycodes*).



(شكل ١١٣): التكاثر الجنسى فى الخلايا الأحادية للخميرة (متشابهة الثالوس Homothallic)

(Fig. 113) Saccharomyces octosporus



2. **<u>Sexual reproduction</u>**. By ascospore formation. Vegetative yeast cells are either haploid or diploid according to their origin. The steps of reproduction vary in both of them.

A. Sexual Reproduction In Haploid Cells (Homothallic):

Two yeast cells (from one parent) come in contact and unite by means of a tube produced to allow the passage of cytoplasm and nuclei between the conjugating cells. The nuclei fuse after the fusion of cytoplasm to give a single diploid nucleus and a zygote is formed. The zygote nucleus divides two or

three divisions, the first of which is reductional to give 4 or 8 haploid nuclei. Each haploid nucleus surrounds itself with cytoplasm, food reserve and wall forming an ascospore. The latter, when released, grows to give a new haploid vegetative yeast cell.

B. Sexual Reproduction In Diploid Cells (Heterothallic):

A normal diploid cell divides usually into 4 ascospores; the first division is meiotic and the ascospores are thus haploid. The produced spores are sexually distinct, i.e. half of them is male and the other is female (+ ve and - ve strains). Fusion between spores may take place inside the ascus, before the release of the ascospores, resulting in the formation of n diploid vegetative cells. If the spores become released from mother cell before fusion, they grow to give male and female haploid vegetative cells, which are smaller in size than the vegetative diploid cells. Two haploid vegetative cells of opposite sex may fuse to form a new normal diploid vegetative cell which can reproduce again either sexually or asexually by budding. Sometimes fusion between spores of the same sex may occur resulting in an abnormal diploid cell which reproduces only budding.

Aspergillus

Kingdom: *Fungi*

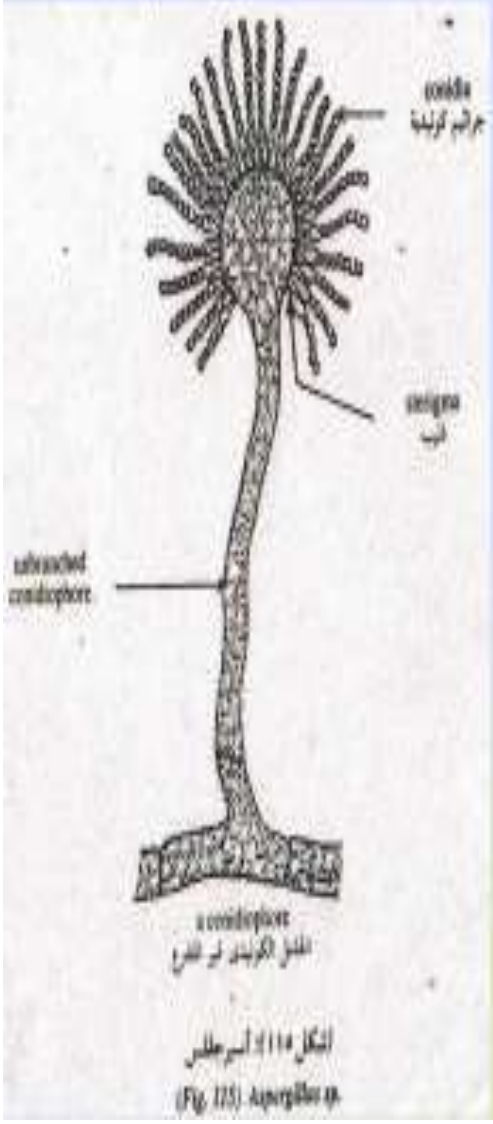
Division: *Eumycota*

Class : *Ascomycetes*

i.e.: Aspergillus

1. It lives saprophytically on dead animal and plant bodies.
2. It causes meat and vegetable molds.
3. It infects the skin and respiratory organs.
4. It is used in the production of organic acids *i.e.* Citric acid and oxalic acid from sugar brewing.
5. *Conidiospores* are arranged on an *Acropetal* succession on a flask-like structure "Sterigmata", where the *Conidiophore* resembles the radiating sun.

- **Reproduction:** by *Conidiospores*, sexual reproduction rarely occurs.



Penicillum

Kingdom: *Fungi*

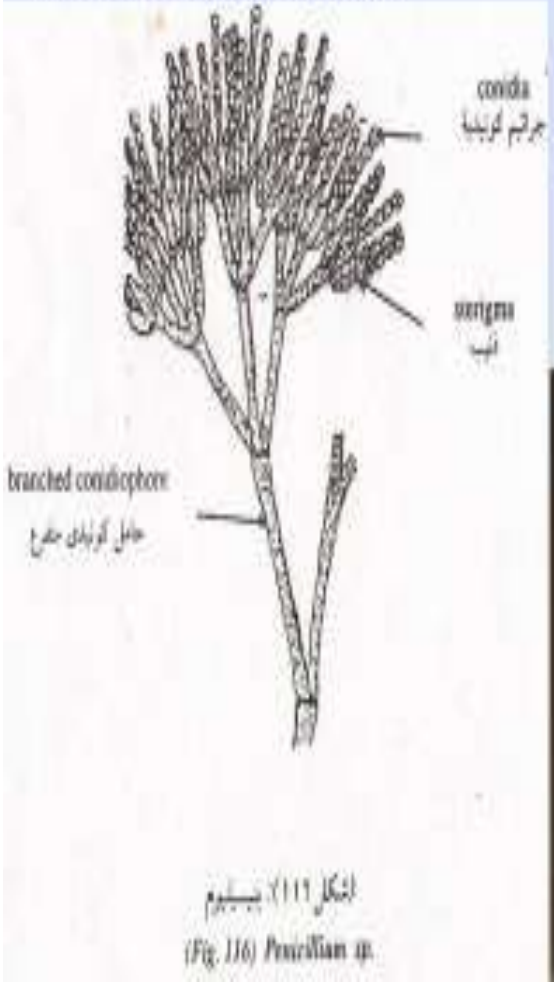
Division: *Eumycota*

Class : *Ascomycetes*

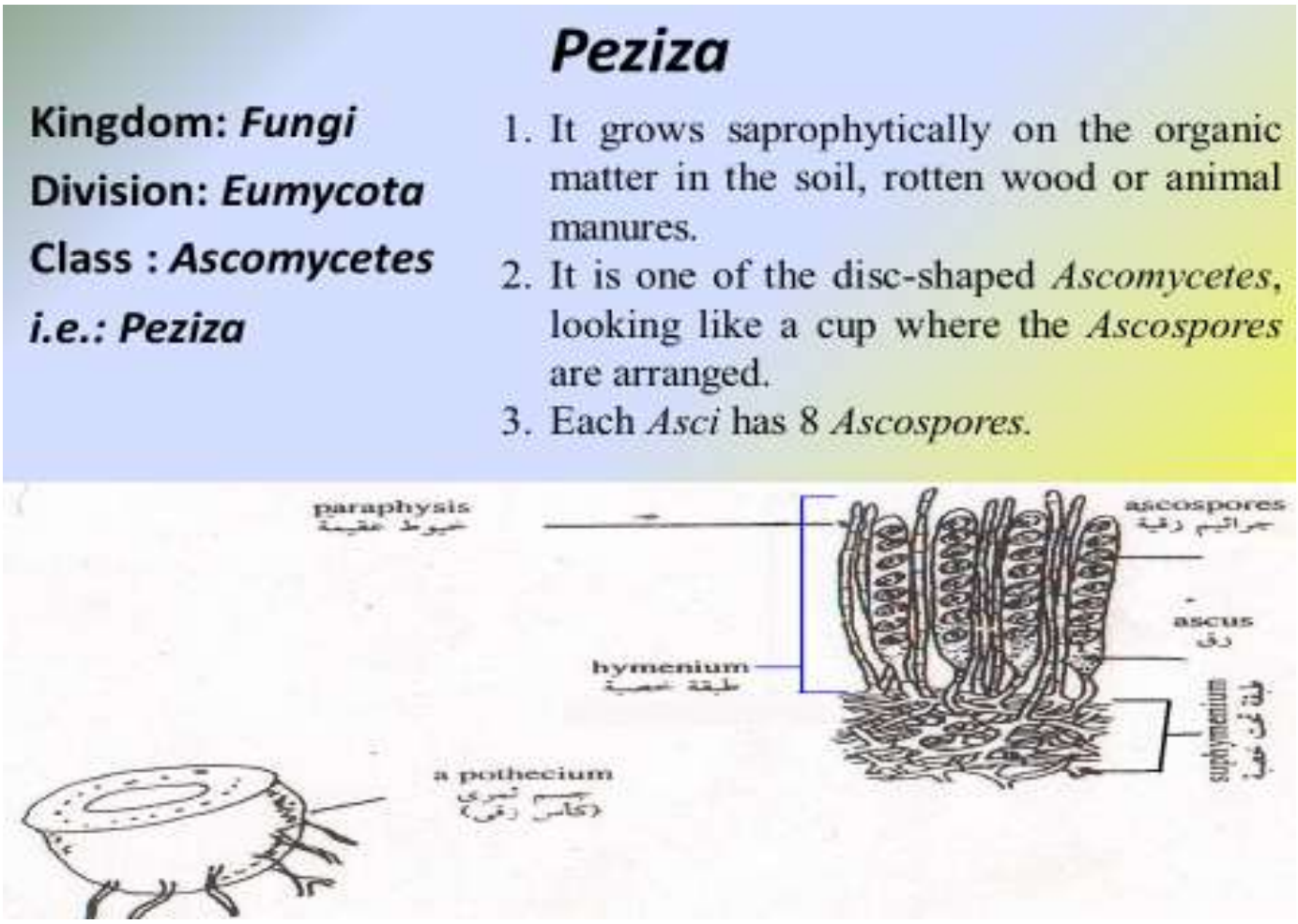
i.e.: Penicillium

1. It grows saprophytically.
2. It ruins a lot of vegetables, cheese and citrus fruits *i.e.* lemons.
3. *Conidiospores* are arranged on an *Acropetal* succession on 1ry , 2ry or 3ry Sterigmata.
4. It produces "Penicillin" one of the most powerful antibiotics.
5. It is used in the production of certain cheese as the blue cheese.

- **Reproduction:** by *Conidiospores*, where the *Conidiophore* resembles the "Broom" or a "Brush".



(Fig. 116) Penicillium sp.



The apothecia of *Peziza* are sessile or shortly stalked cup-shaped structures regular in form and large in size varying from 2 cm. to several inches in diameter. In *P. vesiculosa* the apothecium is of pale fawn colour but *P. aurantia* has brilliant orange apothecium.

1. **Asexual Reproduction:**

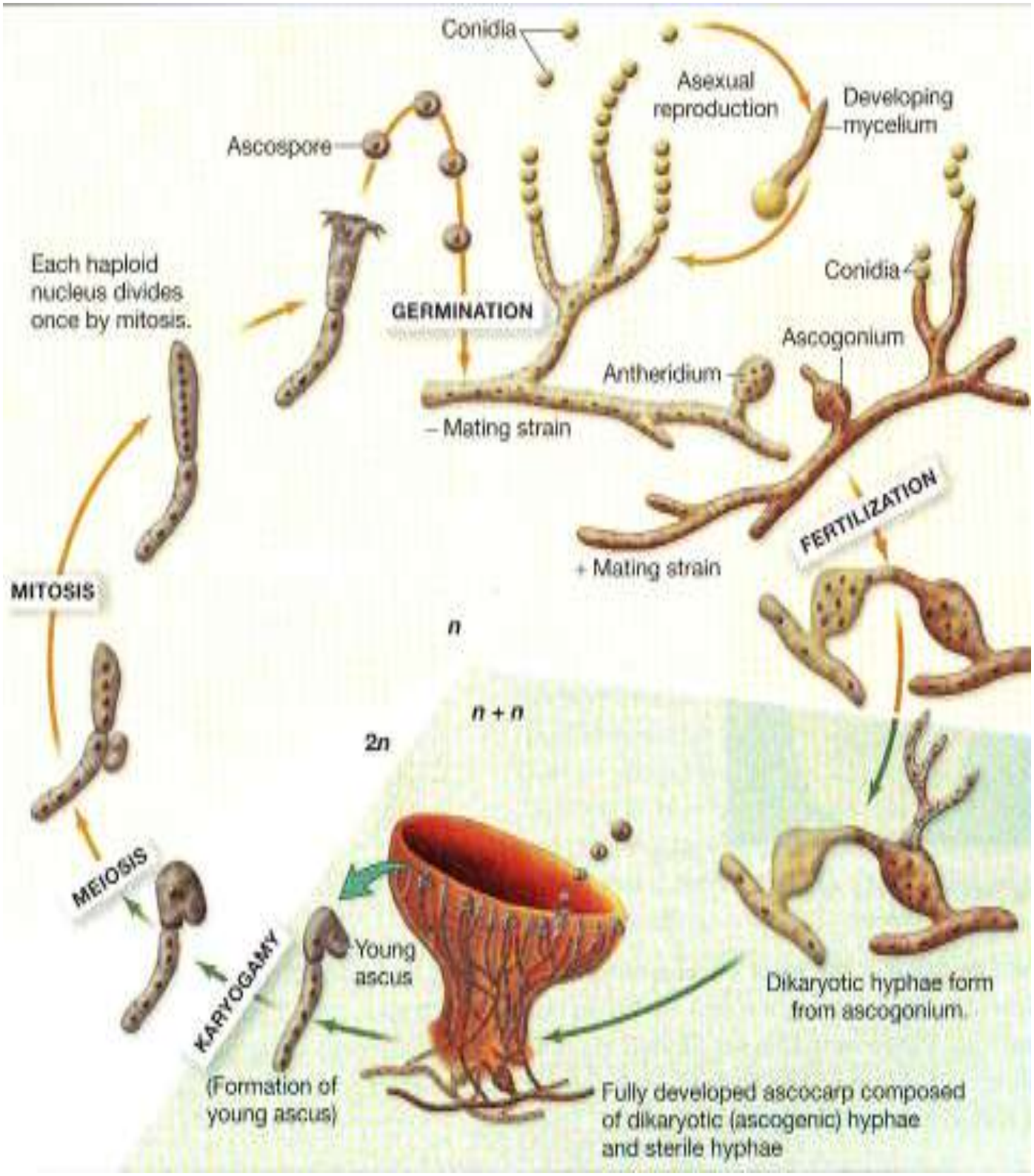
   It takes place by the formation of conidia and chlamydospores. The conidia are exogenously formed spores. They are abstricted from the tips of conidiophores. Each conidium germinates to form a new mycelium.

   The chlamydospores are thick-walled resting cells. They are intercalary in position. They may be formed singly or in series within the cells of the hyphae. Under suitable conditions each chlamydospore germinates and gives rise to a new mycelium.

2. **Sexual Reproduction:**

   The sexual apparatus is wholly lacking in *Peziza vesiculosa*. This does not prevent the development of a fructification which is aerial and relatively a short-lived structure. The sexual process does take place. It is extremely simplified and consists in the association of

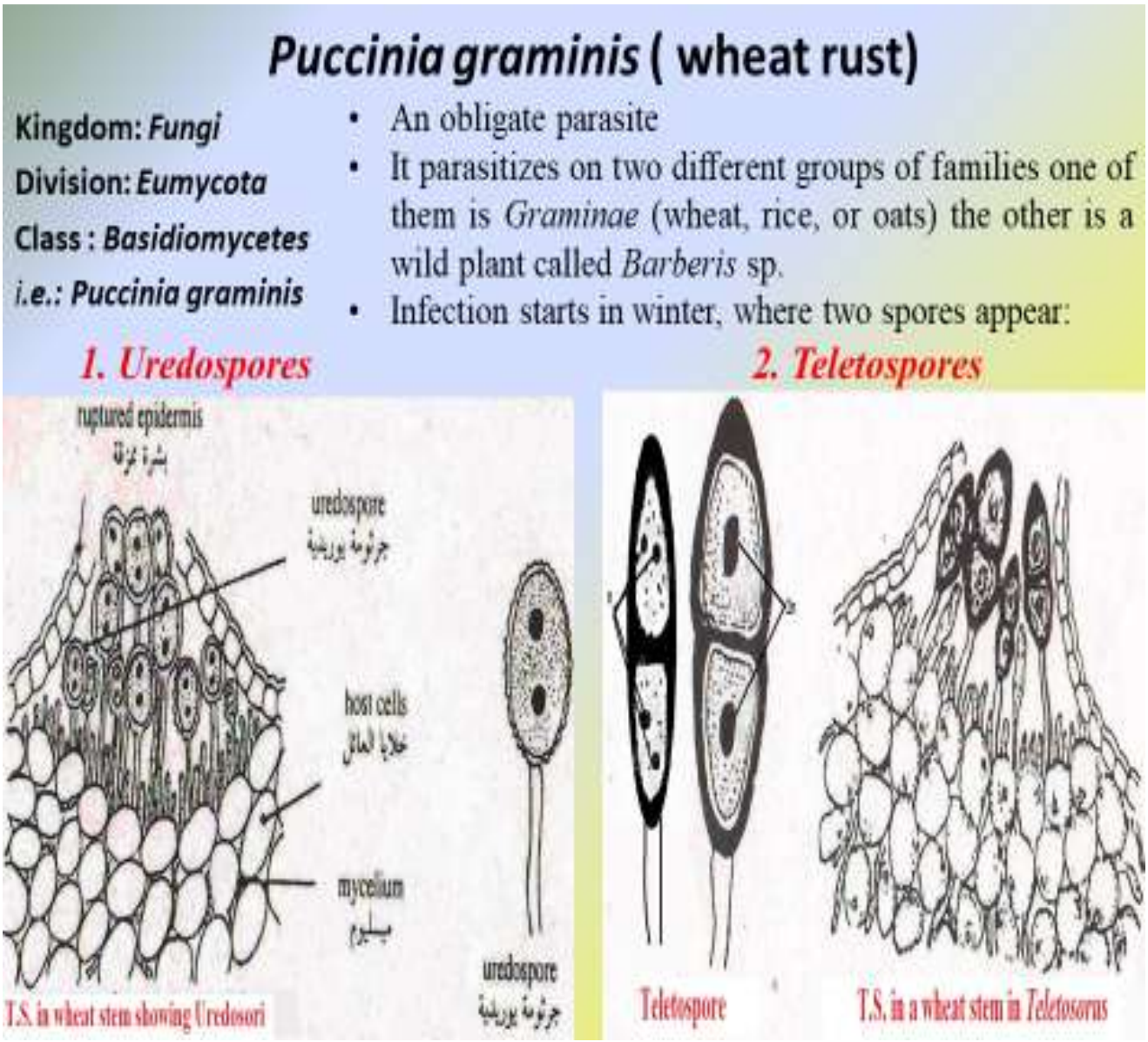
two purely vegetative nuclei in a pair. The adult mycelium consists of a tangled mass of hyphae. Certain vegetative cells in the center of the tangled hyphal mass have been seen to possess nuclei which become associated in pairs.



These pairs of nuclei are called the dikaryons. The dikaryotic condition is brought about either by autogamous pairing or by somatogamous copulation between the vegetative cells of the adjacent hyphae of the tangled hyphal mass. The cells with the dikaryons give rise to the ascogenous hyphae which become multicellular by cross walls. Their cells are binucleate. The terminal binucleate cell of each ascogenous-hypha functions as an ascus mother cell.

The two nuclei of the ascus mother cell fuse to form the synkaryon. The young ascus with the synkayon represents the transitory diplophase .The synkaryon undergoes three successive divisions. Of these the first and the second constitute meiosis. This results in the formation of eight haploid nuclei which become organised into ascospores. The mature ascus is an elongated, cylindrical cell. The ascus wall is lined by a thin layer of cytoplasm (epiplasm) which encloses a central vacuole filled with sap. In the vacuole lie the oval ascospores.

The erect asci lie side by side lining the cavity of the cup-shaped apothecium. The asci near the margin of the cup bend towards the source of light being positively phototropic. Interspersed between the asci are the Sterile hyphae called paraphyses. The rest of the apothecium consists of densely interwoven, branched hyphae forming a pseudoparenchymatous tissue which supports the hymenium.



Puccinia graminis is an obligate parasite which infects many cereals and grasses. Of the infected cereals, wheat, oat rye, and barley can be mentioned. Rust diseases are very serious since they cause heavy losses in crops. *Puccinia graminis tritici* is the fungus which infects *Triticum* or wheat. The parasitic life cycle of the fungus extends through two hosts namely wheat and Berberis vulgaris. of hosts. This phenomenon is called alternation of hosts.

Life cycle:

1. Early in the growing season (early summer), the infected wheat plants show orange-red patches, streaks or spots on their stems and leaves. These are the uredosori. Each uredosorus contains a number of uredospores which are ovoid or biscuit-like, unicellular, and binucleated. It has an outer thick spiny wall, an inner thin wall and 4 germ pores on the

equator. The uredosorus increases in size, accordingly the epidermis is ruptured, and the uredospores can be dispersed by wind. They can infect other wheat plants in the same season. The uredospore can penetrate the host through a stoma by means of the germ tube which appears from one of the germ pores.

2. At the end of the season the intercellular mycelium of the fungus, gives rise, instead of uredospores, to another kind of spores known as teliospores or teleutospores (winter spores). They are produced in a dark brown sorus known as the teleutosorus. The teleutospore is bicellular and stalked with a pointed upper end. It has an outer thick smooth brown wall and an inner thin wall. The germ pores here are only two, one for each cell. The upper cell has its pore apically and the lower one has it pore laterally. The teleutospore differs from the uredospore in the fact that the former is bicellular.

Puccinia graminis (Uredo- and Teletospores)

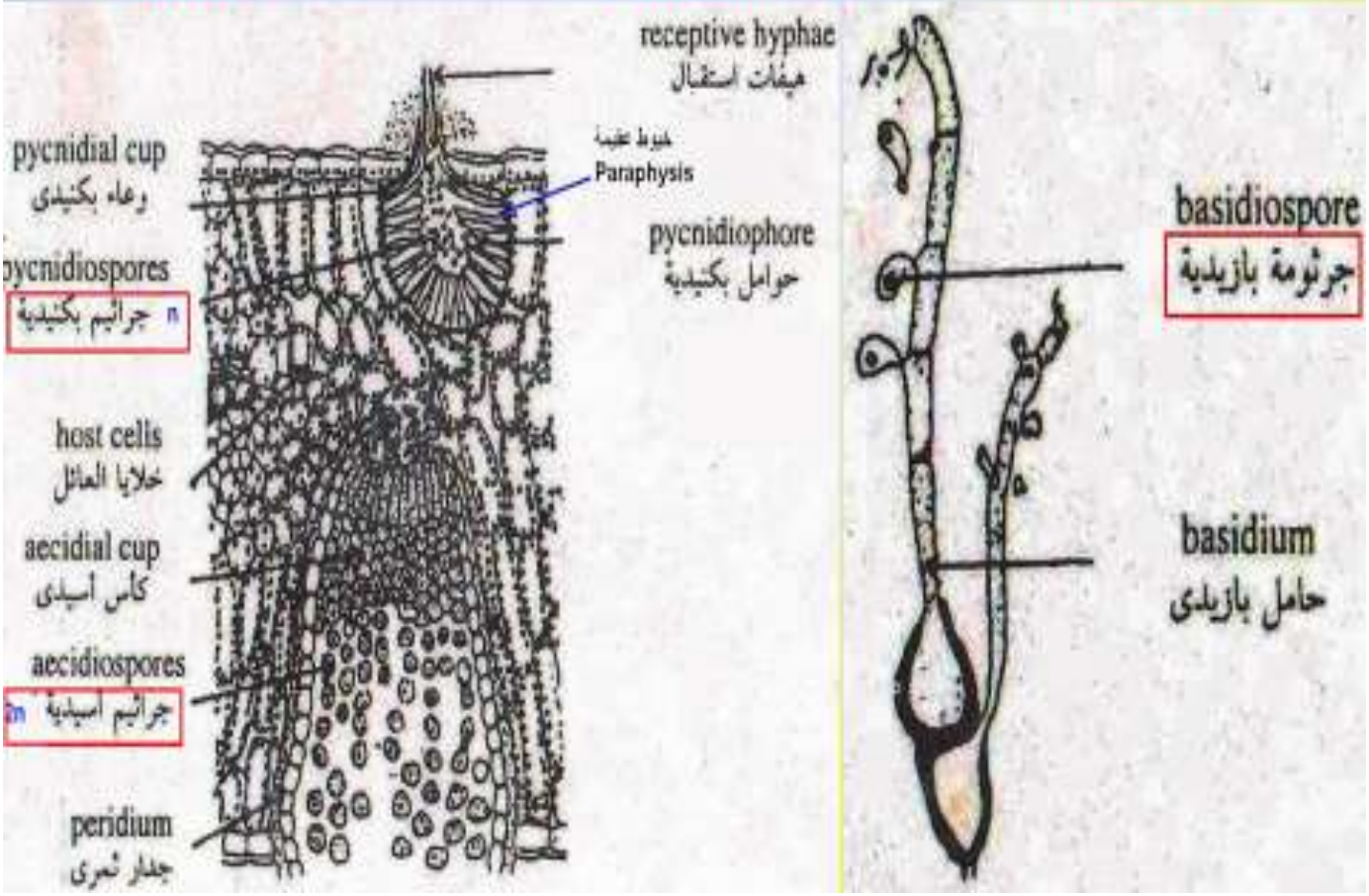
Points of Comparisons	Uredospores	Teletospores
Shape	Unicellular, binucleated spore with haploid number of chromosomes. The outer membrane is thick and dentate, while the inner one is thin and	Bicellular with one nucleus in each cell with a diploid number of chromosome. The outer membrane is thick while the inner one is thin.
Infection	 Leaves and Stems of Wheat plants 	
Colour	Orange	Brown

Each cell is at first binucleated, then the two nuclei, later on, become fused into one diploid nueleus. Teleutospores fall on the ground and remain inactive in soil for a period of time. On the return of favourable conditions (early spring) they begin germination. Each cell gives rise to a germ tube called basidium. The nucleus of each cell dívides two successive divisions the first of which is reductional to give 4 haploid nuclei. These arrange themselves in the basidium and separating walls are formed leading to the development of 4 uninucleated cells. Each cell develops a sterigma which dilates into a basidiospore to which the nucleus migrates. Meiotic division preceding the formation of basidiospores results in segregation of sex in such spores, ie. two spores are sexually different from the other two. In other words, two +ve mycelial strain, while the spores give, on germination, a remaining spores give a -ve mycelial strain.

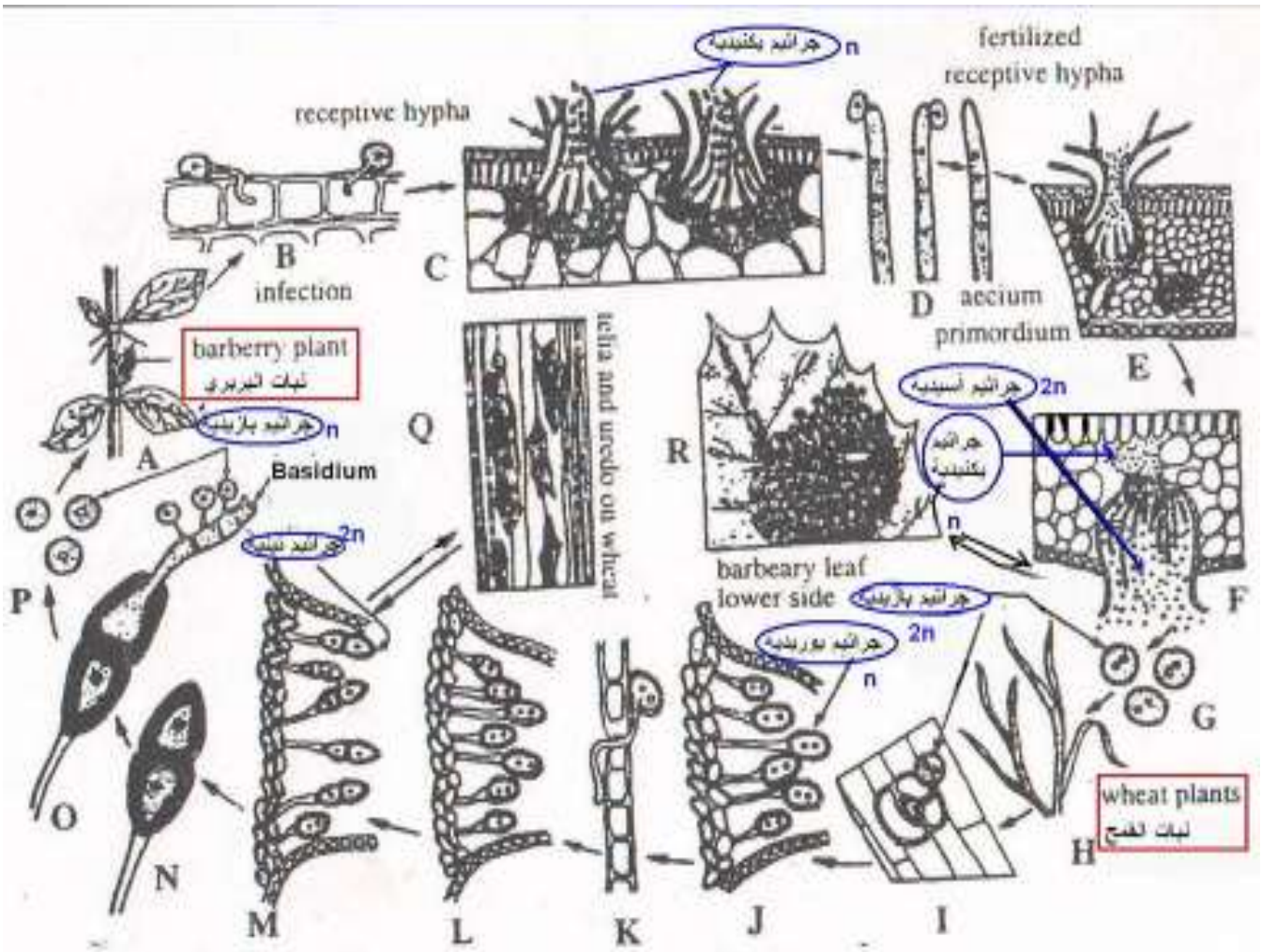
Puccinia graminis (wheat rust)

- Then, *Berberis* sp. (wild plant) is infected during the summer where three types of spores appear:

1. Basidiospores 2. Pycnidiospores 3. Aecidiospores



3. The basidiospores infect the second host known as *Berberis vulgaris*. Infection results in the formation of uninucleated mycelium which grows intracellularly. Such growth leads to the appearance, on the upper surface of *Berberis* leaf, of flask- shaped structures called pycnidia. Each pycnidium contains three types of hyphae:
   a) Pycnidial hyphae, which are fertile filaments, each of which carries a chain of spores called pyeniospores or-spermatia.
   b) Receptive or flexuous hyphae.
   c) Paraplryses or sterile hyphae.



(شكل ١٢٢): الدورة الكاملة لحياة فطرة صدأ القمح

(Fig. 122) Life cycle of Puccinia graminis tritici (black or stem rust of wheat.

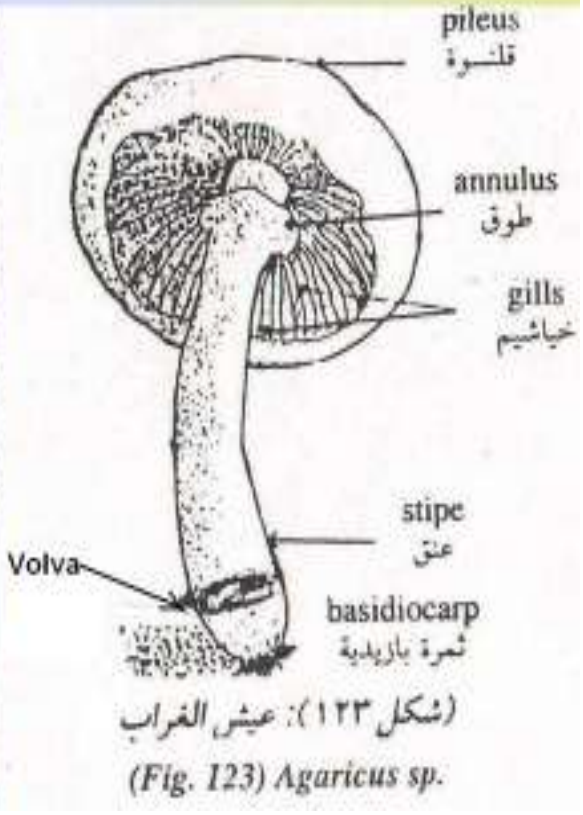
All these hyphae and pycniospores in one pycnidium are either of the positive or negative strain according to the type of the infecting basidiospore.

By the help of insects, the -ve strain receptive hyphae receive the +ve strain pycniospores and vice versa. Fusion takes place between the pycniospore and a terminal cell in the receptive hyphae, the nucleus of the former being transferred to the latter, resulting in the formation of a binucleated cell. This process is known as spermatization and its repetition results in the formation of binucleated mycelium which ramifies between the host cells towards the lower surface of *Berberis* leaf of aecidial cups. Each cup is sur- rounded with a wall of sterile hyphae called peridium. At the base of the cup there is a layer of elongated cells called stalk cells. Each binucleated stalk cell divides to give a chain of cells, some of which are small called intercalary cells and the others are larger known as aecidiospores or aeciospores. Both types of cells alternate one with the other in the chain, and also both of them are binucleated. The aecidia cups open on the lower epidermal surface of the leaf. At maturity the intercalary cells disintegrate and the aecidiospores become free to be dispersed by wind and begin a new infection to wheat plants in its early season of growth.

Agaricus (Mushroom)

Kingdom: *Fungi*
Division: *Eumycota*
Class : *Basidiomycetes*
i.e.: Agaricus

- Basidiomycetes can live saprophytically on humus, parasitically or symbiotically with other higher plants known as *Mycorrhizae*.
- Some types of mushrooms are edible while others are toxic.

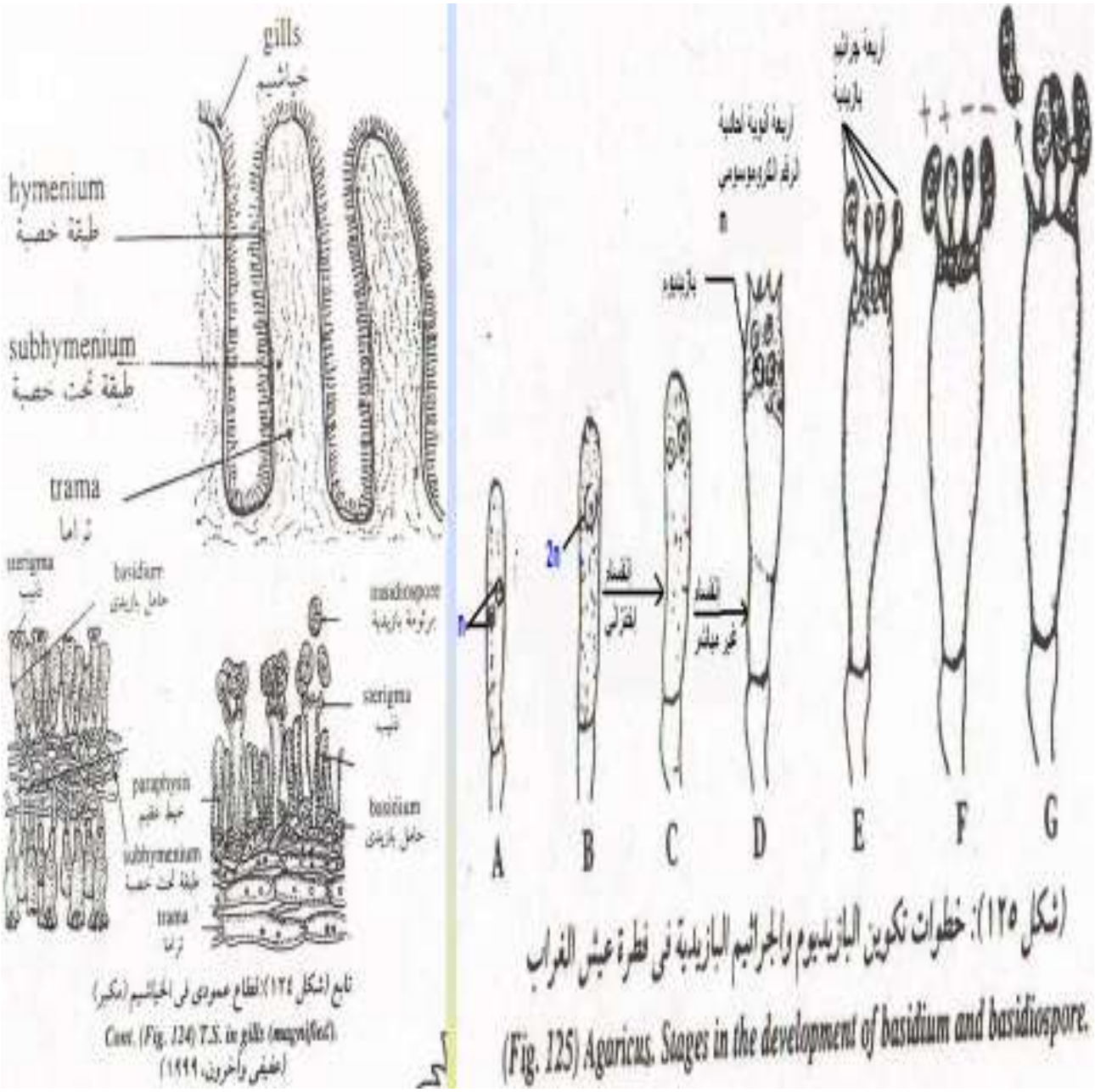


(شكل ١٢٣): عيش الغراب

(Fig. 123) Agaricus sp.

Life cycle:

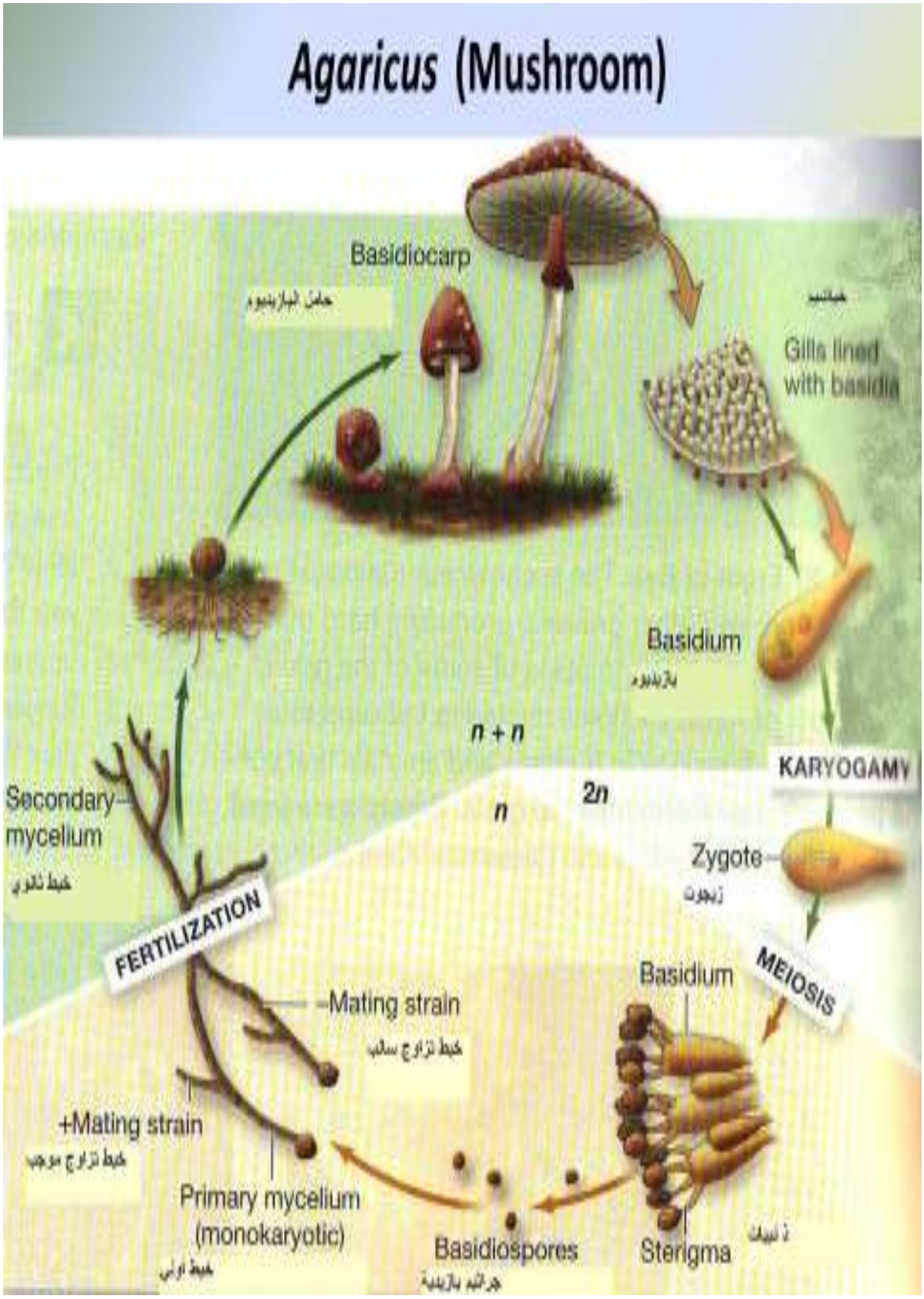
The basidiospores, after dissemination from gills, germinate in the soil to give uninucleated hyphae. These hyphae (primary mycelium) are sexually differentiated. Hayphae of opposite surains conjugate to form binucleated cells. It is these cells that form the secondary mycelium which develops into the fruit body or sporophore. Accordingly, the formed basidia on gills are at first binucleated. These two nuclei, (one plus and the other minus) fuse in the basidium to form a diploid nucleus. Meiosis follows producing 4 haploid nuclei. Meanwhile the basidium developes 4 lobes into which the new haploid nuclei migrate.

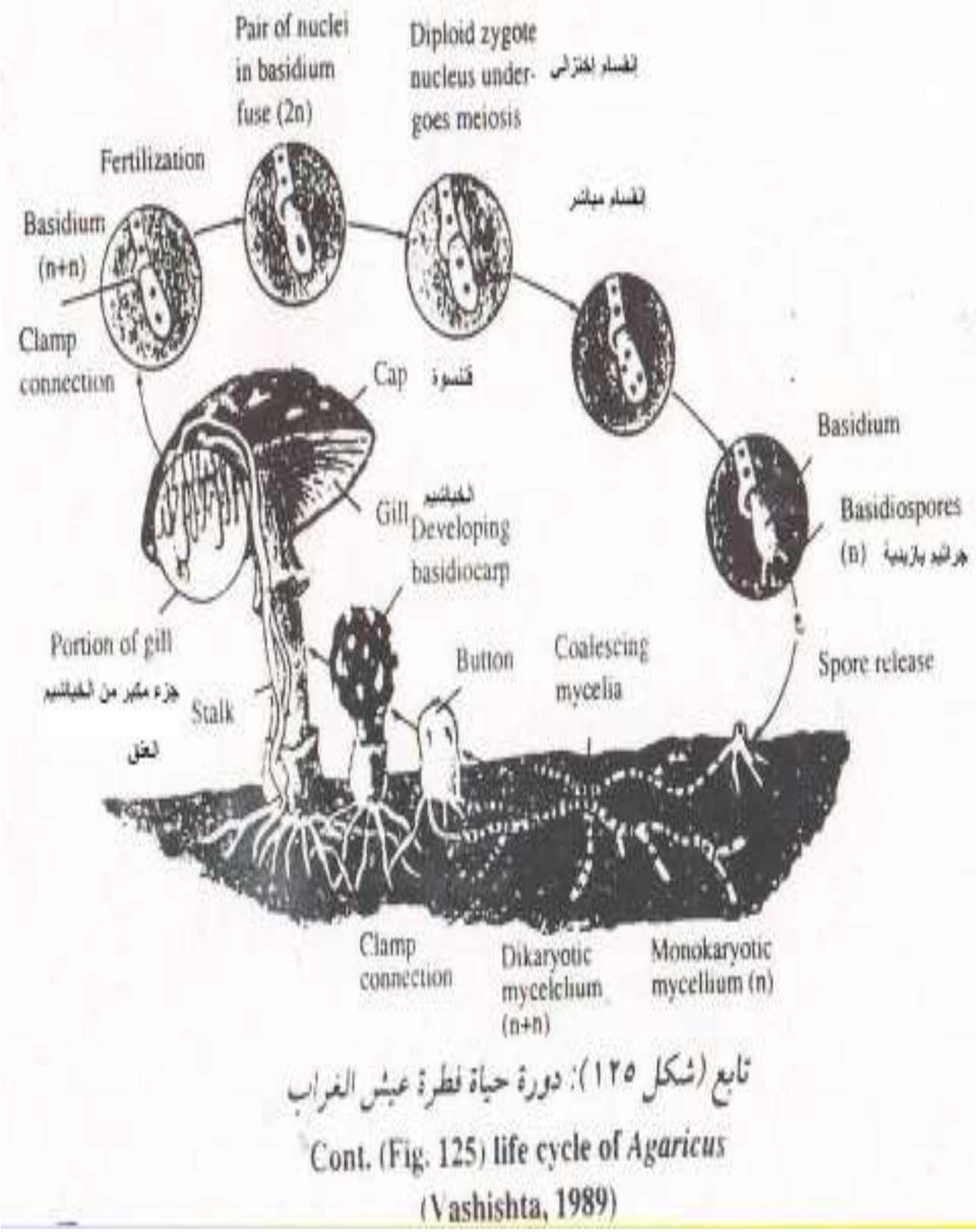


These uninucleated lobes, form the basidiospores carried on short sterigmata. Meiosis of the diploid nuçleus results in segregation of sex characters, thus two basidiospores give, on germination, hyphae a the +ve strain while the two other spores give hyphae of the

-ve strain. The basidiospores are shed from the basidium when they are ripe and a new life cycle starts.

The life cycle of Agaricus (heterothallic) can be represented in the following:





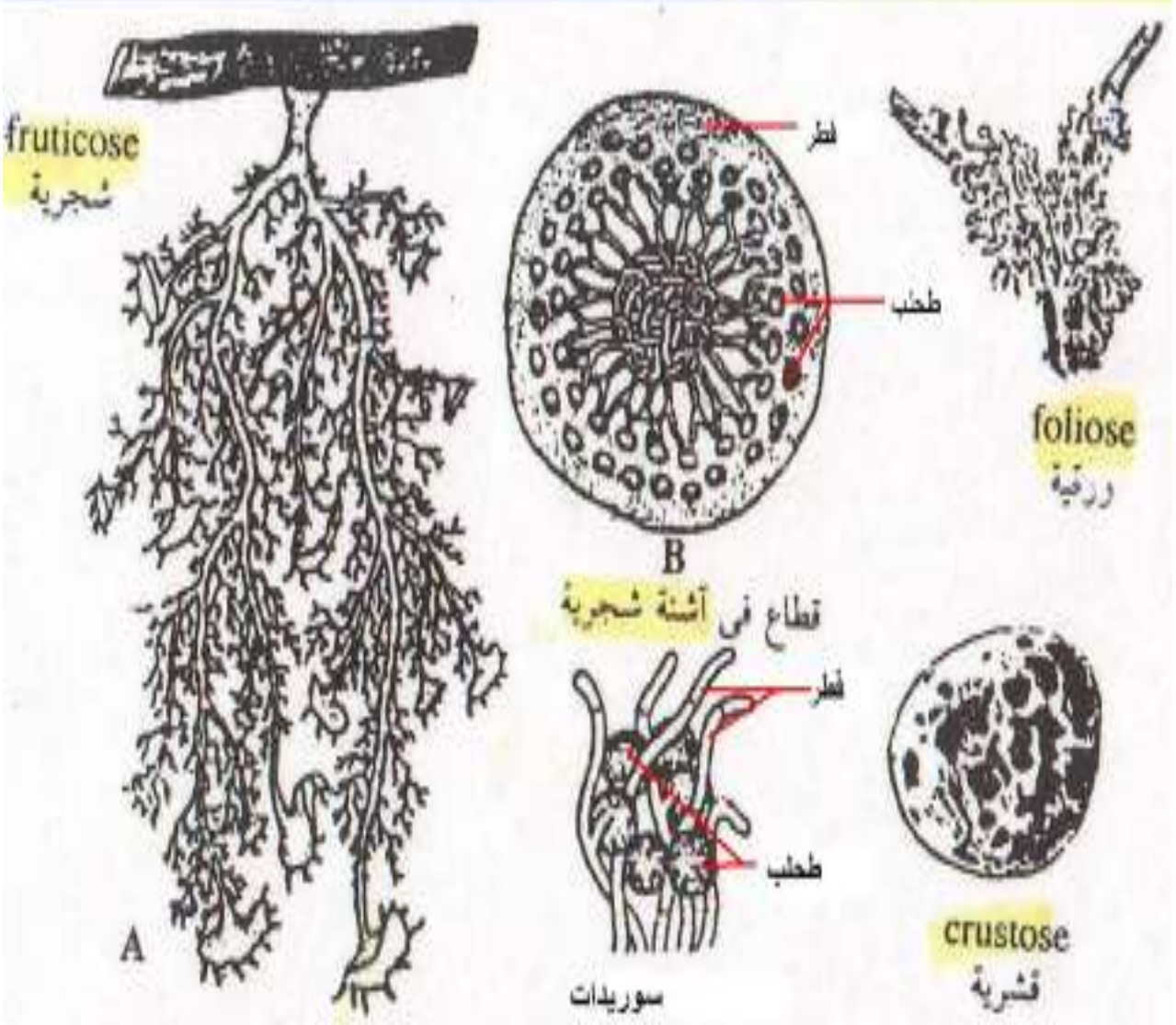
تابع (شكل ١٢٥): دورة حياة فطرة عيش الغراب

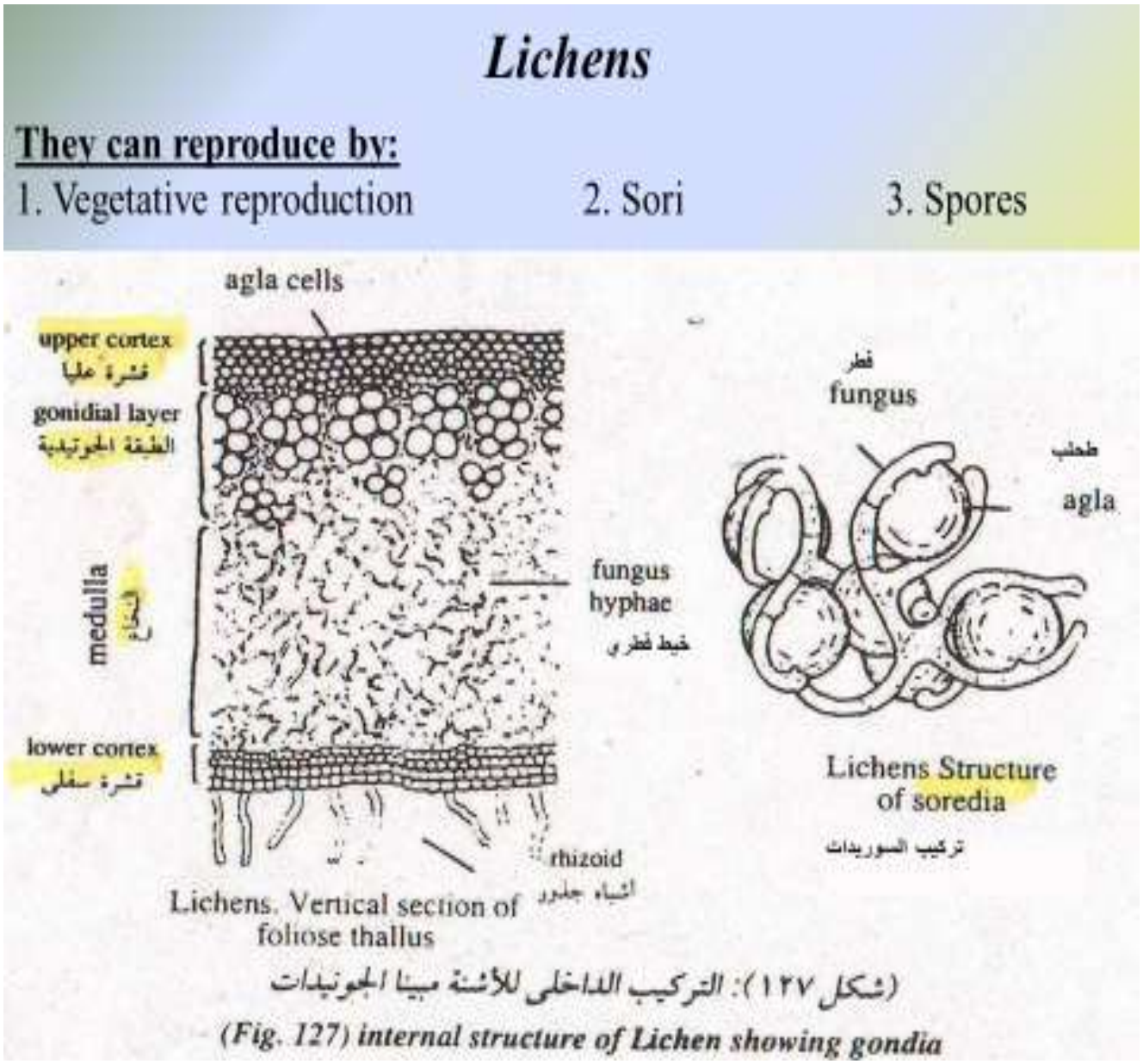
Cont. (Fig. 125) life cycle of *Agaricus*

(Vashishta, 1989)

Lichens

1. It is a symbiotic relationship between *Ascomycetes* or *Basidiomycetes* and *Cyanobacteria* .
2. It is found in mountain tops in moderate, cold or even temperate habitat.
3. It highly resists drought.
4. **It has three types**: 1. *Fruticose* 2. *Foliose* 3.*Crustose*





Reproduction:

1. Vegetative: Detached portions of the plant body can grow into a new thallus.

2. Soredia: Small bud-like out- growths called soredia may appear on the upper surface of the thallus. A soredium consists of one or more algal cells enclosed by few hyphae. It develops into a new thallus when carried by wind and falls on a suitable substratum.

3. Fungal spores: The fungal partner produces its characteristic spores (ascospores or basidiospores) which become shed from the lichen thallus to give a new one if it germinates in the neighbourhood of a proper alga.

Economic Importance Of *Lichens*:

1. They can change soil structure of arid soils by increasing its fertility as it helps in the accumulation of organic matter to the soil.
2. It contains dyes that is used in tanning and dying textile fabrics *i.e. Orchil*.
3. It can be used as food for animal and man.
4. It is used in the production of some antibiotics.
5. Fermentation and brewing of organic matter.
6. It causes several diseases to plants, animals and man.
7. It is used in the dairy and baking industry.
8. It is used as food. *i.e.* Mushroom.
9. In the pharmaceutical industry: as antibiotics and vitamins.
10. It plays an important role in Genetics, Biochemistry, Genetic Engineering because of its fast growth and reproduction.

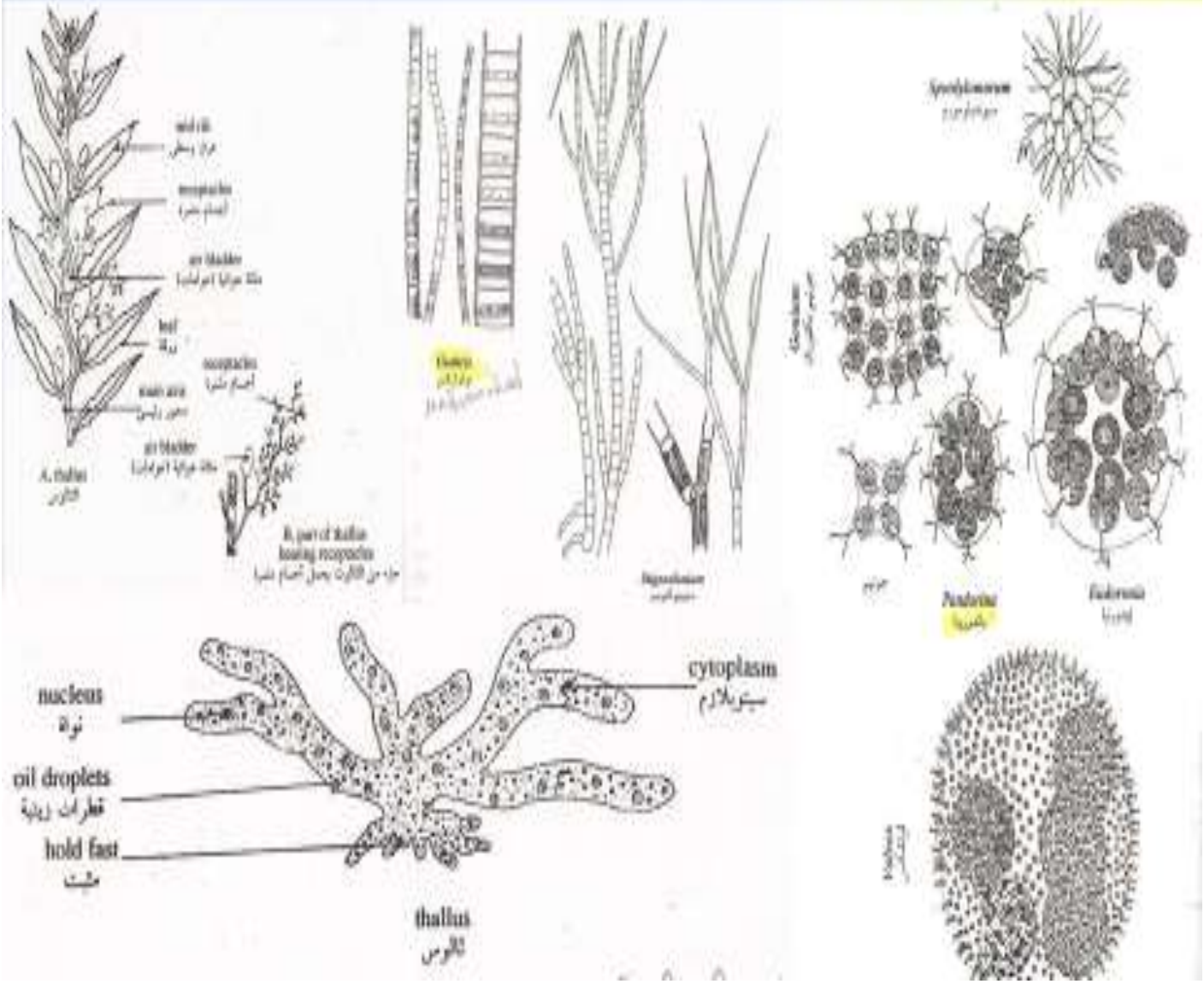
Algae

Comparison between *Cyanobacteria* and *Chlorophyta*

Points of Comparison	*Cyanobacteria*	*Chlorophyta*
Nucleus	Primitive nuclei with neither nuclear membranes nor nucleoli. They are classified under ***Prokaryota***.	They have true nuclei with both nuclear membranes and nucleoli. They are classified under ***Eukaryota***.
Plastids	They don't have plastids, but contain ***Chlorophyll*** **A, B** as well as other pigments like the blue ***Cyanin*** pigment.	They have plastids carrying ***Chlorophyll*** **A,B,C,D** and **H**. Also contain brown, red and orange pigments as ***Carotene*** **to protect *Chlorophyll* from high light intensity**.
Sexual Reproduction	Doesn't exist	Sexual organs are either similar or different (oogamy).
Form	Microscopic uniseriate branched or unbranched trichome covered by a gelatinous sheath.	Vary from microscopic to giant kelps. They are unicellular, multicellular, filamentous, tubular or leafy.
Nutrition	Some are *Photoautotrophic*, others absorb nutrients from the surrounding, while some live *Symbiotically*.	They live either *Photoautotrophic*, *Parasitic*, *Saprophytic*, or *Phagocytic*.

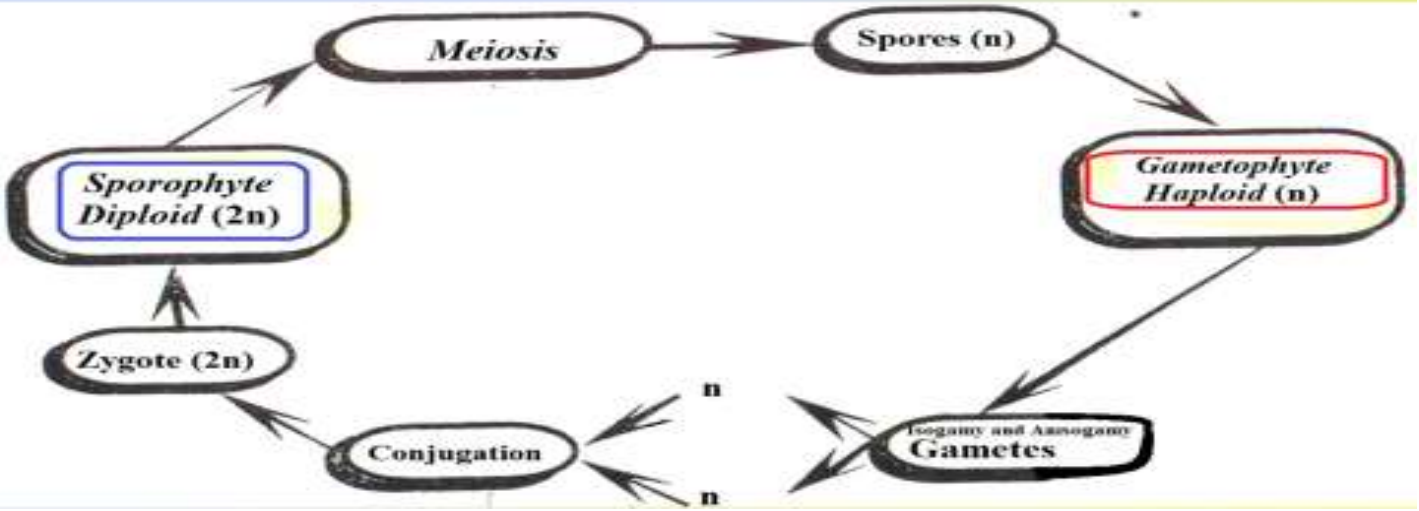
Algae

1. *Eukaryotic thallus*, although some giant *Algae* are differentiated into root, stem and leaf.
2. Unicellular (***Chlamydominas***), multicellular in primitive colonies (with no division of labor as ***Pandorina***), or in advanced colonies (with division of labor as ***Volvox***), filamentous (simple or branched), tubular (*Coenocytes*), or parenchymatic (leafy or herbaceous). They vary from microscopic to giant algae.



3. They have plastids carrying ***Chlorophyll*** **A,B,C,D** and **H**. Also contain brown, red and orange pigments as ***Carotene*** **to protect *Chlorophyll* from high light intensity, where it absorbs light and send it to *Chlorophyll***.
4. They live in aquatic habitats either fresh or marine, in stagnant or running water, in hot or cold springs.
5. They can be cultivated in the laboratory in **liquid (broth) media**.
6. Some live **floating** or **suspended** (*Phytoplankton*) or **Benthic** fixed on the plant outer surfaces (*Epihytic*), on rocks (*Epilethic*), mud (*Epipelic*), gravel (*Epipsamic*), inside animal tissues (*Endozoic*), inside plant tissues (*Endophytic*).
7. Starch, Laminarin (polysaccharide) or Mannitol (alcoholic sugar) are reserve food materials stored in *Pyrenoid* .
8. They live in different habitats of different temperature, where some can live in polar areas while some can live in hot habitats with 80°C.
9. They live either *Photoautotrophic, Parasitic, Saprophytic,* or *Phagocytic.*

10. They reproduce vegetatively, asexually (by Zoospores or *Aplanospores*) and sexually (by iso-and anisogamy). During the life cycles of some algal families only **"Gametophyte"** appear, while **"Sporophyte"** only appears during zygote formation. However, in other families, both stages appear and alternate with each other in the so called "**Alternation of Generation**"



11. **Physical Factors Affecting *Algal* growth:**

Temperature: ranges 0-80 °C

Salinity: Some can with stand high salinity as *Dunaliella*

12. **Factors affecting *Chlorophyll*:**

(a) Organism physiology

(b) Photosynthetic rates

(c) Metabolism (Anabolism & Catabolism).

(d) Type of reserve food material

13. **Classification of *Algae* depends on:**

1. Cell wall chemical structure.
2. Type of reserve food material.
3. Type of pigments.
4. Thallus form.
5. Number and arrangement of flagella.
6. Reproduction.
7. Life cycle.

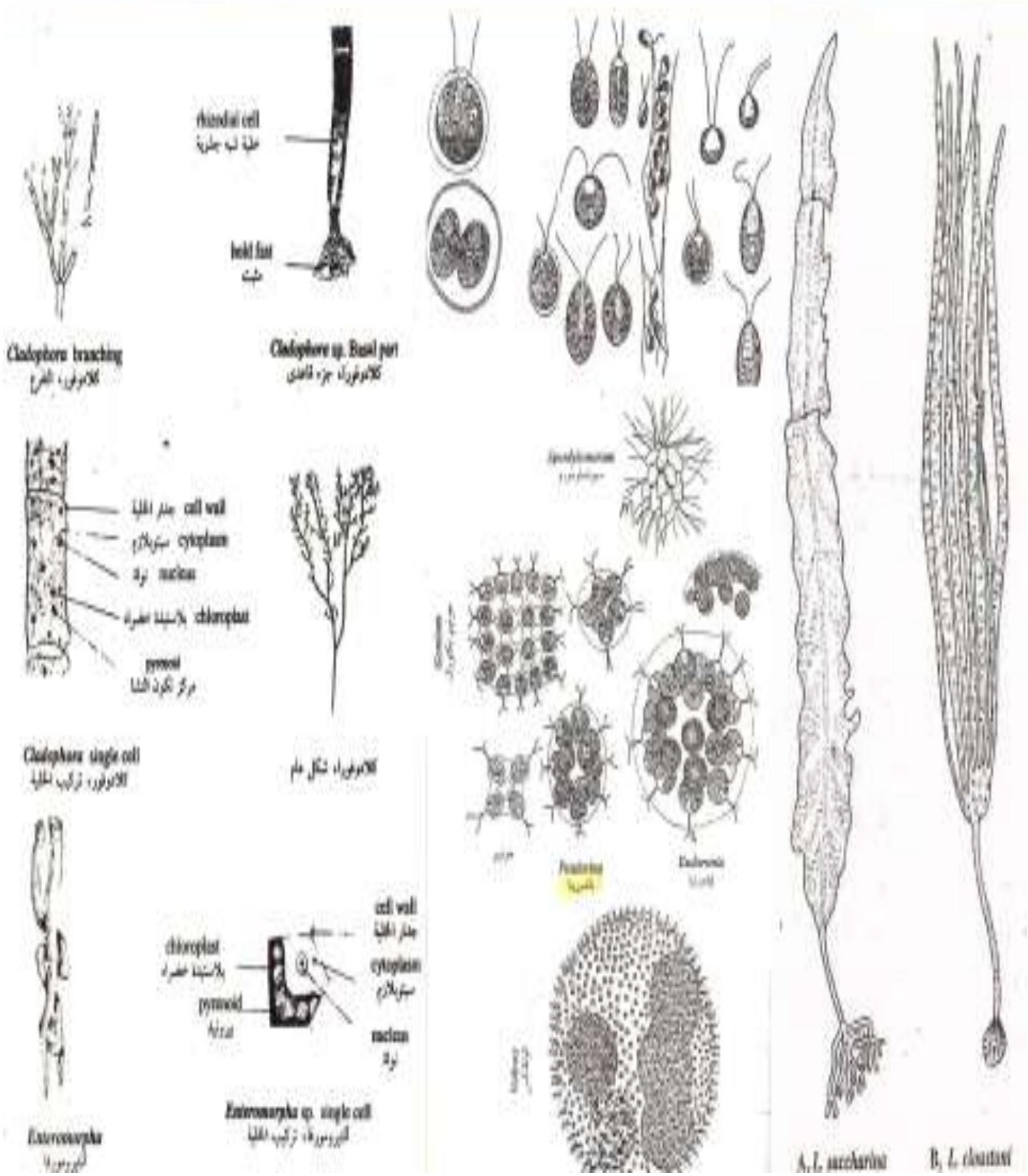
الأسواط، تركيب الجدار الخلوى والمادة الغذائية المدخرة

عدد الأنواع تقريبا	الأسواط	أصباغ البناء الضوئى	مكونات الجدار الخلوى	المادة المدخرة	الموطن البيئة	القسم أو المجموعة
٢٠٠٠٠	أحيانا لا يوجد أو يوجد ١-٨ كرباجية	كلوروفيل أ، ب كاروتينويدات	سكريات عديدة مع سليلوز	نشا	معظمها تقطن المياه العذبة، بعضها فى المياه البحرية أو ارضية أو هوائية	الطحالب الخضراء Chlorophyta
١٥٠٠	٢ جانبية كرباجية أمامية أحيانا	كلوروفيل أ، ج فيكوكزانثين كاروتينويدات	سليلوز مع حامض الألجين سكريات عديدة مع كبريتات	لامينارين مانيتول	كلها غالبا فى المياه البحرية - قلة قليلة للغاية فى المياه العذبة	الطحالب البنية Phaeophyta
٣٩٠٠	لا يوجد	كلوروفيل أ، د كاروتينويدات فيكوبيلينات كلوروفيل أ-ج	جاليدوز مع بكتين وأملاح كالسيوم سليلوز + سيليكات	نشا فلوريدى	معظمها بحرية، البعض منها فى المياه العذبة	الطحالب الحمراء Rhodophyta
٦٠٠٠	لا يوجد، أو يوجد أحيانا واحد أو اثنان كرباجية ١-٣	فيكوكزانثين كاروتينويدات	أحيانا غير موجودة	كريزولامينارين	مياه عذبة مياه مالحة أرضية - هوائية	الطحالب الحمصية (الدياتومات) Bacillariophyta
٧٠٠	لا يوجد	كلوروفيل أ،ب كاروتينويدات كلوروفيل أ،ب كاروتينويدات	لا يوجد جدار سليلوز	أجسام بارامبلونية نشا	مياه عذبة أو مالحة بعضها هوائية. مياه عذبة أو ضاربة للملوحة	الطحالب اليوجلينية Euglenophyta الطحالب الكارية Charophyta
٢٥٠	لا يوجد	كلوروفيل أ،ج كاروتينويدات	لا يوجد	نشا	غالبا مياه عذبة بعض منها بحرية	الطحالب الكريصية
١١٠٠	الغالبية	كلوروفيل أ، ج بيريدينين كاروتينويدات	جاليوز أحيانا غير موجود	نشا	مياه عذبة ومالحة هوائية	الطحالب البيضية لبعض الأسواط

Chloropyta

1. It comprises 2000 species.
2. They are green in color due to the presence of *Chlorophyll* a, b, *Carotene* and *Xanthophyll*.
3. Unicellular or multicellular. They are found in colonies.
4. Plastids are found solitary or in groups, they vary in shape either discoid, cup-shaped, spiral or rod-like.
5. They are widely spread in aquatic marine or fresh habitats.
6. Starch is the reserve food material, stored in structures known as *Pyrenoids*.
7. Their walls are mainly cellulosic, however other species may have other substances.
8. **Plastids differ from those found in higher plants in:**
   1. Large in size 2. Few in numbers 3. Don not contain Grana
9. Unicellular (*Chlamydominas*), multicellular in primitive colonies (with no division of labor as *Pandorina*), or in advanced colonies (with division of labor as *Volvox*), filamentous (simple as *Spirogyra* or branched as *Cladophora*), tubular as *Vaucheria* (*Coenocytes*), or parenchymatic (leafy as *Ulva* or herbaceous as *Caulepra*).
10. **Cells of advanced colonies are characterized by:**
    1. Somatic cells.
    2. Gonidia: Oval (units of asexual reproduction)
    3. *Oogonium*: circular (female sex organ).
    4. *Antheridium: oval (male* sex organ).

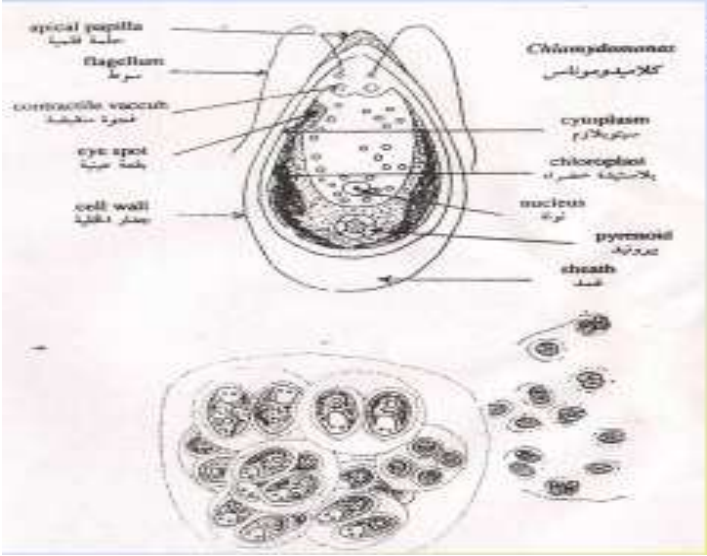
Chloropyta


Rhizoidal cell
خلية ذات جذيرة
hold fast
مثبت
Cladophora branching
كلادوفورا، التفرع
Cladophora sp. Basal part
كلادوفورا، جزء قاعدي
cell wall
جدار الخلية
cytoplasm
سيتوبلازم
nucleus
نواة
chloroplast
بلاستيدة خضراء
pyrenoid
مركز تكون النشا
Cladophora single cell
كلادوفورا، تركيب خلية
كلادوفورا، شكل عام
Enteromorpha
Enteromorpha sp. single cell
A. L. saccharina
B. L. cloustoni

Chlamydomonas

Kingdom: *Protista*
Class : *Chlorophyta*
i.e.: Chlamydominas

1. It lives in fresh water and can be found in wet soil.
2. It blooms during Winter, especially in water bodies rich in ammonia.

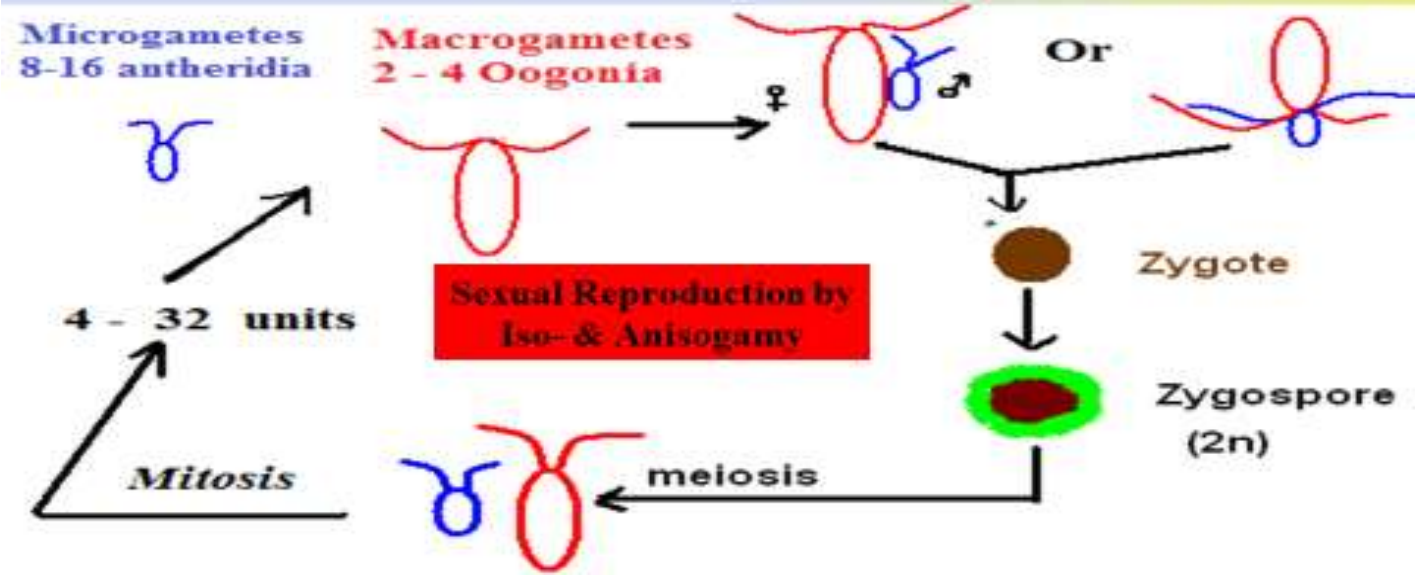


Reproduction:

1. **Asexually:**
   - The cell movement slows down .
   - The cell stops growing.
   - The cell loses their flagella.
   - The cell gets rounded and divides to form 2 to 8 units.
   - Each unit (n) acquires two flagella forming a zoospore.

2- ***Palmellal* Stage:** Happens in unsuitable environmental conditions (low N), as:
- The cell wall is surrounded by a gelatinous sheath. - Each unit divides into 4
- No flagella are formed, until environmental conditions gets better.
- The formed units are then released acquiring 2 flagella forming zoospores.

3. **Sexually:** They reproduce by gametes which differ in size and number according to their type. The gametes are either iso- or anisogamy.



- **Sexual reproduction (Oogamy):** It rarely happens

1. Antheridia divide into fast units.
2. Oogonium (egg cell) content becomes more viscous and darker in color.
3. One of the fast antheridium fertilizes the egg forming the zygote (2n).
4. Meiosis occurs then Mitosis, forming zoospores (n) which give rise to new units.

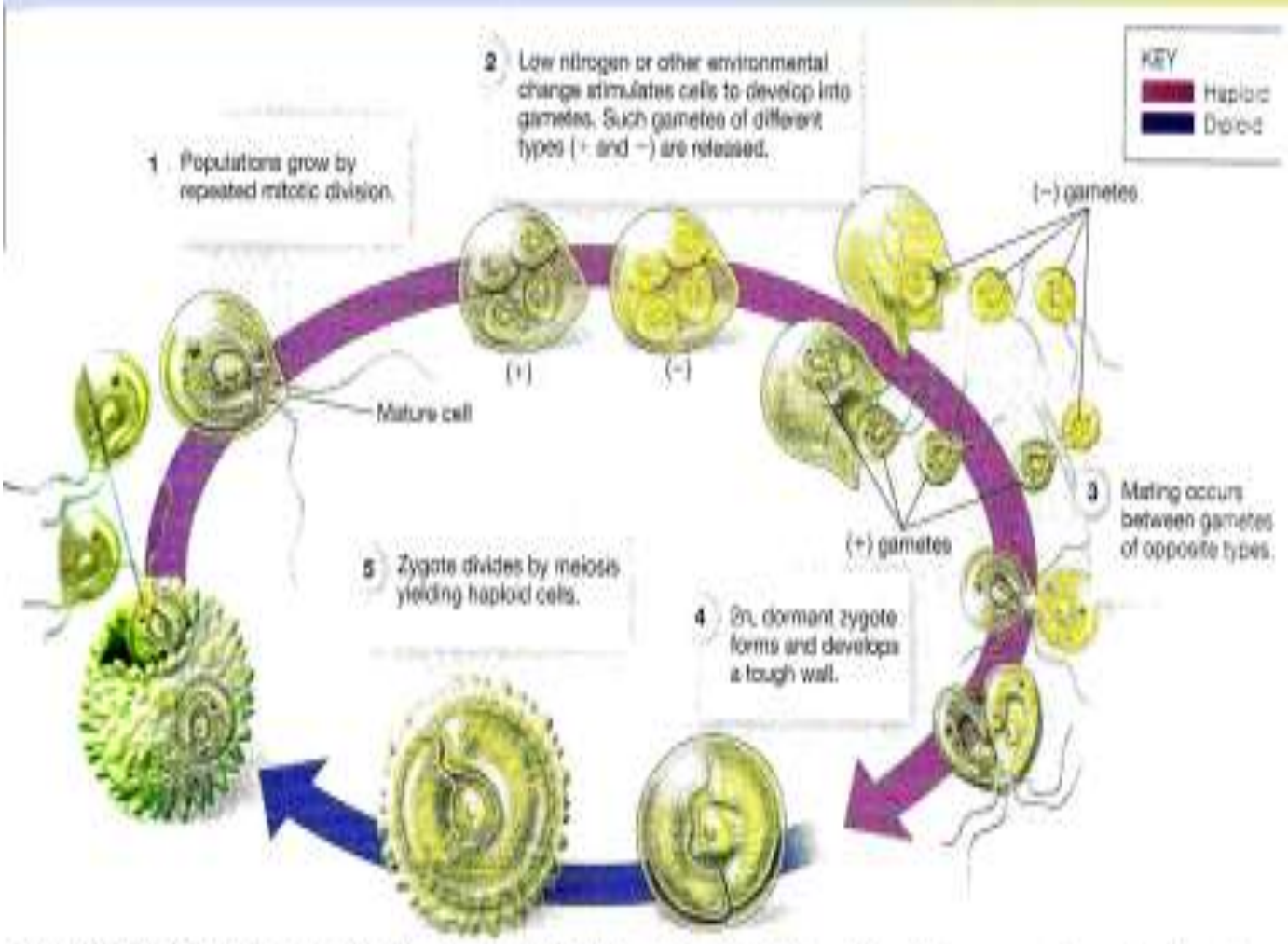


FIGURE 23.20 *Chlamydomonas*: **The Structure and Life Cycle of This Motile Green Alga.** During asexual reproduction, all structures are haploid; during reproduction, only the zygote is diploid.

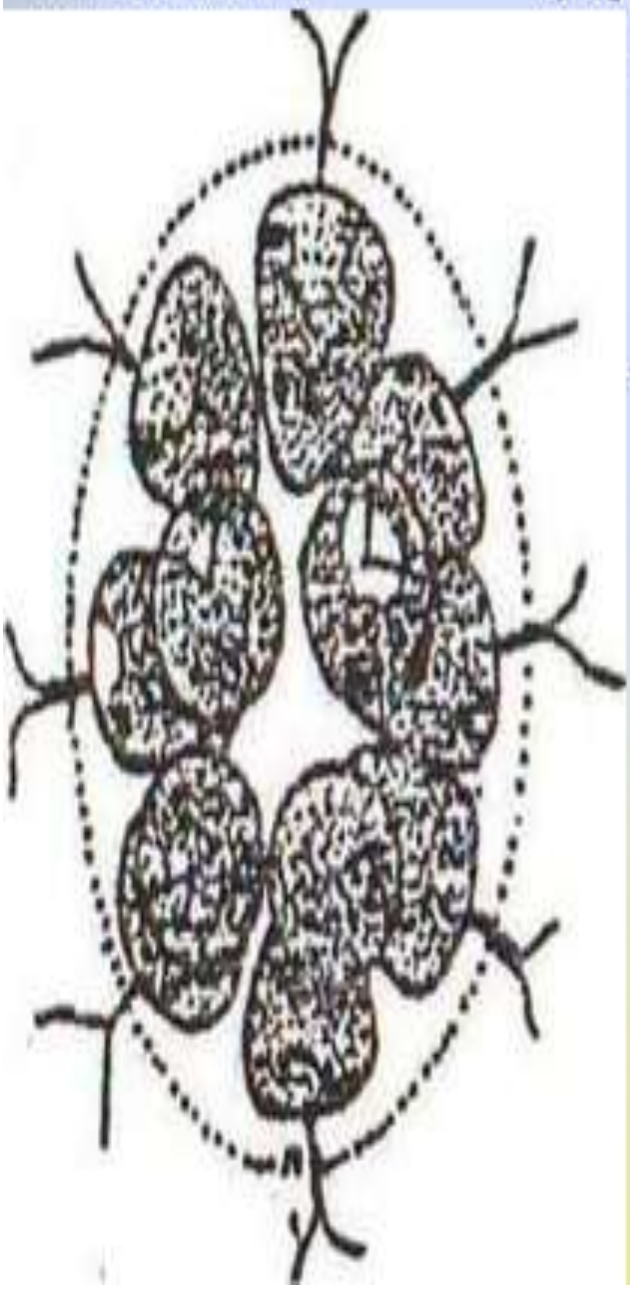
Pandorina

Kingdom: *Protista*

Class : *Chlorophyta*

i.e.: Pandorina

1. It lives in fresh water habitat.
2. It is a primitive solid spherical colony.
3. It consists of 16 Chlamydominal cells, connected by cytoplasmic strands.



4. Their cells have no division of labor, as each cell lives independently. The only function they perform together is locomotion.

- **Reproduction:**

1. Asexually:

- The colony stops moving and sinks in the pond.
- It loses its flagella.
- Each cell divides into 16 units similar to those of the mother colony, forming the daughter colony.
- Upon maturation of the daughter colony, the mother colony wall ruptures releasing the daughter colony where it can grow to form other new colonies.

2. **Sexually:** (Isogamy)

- Each cell in the colony divides into 16 – 32 units, each acquires two flagella.
- Each two cells unites forming the zygote, where it loses its flagella and stops moving.
- The zygote surrounds itself by a thick wall forming "**Zygospore**" (2n).
- When the environmental conditions gets better meiosis takes place, followed by mitosis.
- Each 16 Chalmydominal cells surround themselves by a cytoplasmic mass forming a new colony.
- Upon maturation of the daughter colony, the mother colony wall ruptures liberating the daughter colonies where they can grow to form other new colonies.

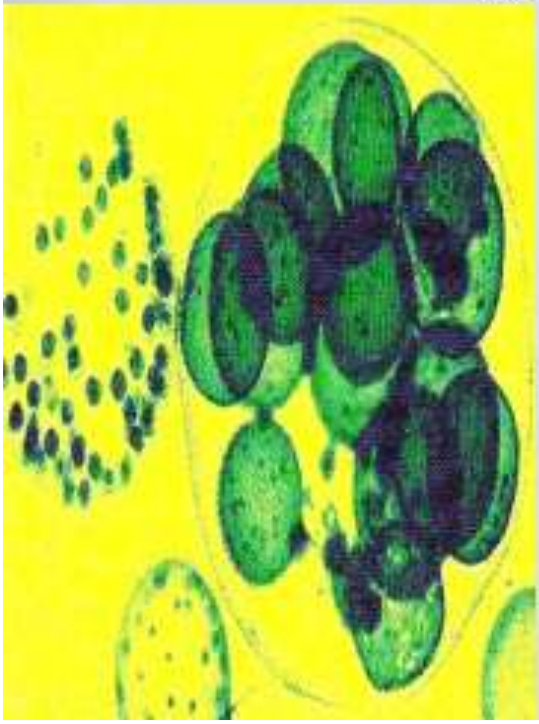
Volvox

Kingdom: *Protista*

Class : *Chlorophyta*

i.e.: Volvox

1. It lives in fresh water habitat.
2. It is an advanced hollow spherical colonyIt consists of 500 to 2000 *Spherella* cells, connected by cytoplasmic strands and moves as a unit by cilia.



3. Cells are characterized into 4 types , each perform a certain function:
   1. **Somatic cells:** for photosynthesis and motion.
   2. **Gonidia:** for Asexual reproduction.
   3. ***Antheridium*** : Oval (2-50 cells), units of male sex organ.
   4. ***Oogonium*:** Non- motile spherical units, found in lesser numbers than *Antheridia*, but are larger in size. They are units of female sex organ.

- **Reproduction:**
  1. **Asexually:** It occurs in Spring where:
     - Gonidial cells enlarge in size, dividing to give daughter colonies that remain inside the mother colony till full maturation.
     - Upon maturation, the mother colony wall ruptures liberating the new daughter colonies.

2. Sexually: (Oogamy) It occurs in late Spring during the **Summer**.

- *Antheridia* divide into a large number of spindle-shape *Antherizoids*.
- One of the *Antherizoid* can reach the *Oogonium* which enlarges in size, its contents become dark and viscous and stops moving. Then fertilization takes place.
- The *Zygote* then surrounds itself by thick wall forming the *Zygospore* (2n).
- *Meiosis* occurs when environmental conditions gets better followed by *Mitosis* forming a new colony.

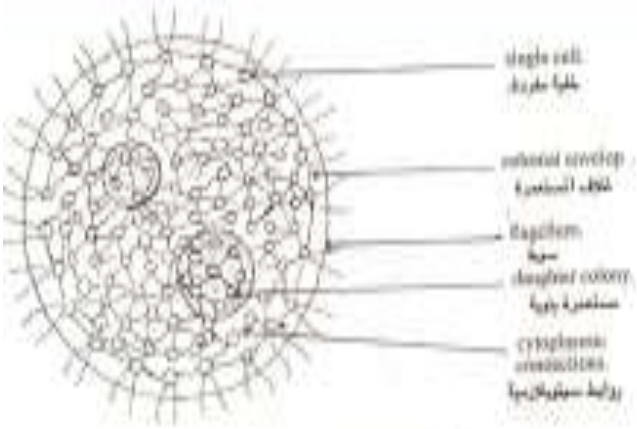


Fig. 12.1, *Volvox* sp. parent colony with daughter colonies
شكل (١٢-١) فولفوكس : مستعمرة أبوية بها مستعمرات بنوية

Fig.12.3, *Volvox* sp. a colony with sex organs.
شكل (١٢-٣) فولفكس مستعمرة يتضح بها الأعضاء الجنسية

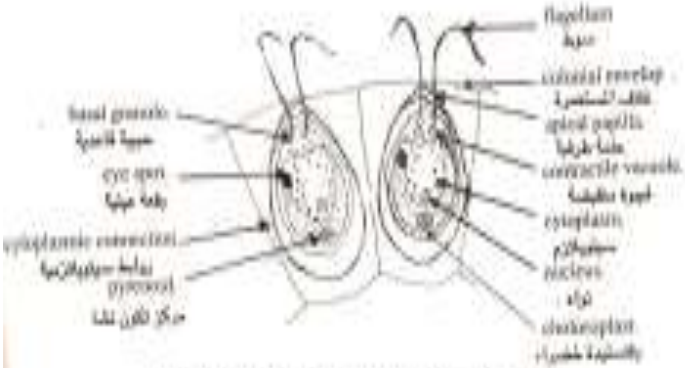


Fig. 12.2, *Volvox* sp. cell arrangement and structure
شكل (١٢-٢) فولفوكس : ترتيب وتركيب خلايا المستعمرة

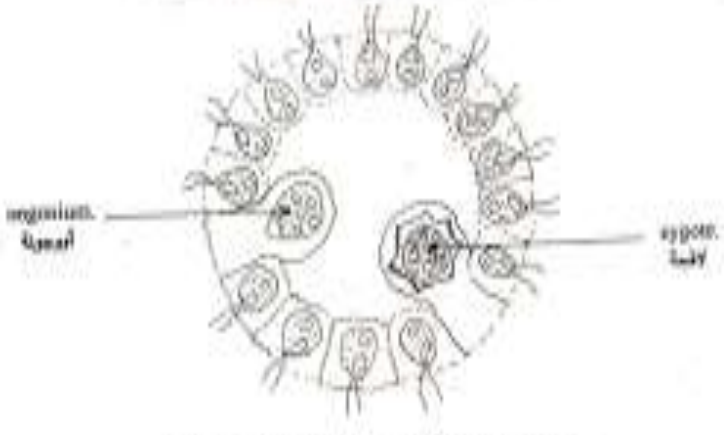
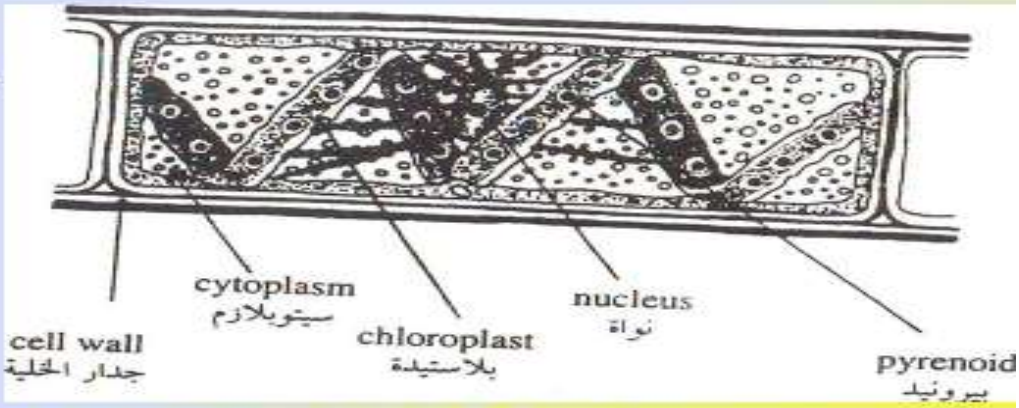
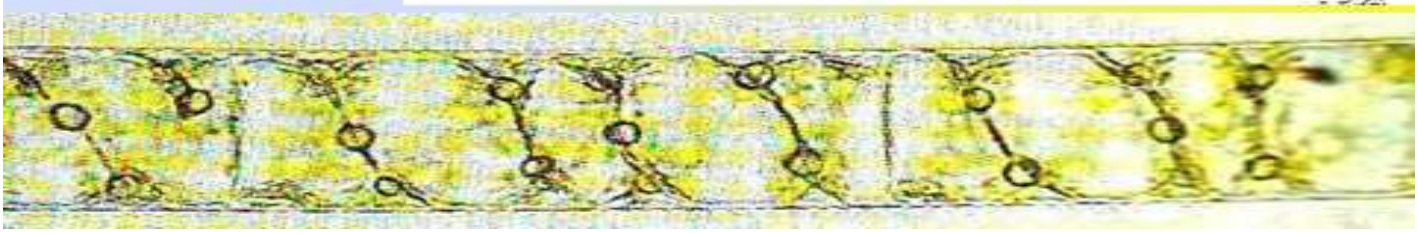


Fig. 12.4, *Volvox* sp. a colony with a zygote
شكل (١٢-٤) فولفكس : مستعمرة يتضح بها اللاقحة

Spirogyra

Kingdom: *Protista*
Class : *Chlorophyta*
i.e.: Spirogyra





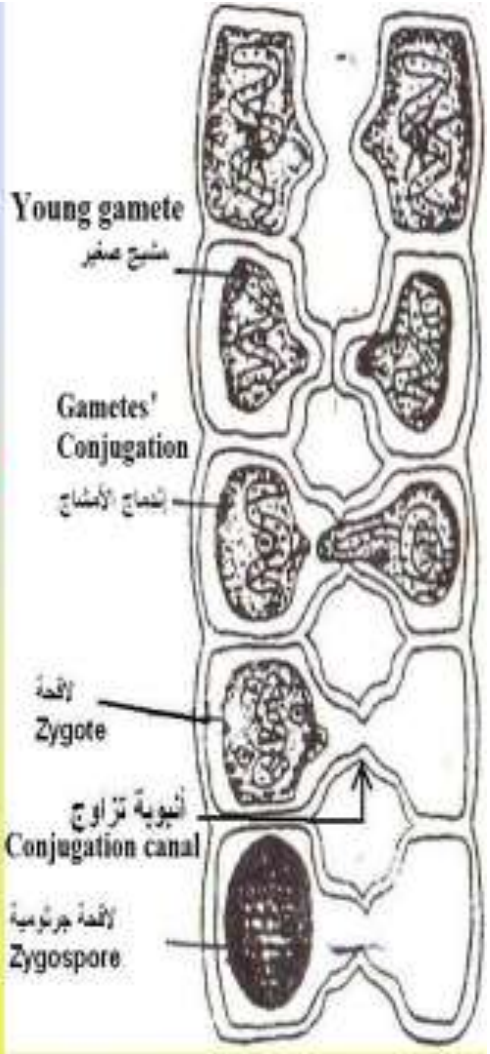
Kingdom: *Protista*

Class : *Chlorophyta*

i.e.: Spirogyra

1. It lives in fresh stagnant waters.
2. It's a simple filamentous unbranched alga.

- **Reproduction:**
  1. **By Fragmentation**
  2. **Sexually: Lateral** conjugation between **neighboring** cells (***Isogamy***), or **scalariform** conjugation between **opposing** cells (***Anisogamy***).
     - The two cells approach each other.
     - Through a conjugation canal the content of one cell (male) moves to the other receiving cell (female).
     - The produced *Zygote* surrounds itself by a thick wall forming *Zygospore* that sinks in the bottom of the pond.
     - The *Zygospore* divides into 4 nuclei.
     - Three of them die and the fourth gives rise to a new *Spirogyra* filament.

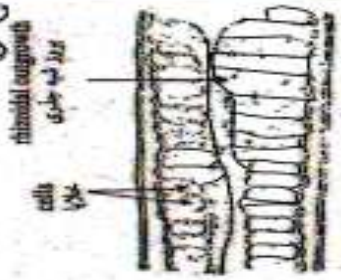


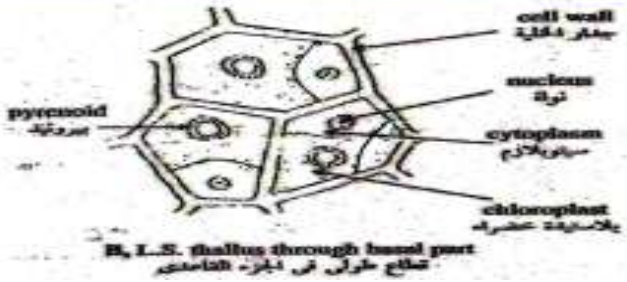
Ulva

Kingdom: ***Protista***
Class : ***Chlorophyta***
i.e.: Ulva

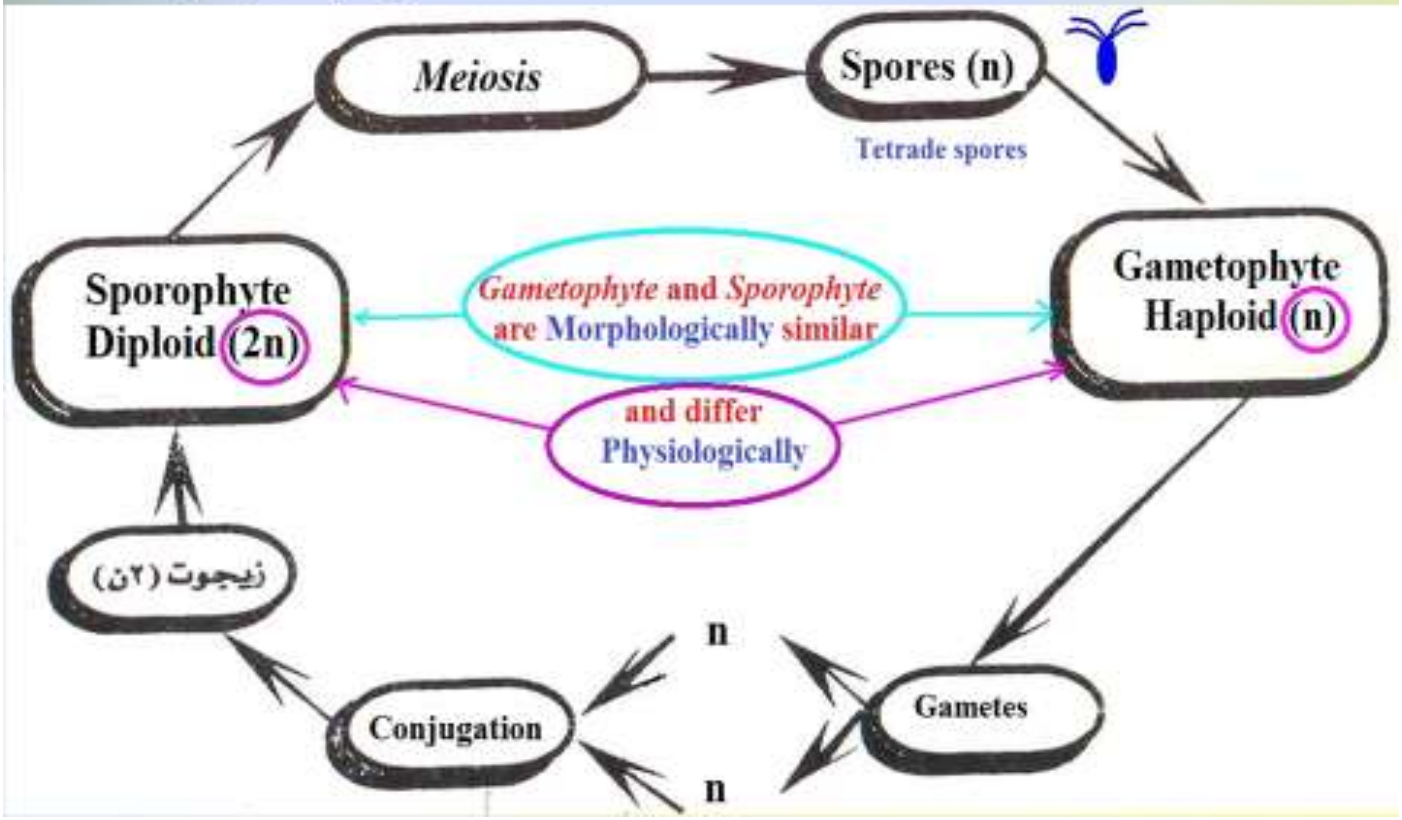
1. It lives in marine habitat where it is widely spread in the intertidal zone.
2. Its existence is a pollution indicator of nitrogenous wastes.
3. It is a wide leafy alga, 2 cells wide and reaches 30 cm in length. It ends with a basal part called the holdfast or foot (perennial) where the alga attaches itself to rocks.
4. It grows by dividing in two perpendicular directions.

- **Reproduction:**
  1. **Vegetatively:** by budding
  2. **Asexually:** by *Zoospores*
     - Each cell turns into sporangium divides mitotically into 4 – 8 *Zoospores.*





3. Sexually: by isogamy

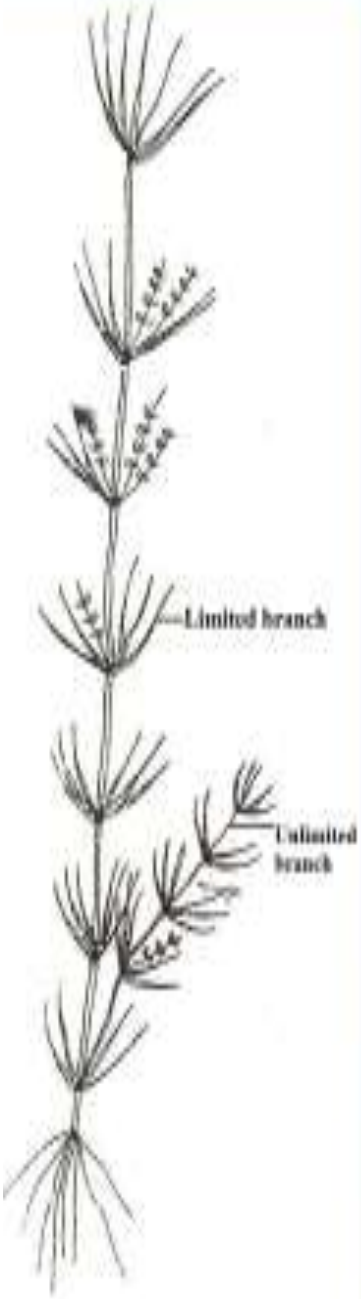


Chara

Kingdom: ***Protista***

Class : ***Charphyta***

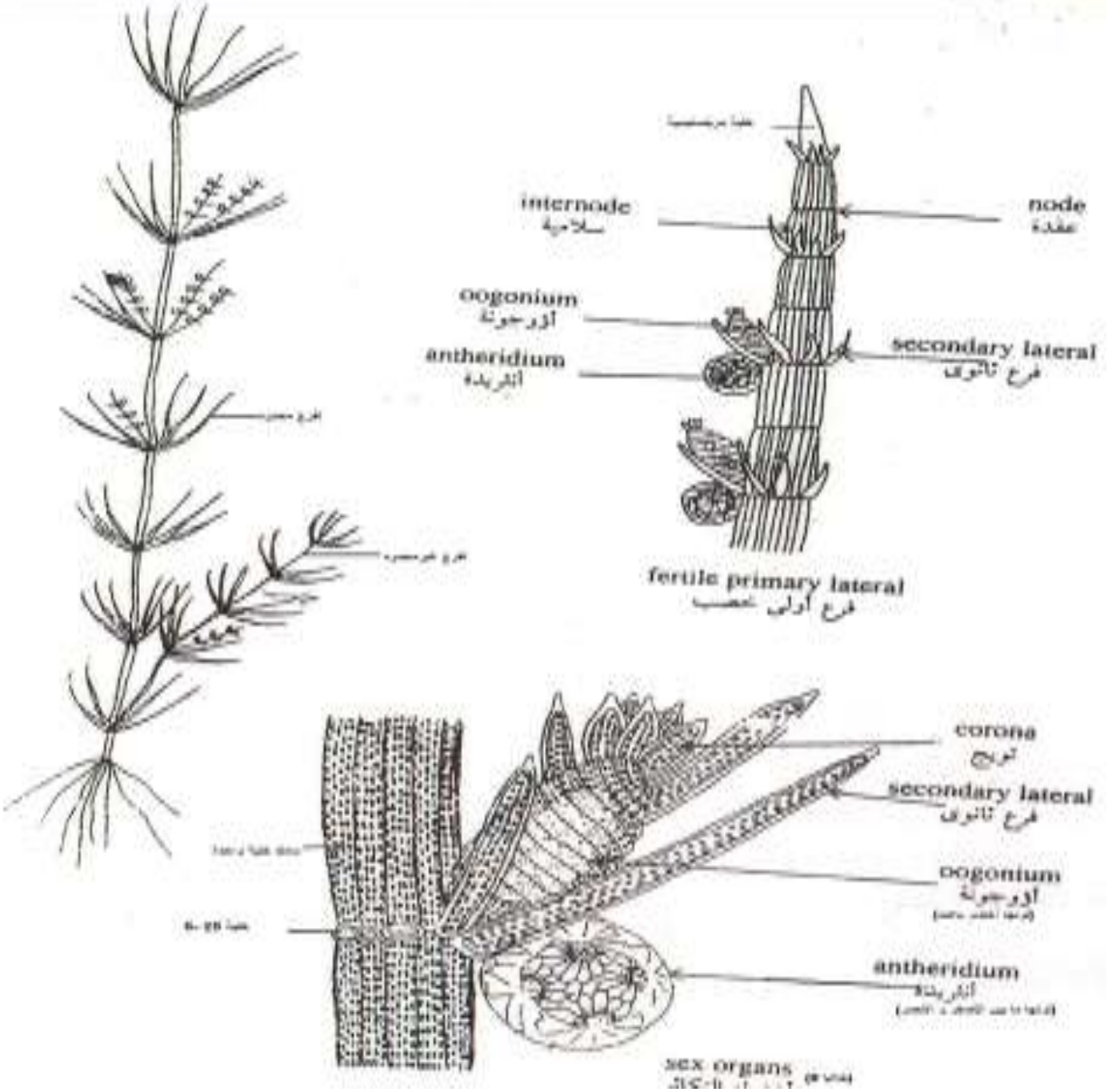
i.e.: Chara



1. It lives in fresh and brackish water habitat. It blooms in warm stagnant water.
2. It looks like herbaceous cover over the shallow stagnant pond
3. It precipitates Ca and Mg carbonates, forming a lime cover in the pond bottom where it can help in the formation of fossils.
4. **Resembles *Chlorophyta* in:**
   - Presence of Chlorophyll
   - Presence of starch as a reserve food material.
   - The *Thallus* is Haploid.
5. **Differ from *Chlorophyta* in:**
   - Presence of *Protonema* (filamentous form) formed after meiosis.
   - Presence of complicated sex units of *Anthridia* and *Oogonia*.
   - The *thallus* is differentiated into nodes and internodes, resembling higher plants.

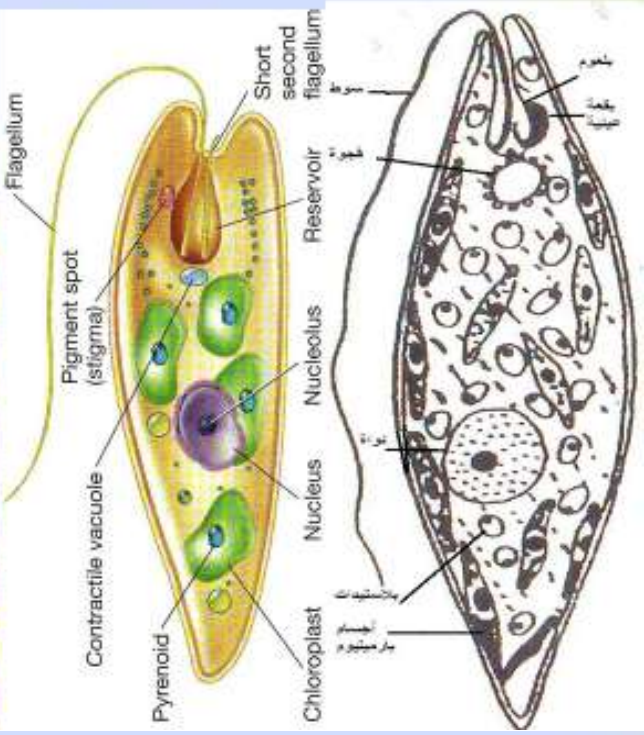
- **Reproduction:**
  1. **Asexually:** There is no asexual spores.
  2. **Sexually:** by Oogamy, where:
     - *Antheridia* mature to form 8 cells, each contain *Antherizoids*.
     - One of the *Antherizoids* fertilize the egg by a canal under the Corona, forming the *Zygote*.
     - The zygote divides into two cells (upper and lower cells).

- The *Zygote* divides meiotically then mitotically resulting in 4 nuclei, one moves to the upper cell while the other 3 remain in the lower one, forming the *Protonema* (n) that divides into nodes and internodes.
- The *Protonema* feeds on the contents of the upper cell.



Euglena

Kingdom: *Protista*
Class : *Euglenophyta*
i.e.: Euglena



1. They can live in fresh and salt waters. They are abundant in waters rich with organic matter.
2. Unicellular with no cell wall. It moves by whipping its flagellum as well as an amoeboid movement.
3. It contains *Chlorophyll* a and b as well as *Xanthophyll* and *Carotene*.
4. The reserve food material is in the form of some lipids and paramylum bodies.

- **<u>Reproduction</u>:**
  1. **Binary fission:** The cell divides longitudinally.
  2. **Palmellal Stage:**
     - The cell divides into several units and surrounds itself by a thick gelatinous sheath.
     - When environmental conditions gets better, the gelatinous sheath lysis, liberating the protoplasmic units.
  3. **Cyst formation:** The cell becomes red in color where it surrounds itself by a thick gelatinous sheath for protection until environmental conditions gets better. Then the gelatinous sheath lysis and the cell regains its activity. **Cyst formation is not considered a method of reproduction, but a way of self preservation.**
  4. **Sexually:** There is no proof that it exists in *Euglena*.

Chromulina

Kingdom: ***Protista***
Class : *Chrysophyta*
i.e.: Chromulina

1. Unicellular with one or two flagella.
2. The cell wall is made up of **silica** and **pectin**.
3. It does not have *Pyrenoid* and the reserve food material is ***Leucosin***.
4. The plastids carries other brown or yellow pigments beside *Chlorophyll*.
5. Sexual reproduction is not known.

- **Reproduction:**

1. Binary fission: The cell divides longitudinally.
2. Asexual reproduction: By *Statospores*, where the cell divides into 2 – 4 amoeboid units or flagellated spores.

Vaucheria

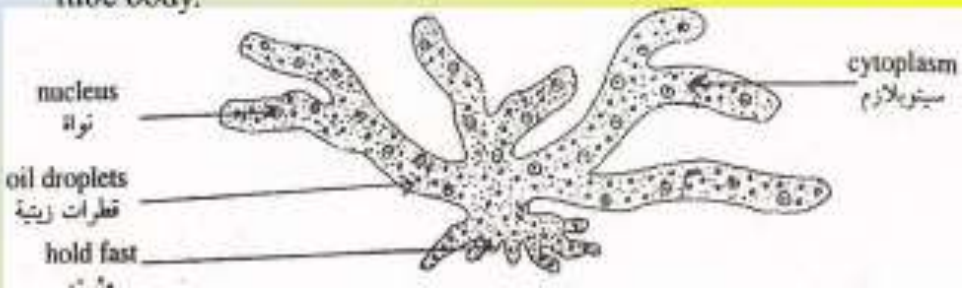
Kingdom: ***Protista***
Class : *Xanthophyta*
i.e.: Vaucheria

1. It lives in fresh water habitat.
2. It is morphologically similar to members of *Chlorophyta*.
3. Plastids are discoid or lens-like, carrying *Chlorophyll* a, b, c, d and h as well as *Xanthophyll* and *Carotene*.
4. There is no *Pyrenoid* and the reserve food material is oil.

- **Reproduction:**

1. Asexually:
- Coenocytic apical growth are formed on the tip of filaments.
- It is filled with cytoplasm, nuclei and plastids.
- A transverse wall is then formed to separate the sporangium from the rest of the thallus, which then acquire several external flagella.
- Mature spores are liberated from a lateral opening.
- Spores germinate forming two tubes, a colorless one gives rise to the rhizoids, whereas the other tube forms the coenocytic tube body.

Fig. 39.1. *Vaucheria* sp.



Vaucheria

2. Sexually: Oogamy on the same thallus.

- The *antheridia* divides to give rise to the *Antherizoids* where one can fertilize the oogonium.
- The *Zygote* surrounds itself by a thick wall forming the **oospore**.
- The diploid nucleus divides meiotically, then mitotically forming a new alga.

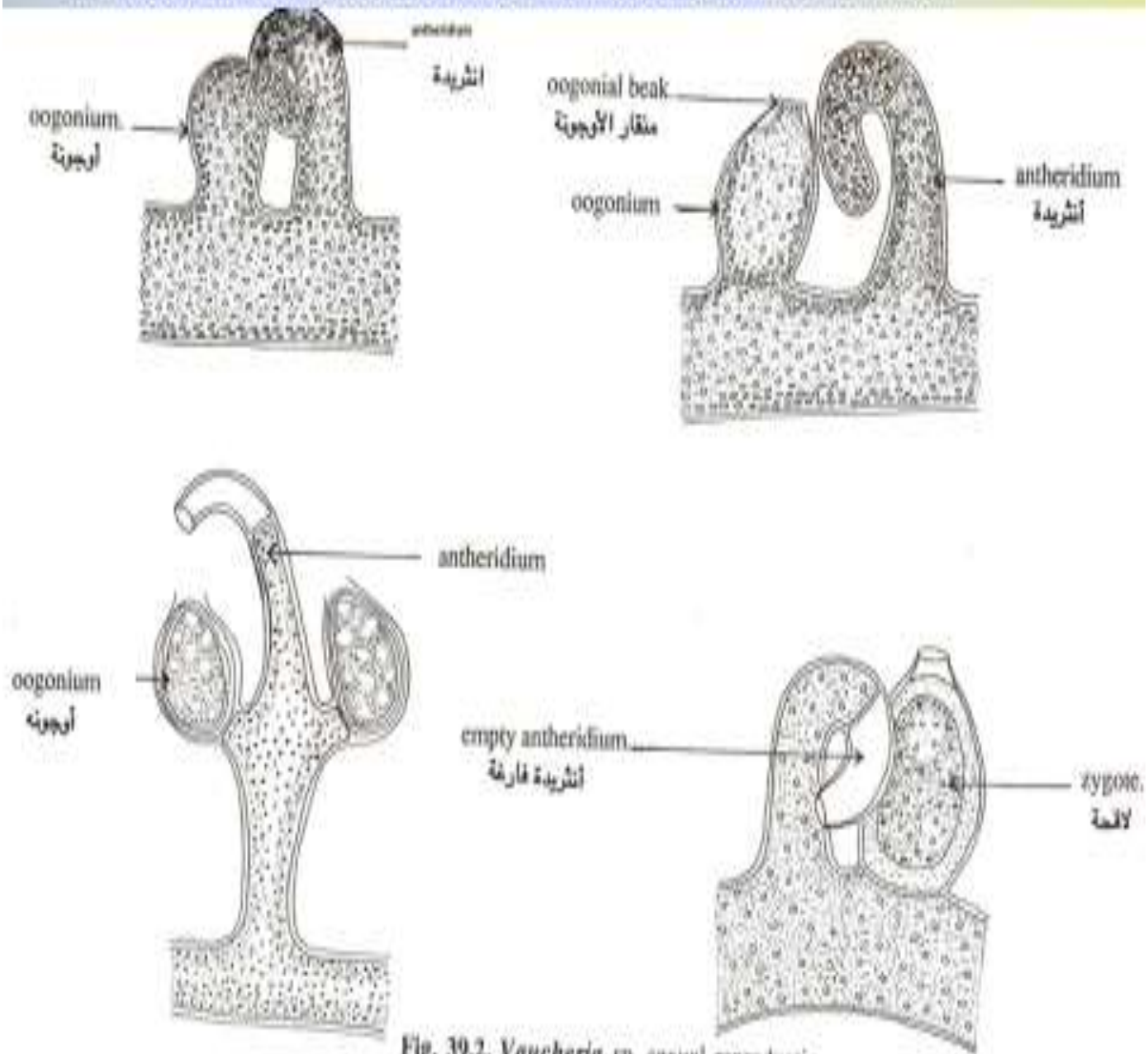
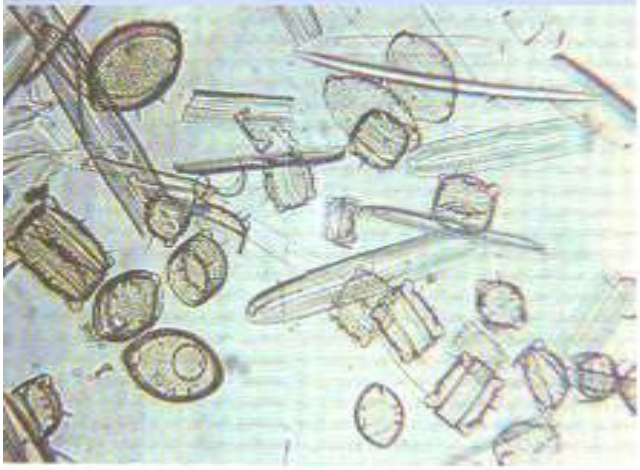


Fig. 39.2, *Vaucheria* sp. sexual reproduction.

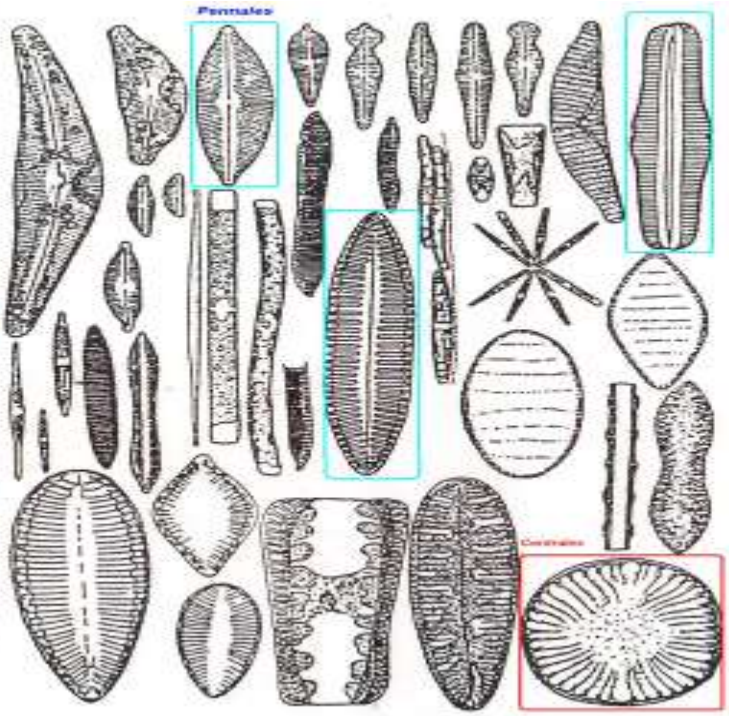
شكل (٣٩ - ٢) فيوشيريا . التكاثر الجنسي

Diatoms

Kingdom: *Protista*
Class : *Bacillariophyta*
i.e.: Diatoms



(b) Diatom frustules



Diatoms

1. The cell wall is formed of Silica and Pectin. When the cell dies Silica precipitates forming diatomaceous earth that is used in making explosives, filters that can with stand high temperatures, varnishes, tooth pastes and food for fish.
2. They live in fresh and salt waters as well as wet soils. They are of up to 5000 species.
3. They are either floating or suspended on other bodies, either solitary or in colonies.
4. The reserve food material is leucosin and oil.
5. The nucleus is diploid.

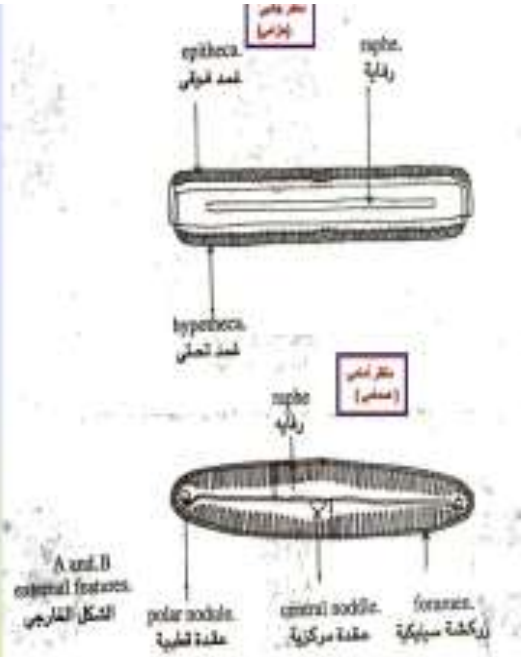
- **Reproduction:**

  1. Asexually: - The frustule divides into two valves, where the diploid nucleus divides into two nuclei.

  - Continuing to divide asexually, the cell gets smaller in size to the extent that it **stops** dividing asexually and starts sexual reproduction.

  2. Sexually:

  - The two cells approach each other and surround themselves by a common gelatinous sheath. Each nucleus divides meiotically producing 4 nuclei, 2 or 3 vanish later.
  - A gamete of each cell conjugate with the other, forming two zygotes (or one) where they form two spores that gradually grow to form two new frustules.



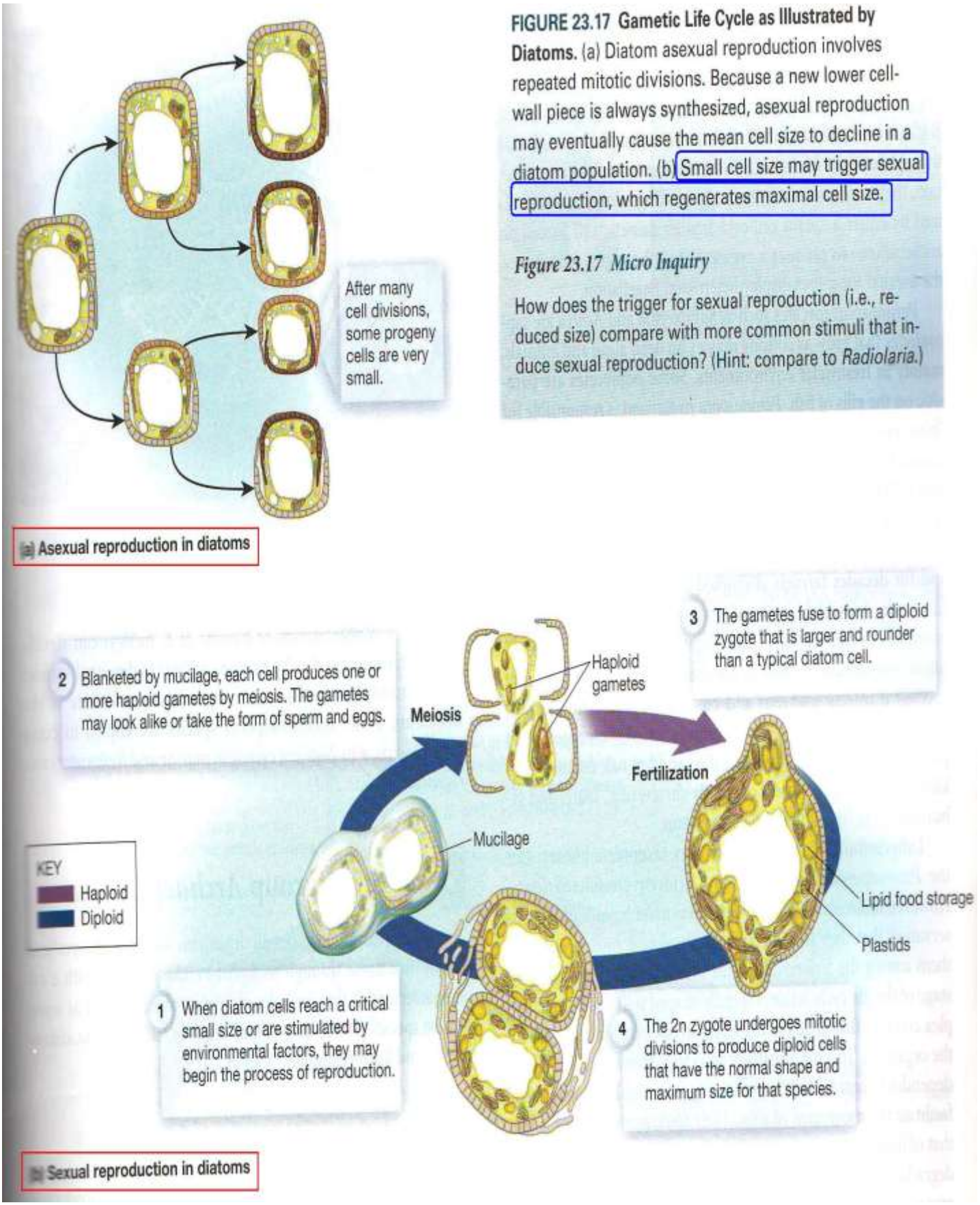


FIGURE 23.17 Gametic Life Cycle as Illustrated by Diatoms. (a) Diatom asexual reproduction involves repeated mitotic divisions. Because a new lower cell-wall piece is always synthesized, asexual reproduction may eventually cause the mean cell size to decline in a diatom population. (b) Small cell size may trigger sexual reproduction, which regenerates maximal cell size.

Figure 23.17 Micro Inquiry

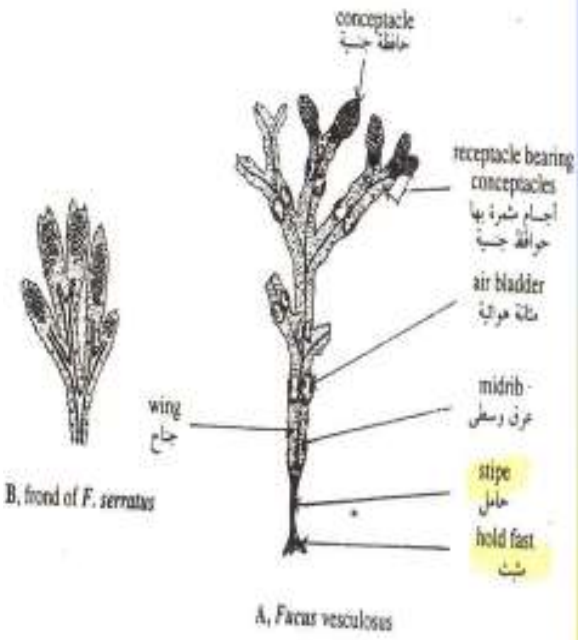
How does the trigger for sexual reproduction (i.e., reduced size) compare with more common stimuli that induce sexual reproduction? (Hint: compare to *Radiolaria*.)

Fucus

Kingdom: ***Protista***
Class : *Phaeophyta*
i.e.: Fucus

1. They mostly live in salty waters.
2. Their color vary from brown to olive green due to the presence of Fucoxanthin, Chlorophyll (a, b, c) in addition to carotene and Xanthophyll.
3. They are dichotomously branched filamentous or herbaceous forms, reaches up to 60 m in length.
4. The reserve food material is mannitol or laminarin.
5. The cell wall is made up of cellulose and algin.

- **Economic Importance:**
  1. It is a source of iodine and algin.
  2. It is used as a biof-ertilizer and a fodder.
- **Reproduction:**
  1. **Vegetatively:** by fragmentation.
  2. **Asexually:** by *Aplanospores* or *Zoospores* which are characterized by the presence of two flagella, one is feathery-like while the other is whip-like.
  3. **Sexually:** isogamy or anisogamy or oogamy.



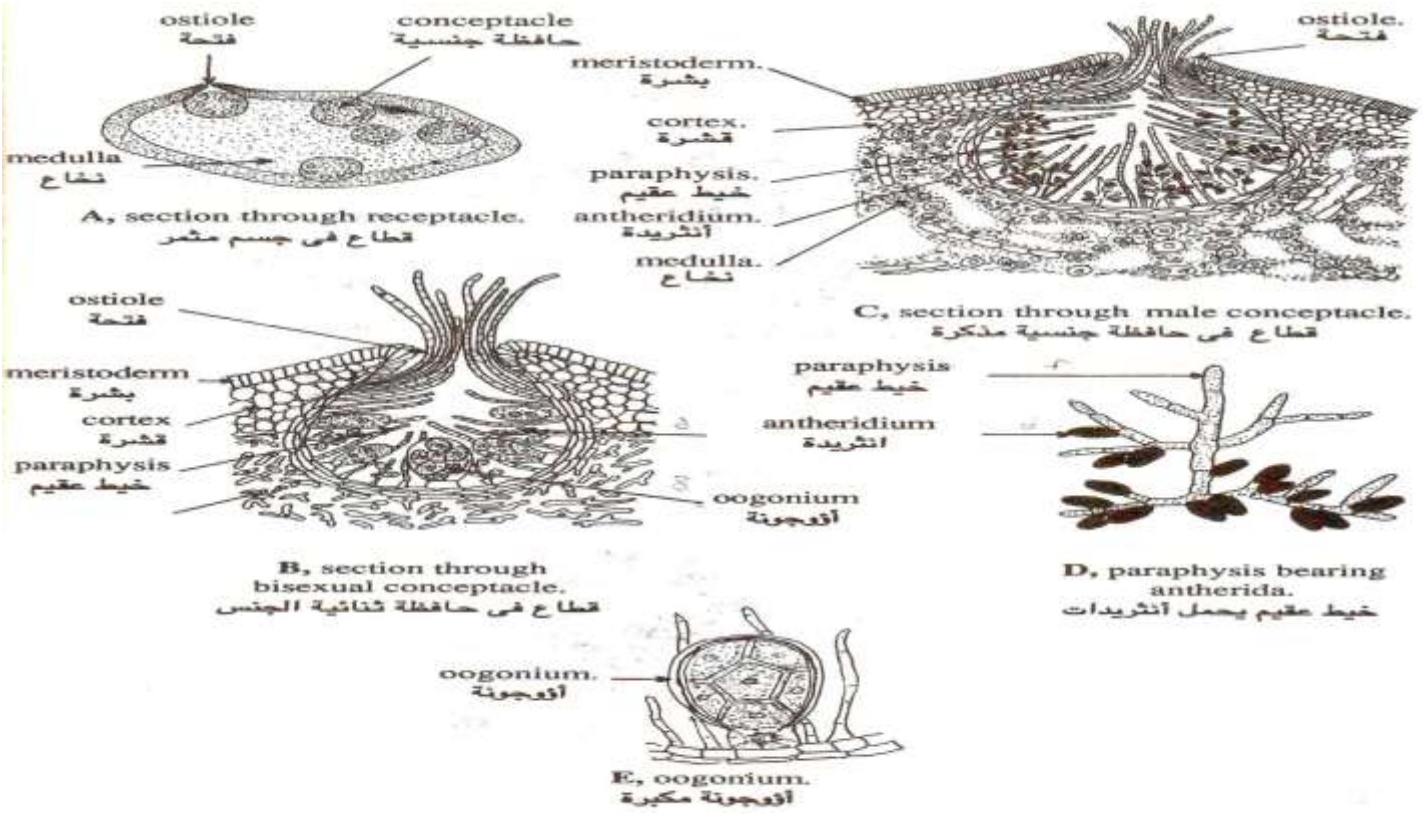


Fig. 46.2. *Fucus* sp.
شكل (٤٦-٢) فيوكس .

Fucus

The zygote grows to give a sporophyte thallus, then meiotic division occurs. **Gamtophyte is reduced** and is only represented by male and female gametes. **Hence, there is no alternation of generations** . Where the alga is only represented by Sporophyte.

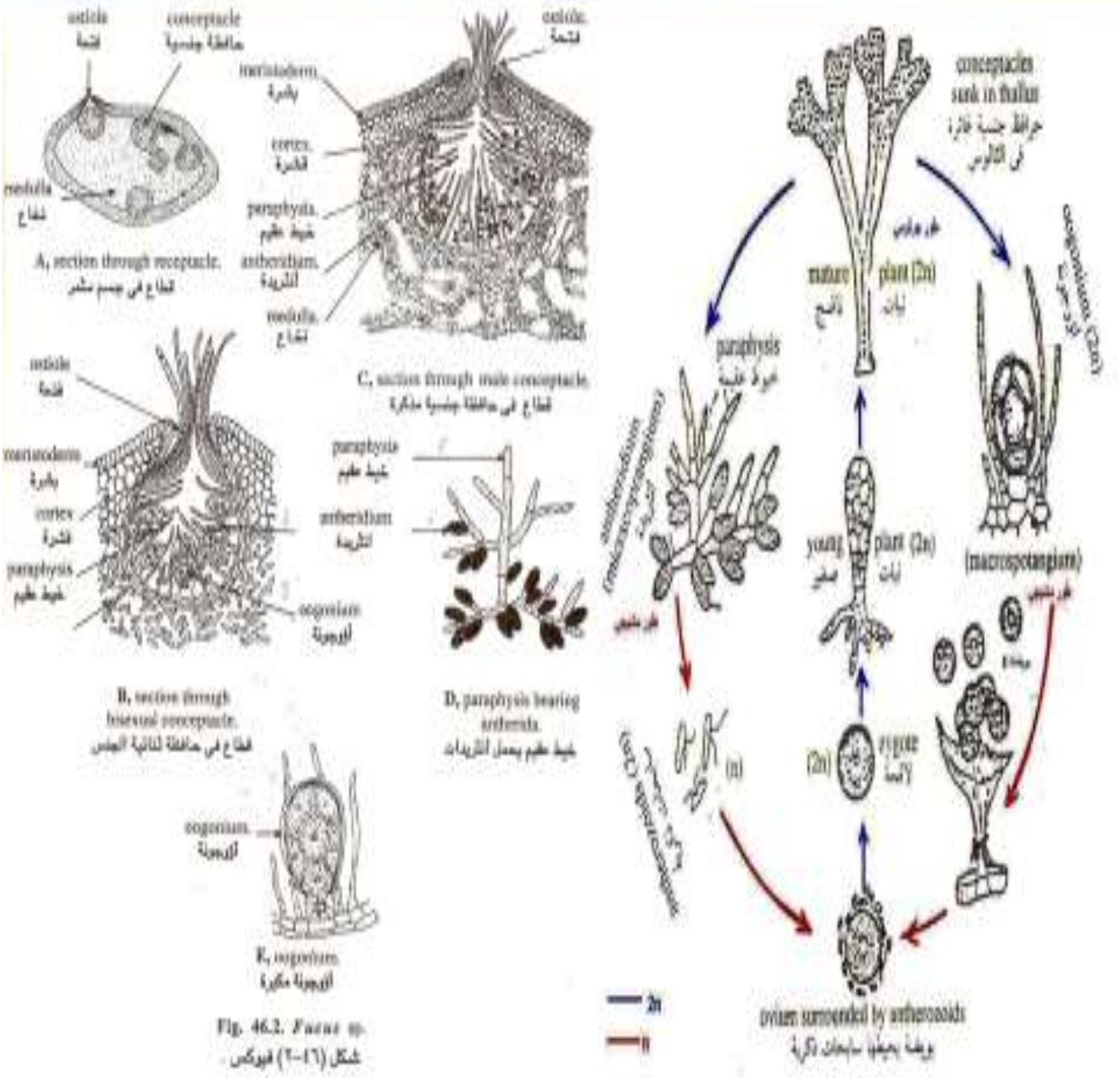


Fig. 46.2. *Fucus* sp.

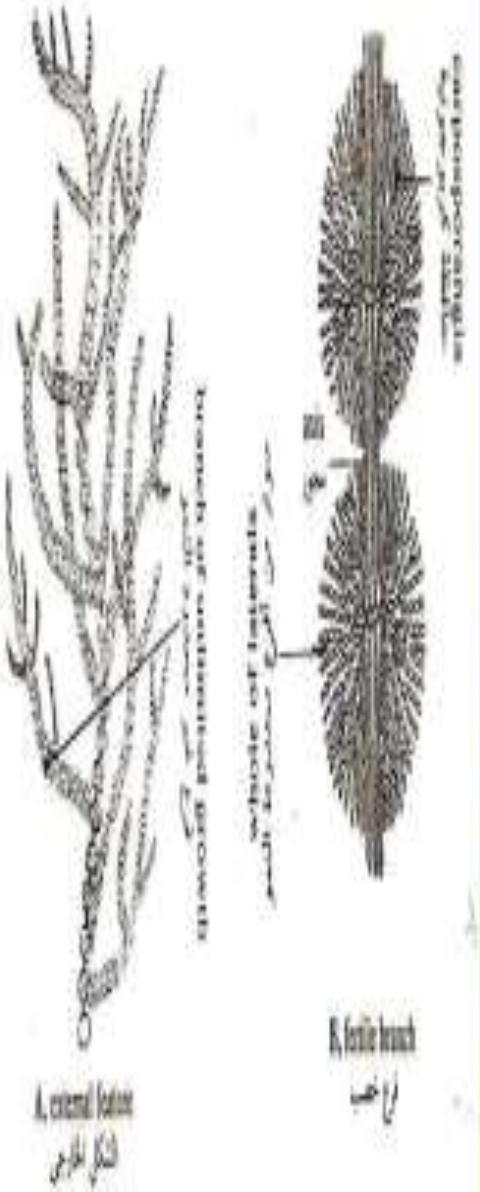
شكل (١٦-٢) فيوكس

Batrachospermum

Kingdom: *Protista*

Class : *Rhodophyta*

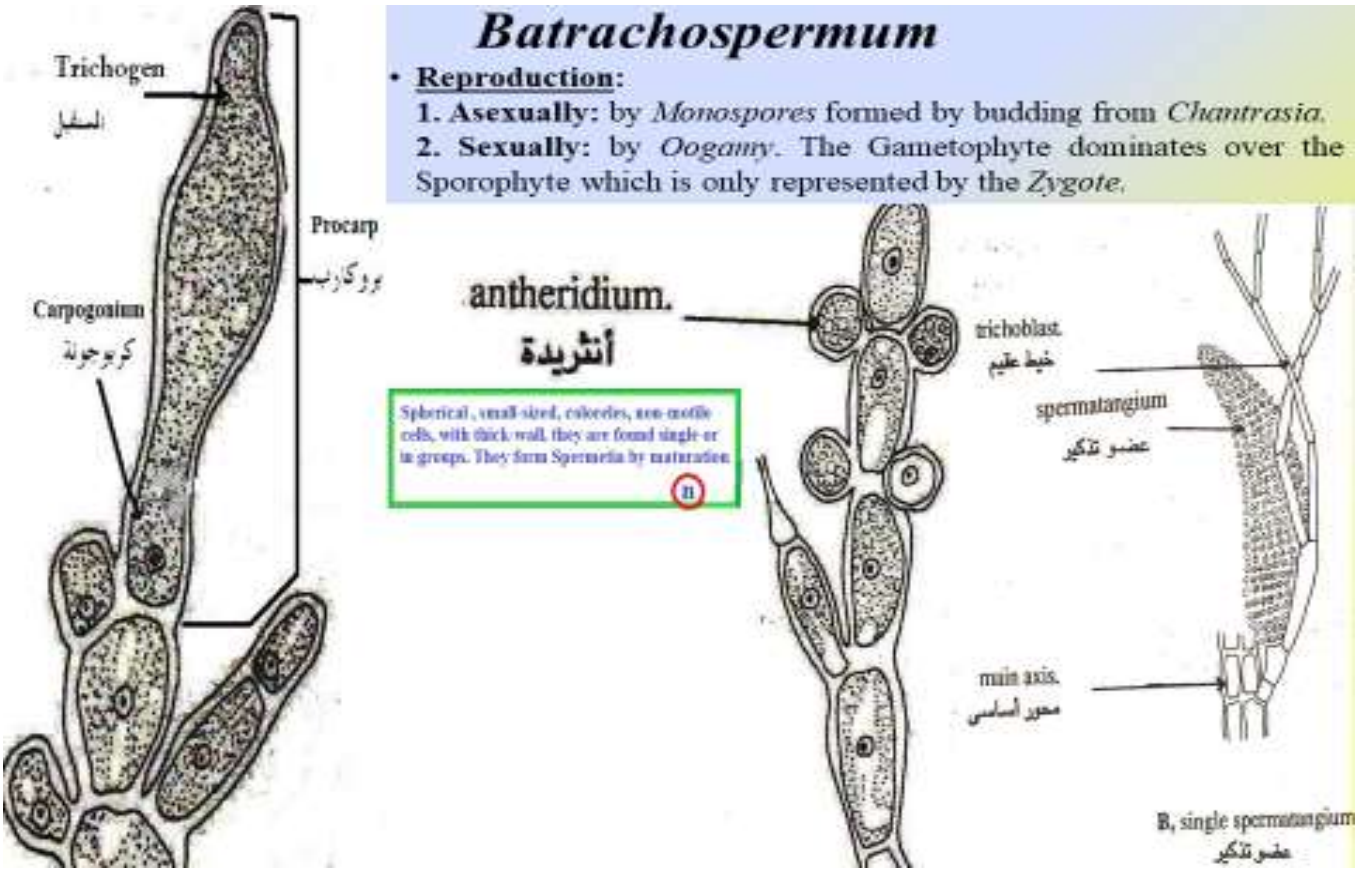
i.e.:



1. They live mostly marine habitat, although some can live in fresh ones.
2. Benthic forms on rocks, stones or endo- or epiphytic.
3. Forms a large amount of Ca in their cells and help in coral formation.
4. It Contains **Chlorophyll (a,d) and Carotenoids** as well as the **red Phycoerythrin** or the **blue Phycocyanin**. Thus they range in color from **red** to **violet** or **dark brown**, according to:
   - Age of alga.
   - Concentration and percentage of pigments.
   - Environmental conditions.
   - Depth of water where the alga lives in.
5. It is used as food.
6. A source of **Agar**, necessary for solid lab media preparation.
7. A source of **Carrageenan**, used in food industry.
8. The alga is filamentous or leafy- like in structure.
9. Multicellular with thick cell wall of two layers:
   - The external; is made up of gelatin and pectin.
   - The internal; is cellulosic.
10. The reserve food material is **Floedean Starch**.

***Batrachospermum*:**

- A fresh water alga, reaches up to 15 cm in length.
- The thallus axis is thread-like. Monecious or dioecious.
- Cells have lining plastids with one Pyrenoid.



Sexual reproduction:

It is a case of advanced oogamous condition. Thallus may be monoecious or dioecious depending on species. The carpogonia (female sex organs) are borne terminally on small branches of the thallus. The carpogonium at its upper end is prolonged into a trichogyne which shrivels away after fertilization.

The nucleus, chromatophores and the reserve food material are located in the lower swollen portion of the carpogonium. Antheridia or spermatangia (male sex organs) are single-celled spherical structures borne in clusters at the tip of the lateral branches of the thallus. Contents of each antheridium become metamorphosed into a non-motile, spherical male gamete or spermatium, which is lib The spermatium thus liberated floats in water and is finally carried away by water current to come in contact with the trichogyne of the carpogonium.

The walls dissolve at the point of contact of the spermatium and the trichogyne and the contents of the spermatium pass through the open passage and move down the trichogyne into the base of the carpogonium where both male and female nuclei fuse together.

After fertilization the trichogyne is separated from the carpogonium by a mucilage plug and finally shrivels and disappears. The diploid carpogonial nucleus divides meiotically into two haploid nuclei.

Aerated through a narrow apical slit of the antheridial wall. Simultaneously with the nuclear division a lateral protuberance is developed from the carpogonium. One of the two daughter nuclei moves into this protuberance, the other remaining in the carpogonium. The protuberance is cut off from the carpogonium by a wall and is known as gonimoblast initial.

Then the daughter nucleus of the carpogonium divides mitotically along with the formation of another protuberance on the other side of the carpogonium in which the daughter nucleus migrates and ultimately a second gonimoblast initial is produced and like this several gonimoblast initials are produced which by repeated divisions form branched or unbranched filaments known as gonimoblast filaments.

The terminal cells of the gonimoblast filaments become enlarged, each one developing into a carposporangium, the contents of which become metamorphosed into a single, non-motile carpospore. Along with the development of the carposporangium and carpospore numerous sterile threads are developed from the cells below the carpogonium which ultimately envelope the gonimoblast filaments. These threads are known as the enveloping threads.

The structure so formed with gonimoblast filaments surrounded by the enveloping threads is the cystocarp. The carpospore is liberated from the carposporangium and germinates into a heterotrichous filament which morphologically is quite different from the main thallus.

The heterotrichous filament is known as Chantransia stage or juvenile stage. For long time this heterotrichous filament was considered to be a new genus Chantransia.

But later on it was found that the apical cells of the lower branches of the erect threads develop into new Batrachospermum thallus and the so-called Chantransia is nothing but a stage in the life cycle of the alga Batrachospermum. Finally, it was linked up in the life cycle of Batrachospermum naming as Chantransia stage.

The life cycle of *Batrachospermum* consists of two gametophytic phases alternating with one sporophytic phase which is, however, confined in the zygotic stage. The early gametophytic phase—*Chantransia* stage, is formed by the germination of the carpospore which is the product of post-fertilization stages. The late gametophytic phase, the main *Batrachospermum* alga is developed from the *Chantransia* stage.

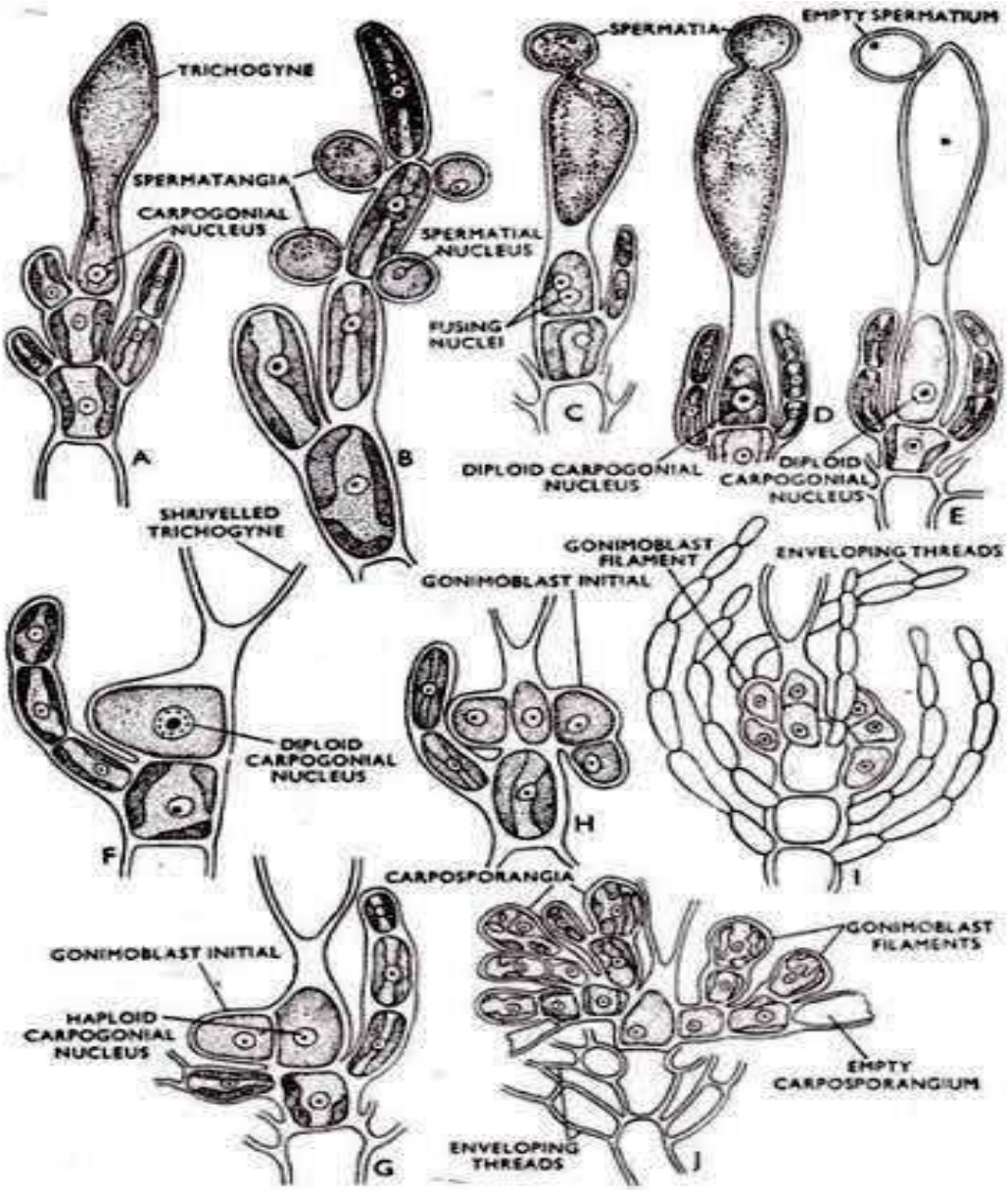


Fig. 120. *Batrachospermum* sp. A. Mature carpogonium. B. Spermatangial branch bearing spermatangia. C–F. Stages in fertilization. G–H. Development of gonimoblast initial. I. Development of gonimoblast filament and enveloping threads. J. Mature gonimoblast filaments, carposporangia and enveloping threads.

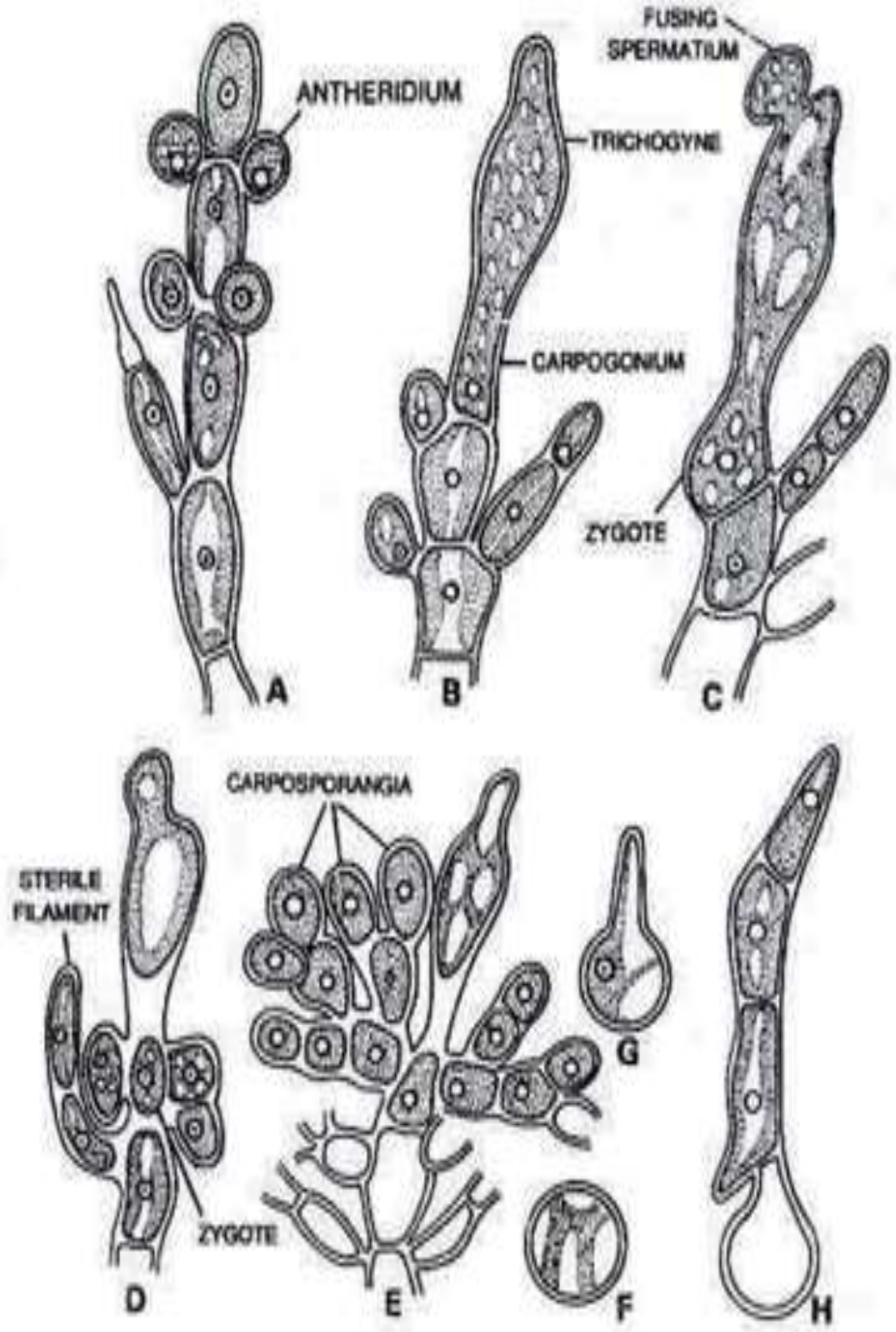
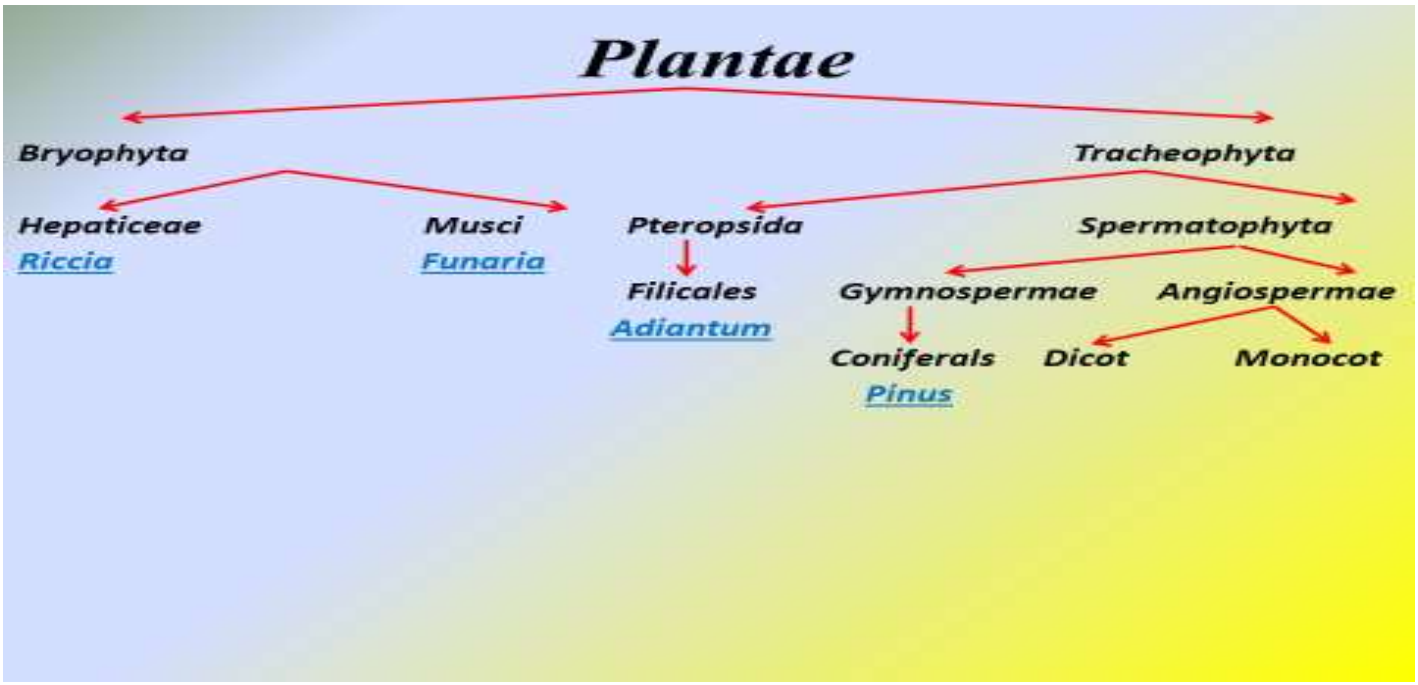
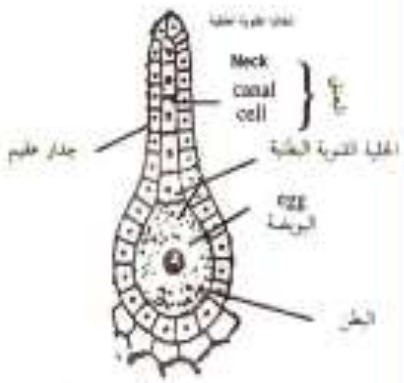


Fig. 7.8. *Batrachospermum*, A, antheridial branch with globular antheridia; B, carpogonial branch with carpogonium; C, fusion of trichogyne with spermatium; D and E, germination of zygote and formation of carposporangia; F, carpospore; G,germination of carpospore; H. *Chantransia* Stage.

Economic Importance of *Algae*

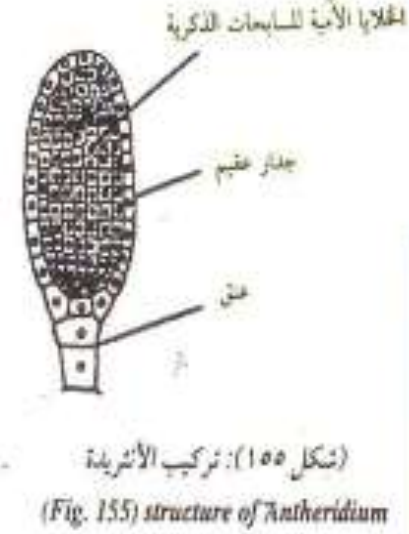
1. It is the basis of food chain.
2. Keeps the ecological balance in aquatic environments.
3. Absorption of Carbon dioxide CO_2.
4. It is used as food in certain countries. *i.e.* Japan
5. It increases soil fertility and it has been used as a bio-fertilizer.
6. It is used as pollution indicators.
7. It produces **Carrageenan** which is used in food and pharmaceutical industry.
8. It produces **Agar**, necessary for solid lab media preparation.
9. It produces **Alginic acid** which is used in the manufacture of almost 80 industrial product, *i.e.* rubber, textile fabrics, plastics, medicinal drugs and ice cream.
10. It is a source of ***Carotene*** which is an important antioxidant. Also, it is the source of many important vitamins, fatty and amino acids.
11. It is used for isolation (*i.e.* air-conditions and fridges) and filters. It also take part in many industries *i.e. Dynamite*. It is useful in water purification and sewage treatment plants (*Diatoms*).
12. It is used in space research as an Oxygen donor.
13. It is used in the production of **β- *Carotene*** and **Glycerin**.


Plantae
Bryophyta
Tracheophyta
Hepaticeae
Riccia
Musci
Funaria
Pteropsida
Filicales
Adiantum
Spermatophyta
Gymnospermae
Angiospermae
Coniferals
Pinus
Dicot
Monocot



(شكل ١٥٤): تركيب الأرشيجونة

(Fig. 154) structure of archegonium



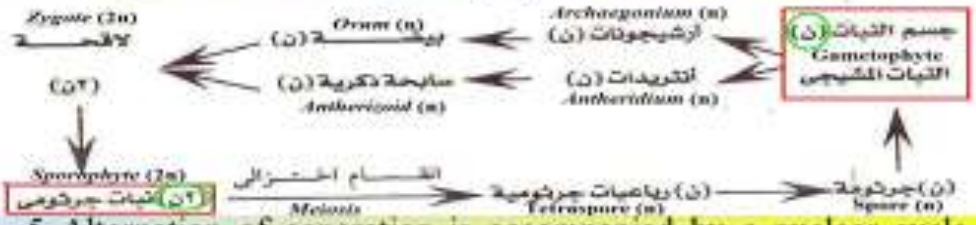
(شكل ١٥٥): تركيب الأنثريدة

(Fig. 155) structure of Antheridium

Plantae (*Embryophyta*)

- **It is characterized by:**

1. Presence of different sex organs *i.e. antheridia* and *Archegonium*.
2. The *Antherizoids* are liberated to fertilize the *Archegonium*.
3. Upon the *Archegonium* maturation, the neck cells degenerate forming a gelatinous substance with a distinct odor, to attract *Antherizoids* chemically.
4. After the *Zygote* formation, it surrounds itself by a thick wall. it divides two times meiotically and then mitotically resulting in a tetraspore that forms a gametophyte.



5. Alternation of generation is accompanied by a nuclear cycle, alternating between haploid (n) and diploid (2n).
6. *Embryophyta* includes green plants.
7. Dominancy of Sporophyte and Gametophyte varies.
8. The more dominant the Sporophyte is on the Gametophyte the more developed the organism is.

Kingdom: Plantae المملكة النباتية

Embroyonic plants أو النباتات الجنينية

Division: Bryophyta	قسم: النباتات الحزازية
Class: Hepaticeae	صف : الحزازيات المنبطحة
e.g Riccia	نبات الريشيا
Class: Musci (Mosses)	صف : الحزازيات القائمة
e.g. Funaria	نبات الفيوناريا
Division: Tracheophyta	قسم: النباتات الوعائية
Class: Pteropsida	صف: النباتات التريدية
Order: Filicales	ربة: السراخس
e.g. Adinatum	نبات كزبرة البئر
Class: Gymnospermae	صف : معراة البذور
Order: Coniferals	رتبة : المخروطيات
e.g. Pinus	الصنوبر
Class: Angiospermae	صف: مغطاة البذور
Subclass: Monocotyledonae	تحت صف النباتات ذات الفلقة الواحدة
Subclass: Dicotyledonae	تحت صف النباتات ذوات الفلقتين

Comparison between *Bryophyta* and *Tracheophyta*

Points of Comparisons	*Bryophyta*	*Tracheophyta*
Dominancy	**Gametophyte** is dominant	**Sporophyte** is dominant
Vascular Tissues	Non- vascular plants, lacking any roots, but absorbs water through its thallus	It is characterized by the presence of bundles and vascular elements differentiated into *Xylem* and *Phloem*.
Nature	Terrestrial plants that require a lot of water to grow and live in tropical habitat.	Terrestrial plants, their spores are found within sporangia arranged in the axile of sporophylls that can undergo both vegetative and reproduction functions.
Formation	The stem is either **weak** (***Hepatiaceae***) on which leaves are arranged in two rows or **erect** where leaves are arranged in three rows (***Musci***)	It is divided into two subdivisions ***Pteropsida*** and ***Spermatophyta***

Comparison between *Hepatiaceae* and *Musci*

Points of Comparisons	*Hepatiaceae*	*Musci*
Gametophyte	A leafy thallus form with a prostrate weak stem.	An erect leafy thallus differentiated into stem and leaves.
Germination	The spore germinate into a *Gametophyte*.	The spore germinate into a filamentous branched structure called the *Protonema*, carrying several buds that grows into a *Sporophyte*.
Leaves	Characterized by leaves arranged in **two rows**.	Characterized by leaves arranged in **three rows**
Examples	***Riccia***	***Funaria***

Riccia

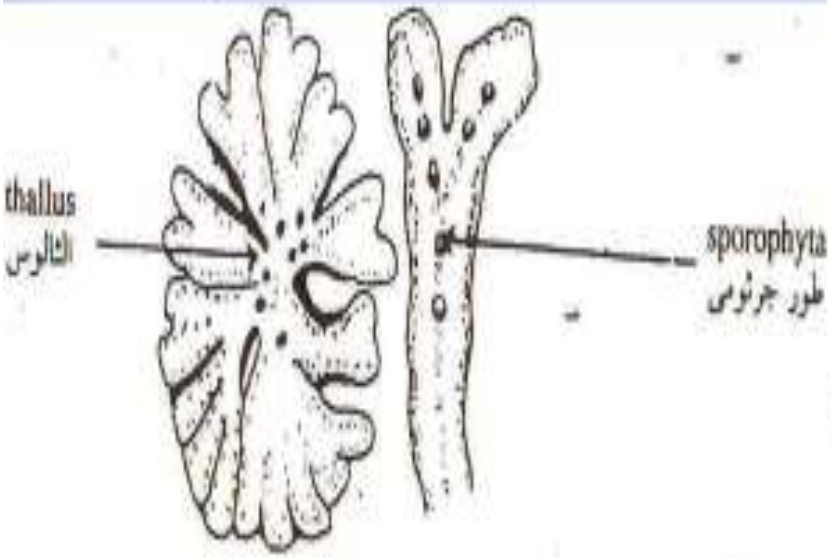
Kingdom: *Plantae*

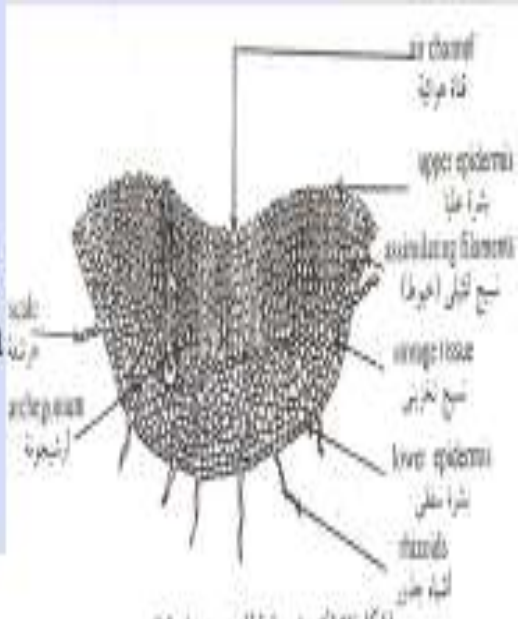
Division: *Bryophyta*

Class : *Hepaticeae*

i.e.: ***Riccia***

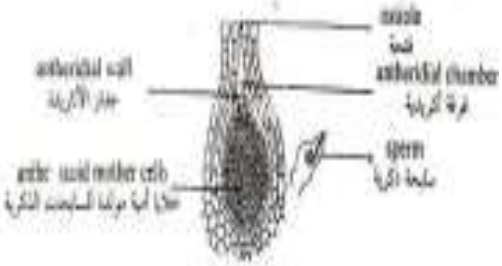
1. Green broad thallus.
2. Dichotomously branched.
3. The **midrib** is swollen where the rhizoids arise.





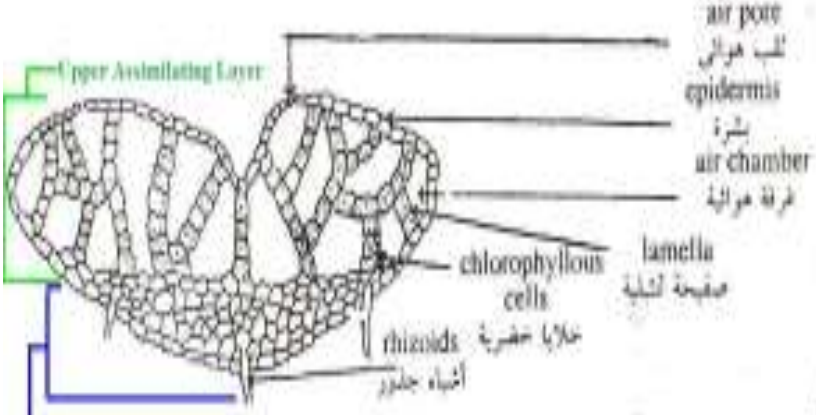
(شكل ١٥٦): ريشيا قطاع عرضي في الثالوس

(Fig. 156) *Riccia sp. V.S. of the thallus*



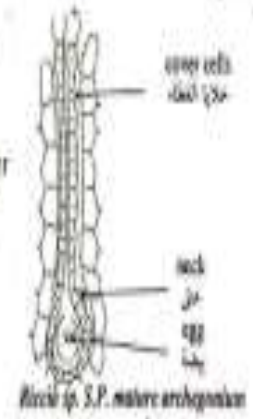
Riccia sp. S.P. antheridium showing structure

ريشيا تركيب الأنثريدة



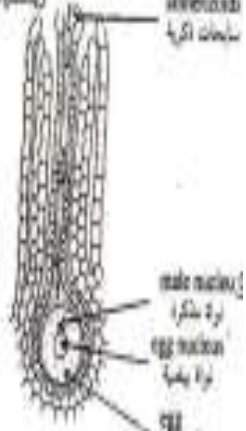
تابع (شكل ١٥٧): ريشيا فلبانس، قطاع عرضي في الثالوس

Cont. (Fig. 157) Riccia fluitans T.S. of the thallus



Riccia sp. S.P. mature archegonium

ريشيا أرشيجونة ناضجة



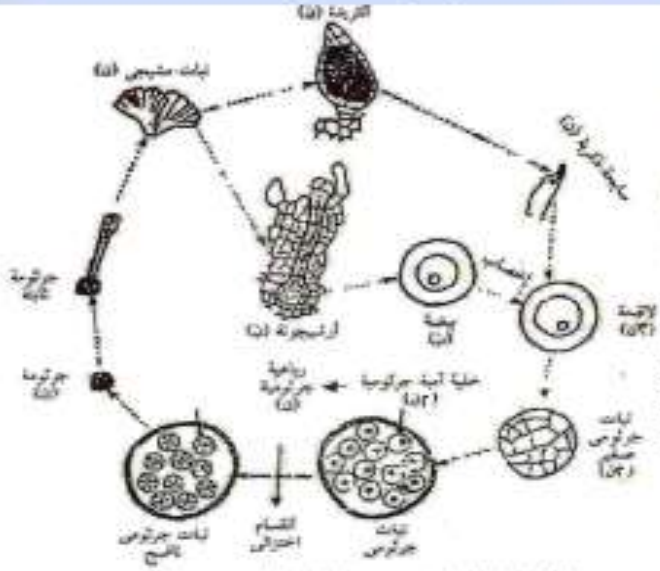
Riccia sp. S.P. fertilized egg

ريشيا بيضة مخصبة

Riccia

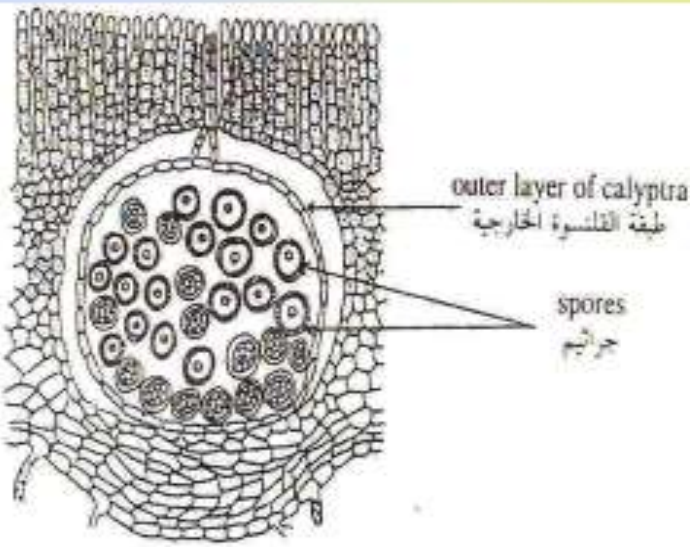
- **Sexually:**

1. Upon maturation, each *Antheridium* divides into 2 *Antherizoids* (bear-shaped with 2 flagella).
2. One *Antherizoid* fertilize the egg after the lysis of the neck canal cells. The zygote surrounds itself by a sterile wall where 2 divisions occur resulting in 4 spores.
3. The sporophyte grows parasitically on the gametophyte. The spores are then released after the gametophyte dies out.



(شكل ١٥٨): ملخص دورة حياة الريشيا (عن رويز وزملائه)

(Fig. 158) life cycle of Riccia



Riccia sp. T.S. through sporophyte

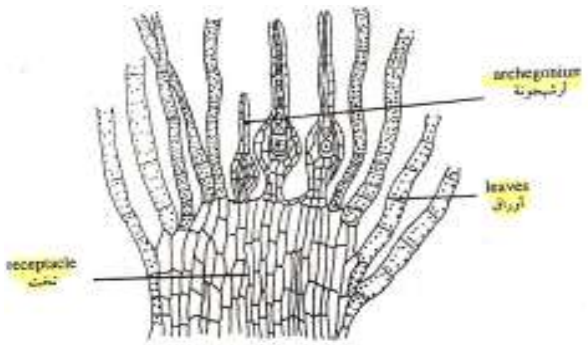
شـــا، قطاع عمودي في الطور الجرثومي

Funaria

Kingdom: *Plantae*
Division: *Bryophyta*
Class : *Musci*
***i.e.:* Funaria**

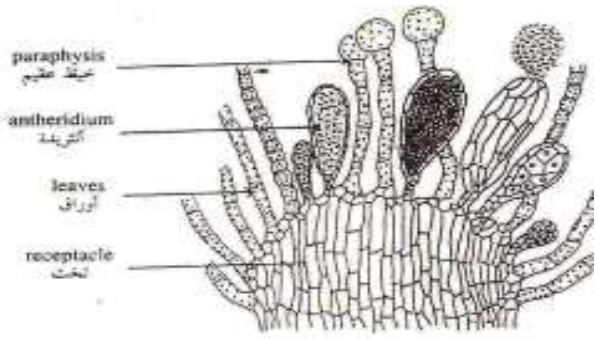
1. It blooms in Egypt in wet places.
2. Gametophytes dominates
3. Moss flowers are either *Monecious* or *Dioecious*.

Fig. 8.7, ***Funaria*** sp. protonema.
شكل (٨–٧) فيوناريا . الخيط الأولى



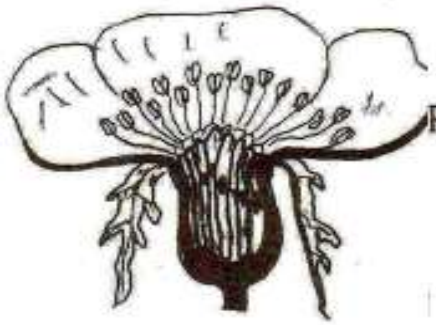
(شكل ١٦٠): فيوناريا، ق. ط. في زهرة حزازية مؤنثة

(Fig. 160) Funaria sp. L.S. of female moss)



(شكل ١٥٩): فيوناريا، ق. ط. في زهرة حزازية مذكرة

(Fig. 159) Funaria sp. L.S. of male moss flower



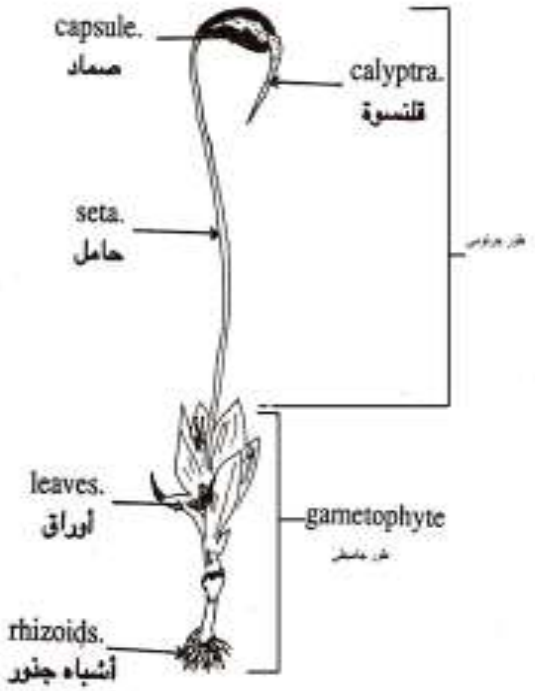


Fig. 8.1, ***Funaria*** sp. gametophyte bearing sporophyte.

شكل (٨–١) فيوناريا . نبات مشيجي يحمل نبات جرثومي

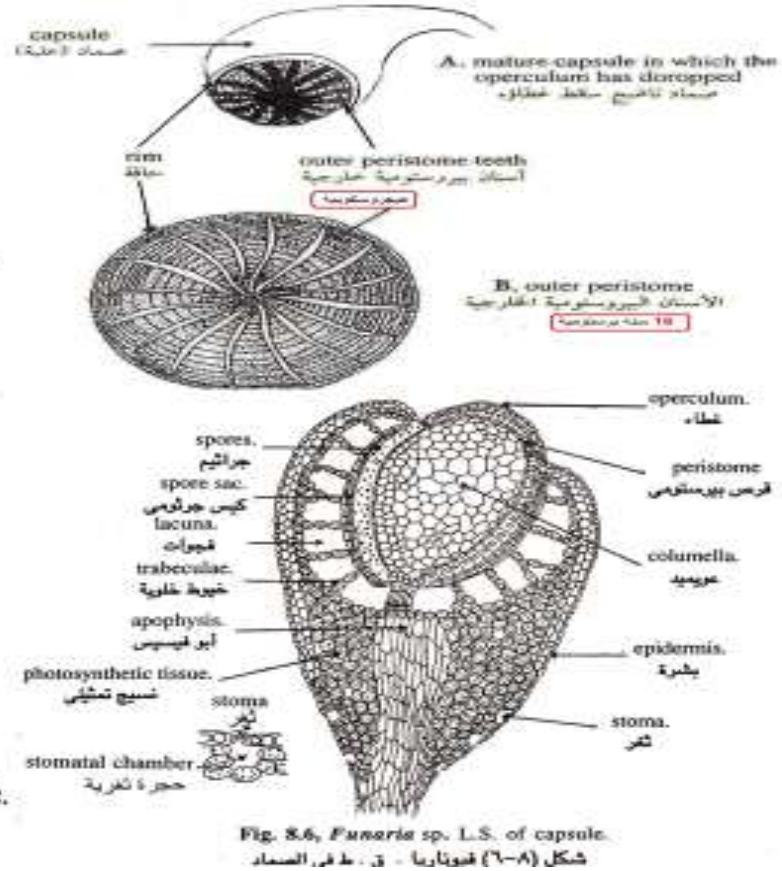


Fig. 8.6, *Funaria* sp. L.S. of capsule.

شكل (٨–٦) فيوناريا . ق . ط في الصماد

Sexual reproduction:

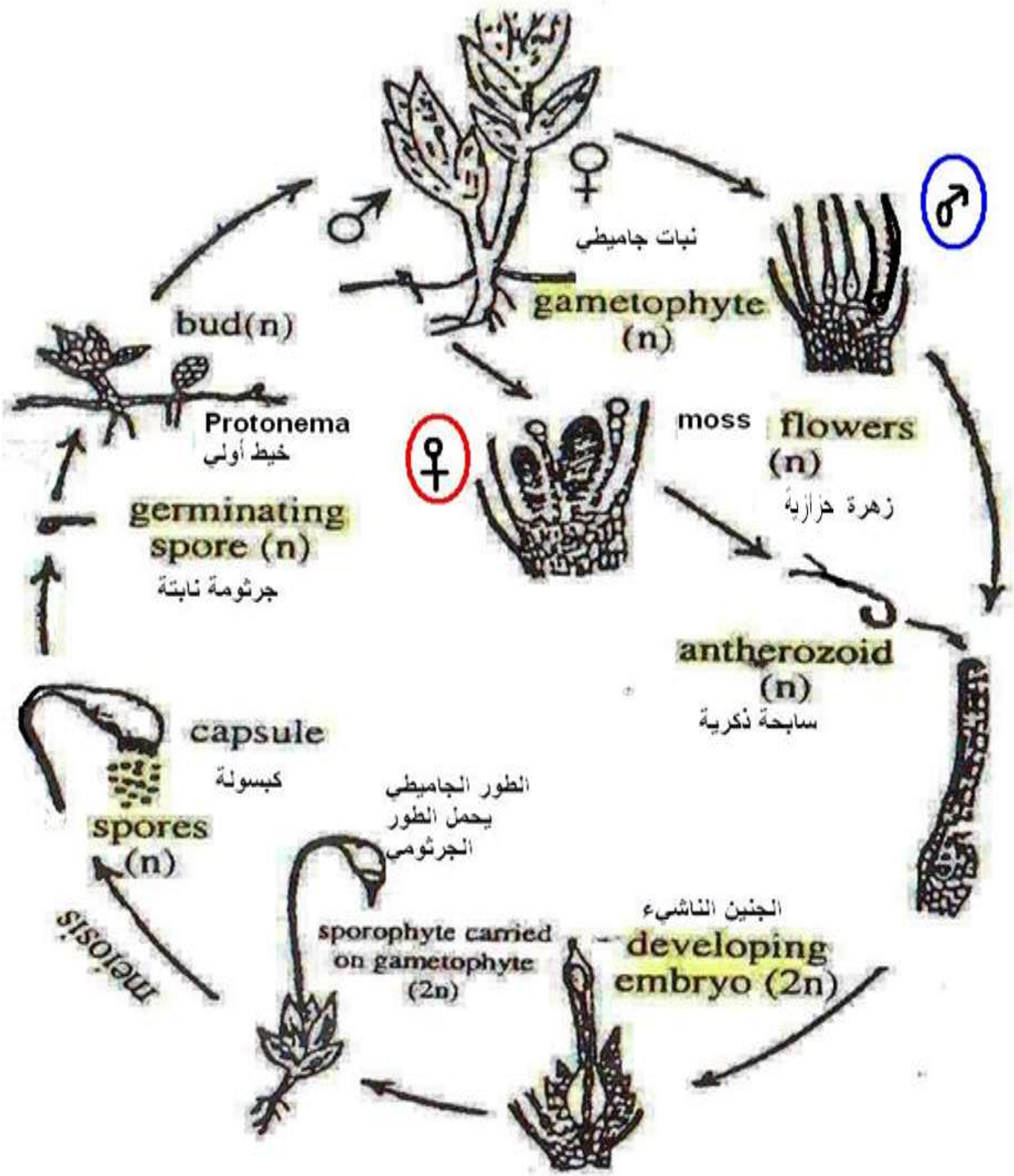
Sexual reproduction is oogamous. Male reproductive structure is known as antheridium and female as archegonium. Funaria is monoecious (having male and female sex organs on the same thallus) and autoicous (antheridia and archegonia develop on separate branches of the same thallus).

Sex organs are borne on leafy gametophores in terminal clusters. The main shoot of the leafy gametophore bears antheridia and act as male branch. Female branch develops as a lateral outgrowth from the base of the male branch and bears archegonia. It grows higher than the male branch. Funaria is protandrous (antheridia mature before the archegonia). It ensures the cross fertilization. As a result, cross-fertilization occurs. Water is required for fertilisation. During heavy rains, antherozoids reach the archegonial neck and swim down to the ventral. Any antherozoid can fuse with an egg to form a zygote (2n). Soon after, the zygote secretes a cell wall and develops into an oospore. To form an embryo, the oospore divides and redivides. The embryo eventually develops into a sporophyte or sporogonium. Thus, the first cell of sporophyte generation is the zygote or oospore.

Funaria sporogonium is photosynthetic, making it semi-parasitic on gametophore. It is divided into three parts: the foot, the seta, and the capsule. The foot is embedded in the female receptacle, where it absorbs inorganic nutrients. Seta is a tall stalk with a pear-shaped capsule at the tip.

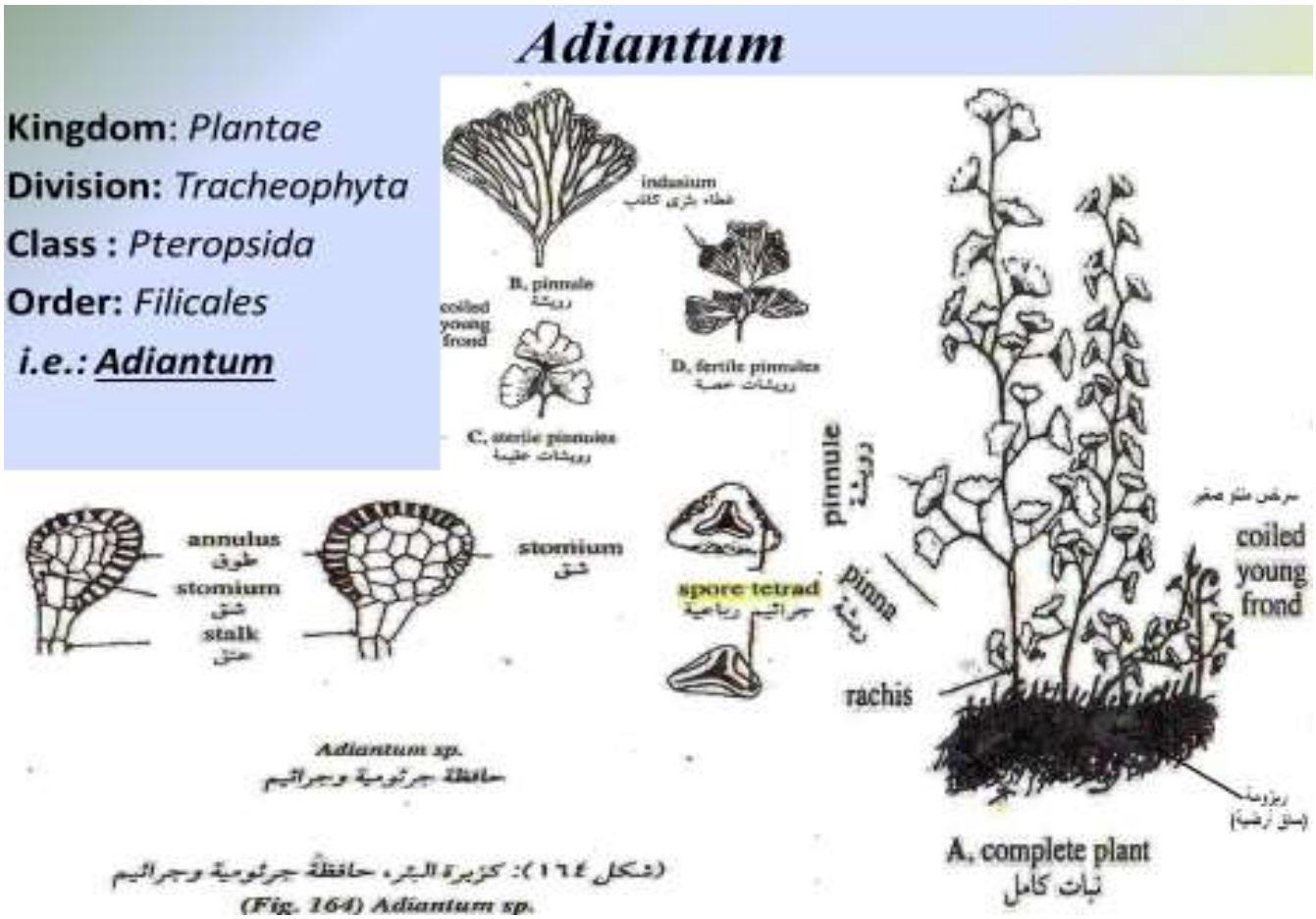
The capsule is made up of three parts: the basal apophysis, the central theca, and the terminal operculum. Annulus is a ring-like cell that separates the operculum from the Theca. From the center to the outside, the middle fertile theca is made up of a sterile columella surrounded by a barrel-shaped spore sac, a cylindrical air space with trabeculae, hypodermis, and epidermis. As the sporogonium grows, so does the venter, which takes the form of a protective covering called calyptra. Later, the calyptra ruptures and remains attached to the capsule like a cap. Calyptrais is haploid because it develops from the ventriloquine wall.

When the capsule dries up, the Operculum is thrown off, revealing the peristome, which is made up of two overlapping rings of periostomial teeth. Each peristome ring contains 16 teeth. The teeth of the outer ring (exostome) are conspicuous, red, and have thick transverse bands, whereas the teeth of the inner ring (endostome) are small, colourless, and soft. Spore dispersal is caused by hygroscopic movements (movement caused by moisture content of the atmosphere) of the exostome of peristomial teeth. The inner ring of peristomial teeth does not move due to hygroscopic forces.



(شكل ١٦٣): دورة حياة الفيوناريا

(Fig. 163) life cycle of Funaria

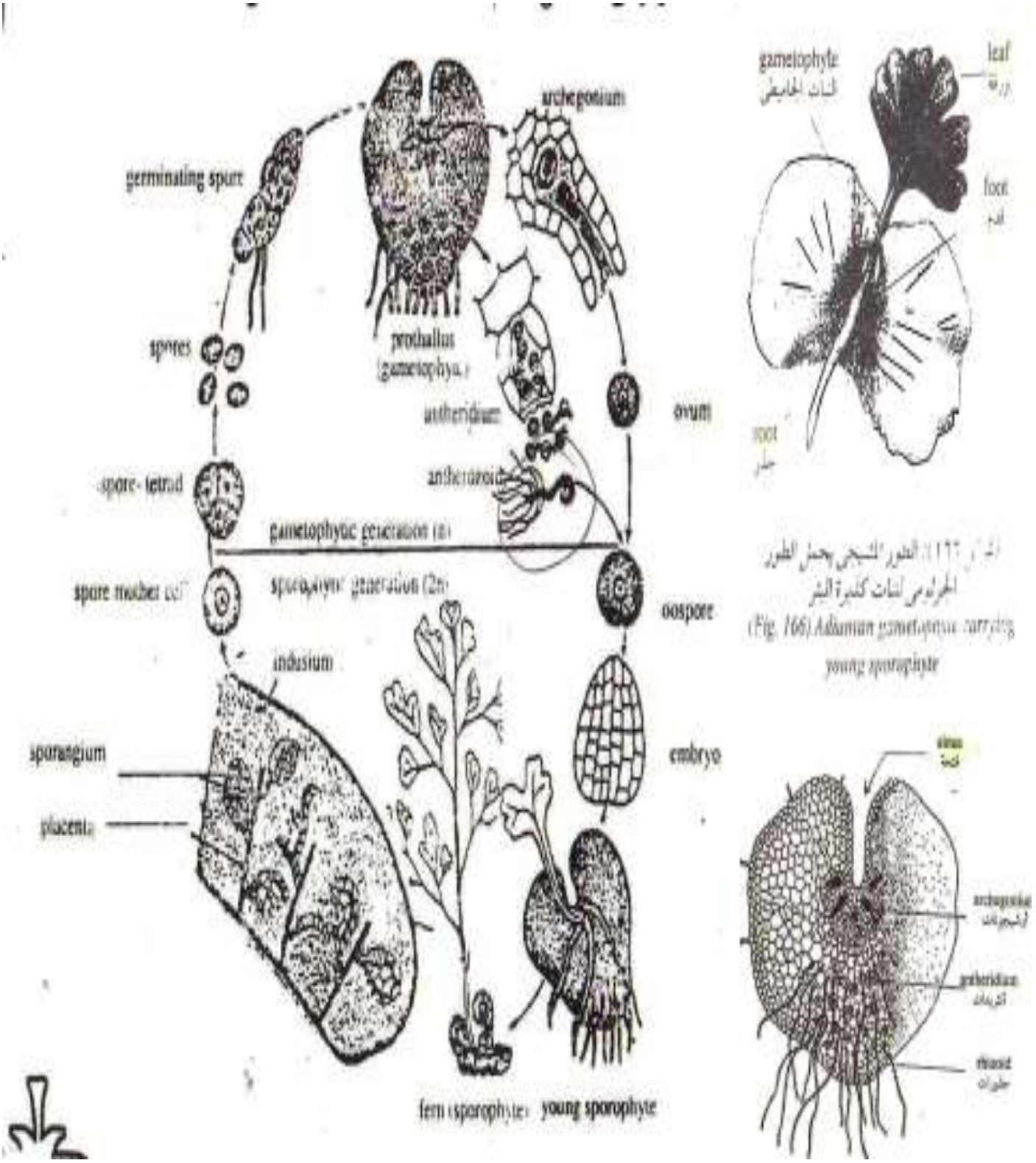


Reproduction:

It takes place by the production of spores. The spores are produced in sporangia. A group of sporangia forms sori. The sori are marginal but the reflex margins of the pinna form a protective membranous structure called false indusium. The development of sporangium is of leptosporangiate type. The sorus does not show any definite sequence hence fall under mixed type.

A mature sporangium bears a multicellular stalk and a spherical or elliptical single layered structure called capsule. The capsule contains haploid spores. The wall of the capsule is differentiated into thick walled annulus and thin walled stomium. On maturity the sporangium bursts and spores are released. The spores germinate and undergo repeated division to produce a prothallus. The prothallus is flat, green and heart shaped. It is monoecious and represents the gametophytic phase. Sex organs called antheridia and archegonia develop on the prothallus. Antheridia release multiflagellate antherozoids which swim in water and reach the egg of the archegonium to accomplish fertilization.

The fertilization results in zygote(2n) and it represents the first cell of sporophytic generation. The zygote develops into embryo which further differentiates into sporophyte. Thus Adiantum shows alternation of generation.



The Relation Between *Pteropsida* and *Spermatophyta*

1. Spores are differentiated into *Microspores* (male) and *Macrospores* (female).
2. *Macrospores* are reduced to one spore.
3. *Microspores* are called the "**Pollen Grains**".
4. *Macrospore* is called the "**Egg**" or the **unfertilized seed**.
5. *Macrospore* is coated by the integuments which is known as the "**Embryonic sac**".

6. Sporophyte (embryo) lives parasitically on the embryo sac of the *Macrospore*.
7. The pollen grain form a tube to reach the *Macrospore* (Embryonic sac) to deliver the male nucleus to the *Nucellus*.
8. *Megaspores* and *Microspores* are formed on *Megasporophylls* and *Microsporophylls* respectively.
9. *Microsporophylls* become the **Stamens**, whereas the *Megasporophylls* become the **Carpels**.
10. *Megaspore* (Embryonic sac) remains inside the ovum until the end of fertilization and the formation of the *Embryo*.
11. The **Endosperm** is the female thallus.
12. In *Gymnospermae*, the carpel **does not surround** the ovules, so the *Micropyle* is exposed to the outside. Whereas in *Angiospermae* the carpel **covers** the ovules completely so the *Micropyle* is not exposed to the outside and the carpel consists of the stigma, style and ovary.
13. In *Gymnospermae*, the carpel inside the embryo sac is differentiated into an *Archegonium*, whereas in *Angiospermae* the *Archegonium* disappears to be replaced with the *Nucellus*.

Pinus

Kingdom: *Plantae*

Division: *Tracheophyta*

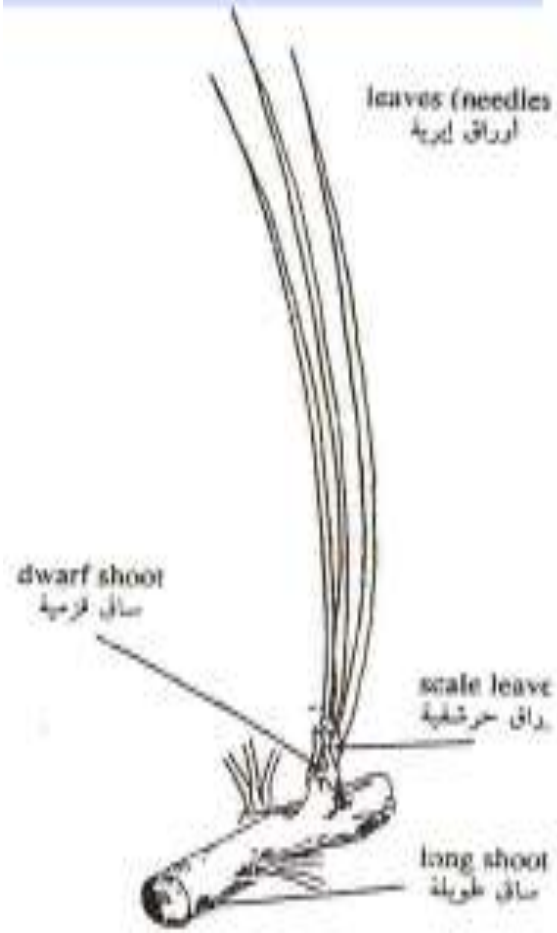
Subdivision : *Spermatophyta*

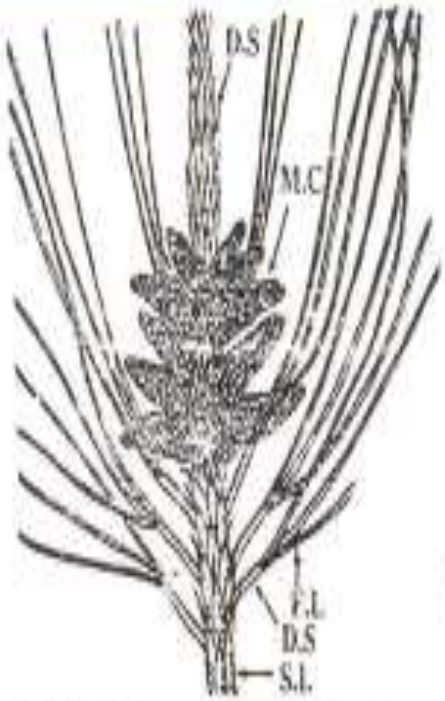
Class: *Gymnospermae*

Order: *Coniferals*

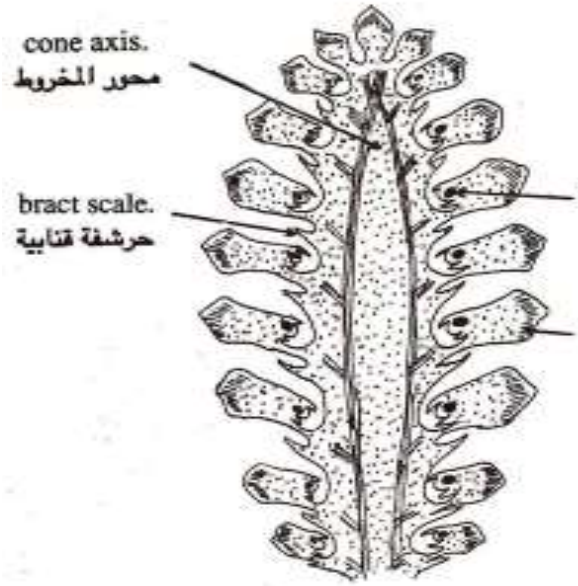
***i.e.*: Pinus**

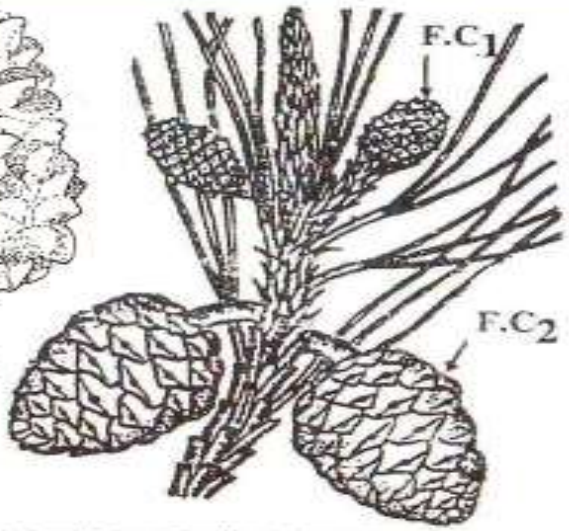
1. It is widely spread in the northern hemisphere.
2. Evergreen trees, where sporophyte dominates.
3. Scale leaves are arranged on the stem, where in their axiles found 1-5 acicular leaves.
4. *Pinus* trees are monecious, where female and male cones are carried on separate branches.





Pinus
L.S. in Female Cone of *Pinus*

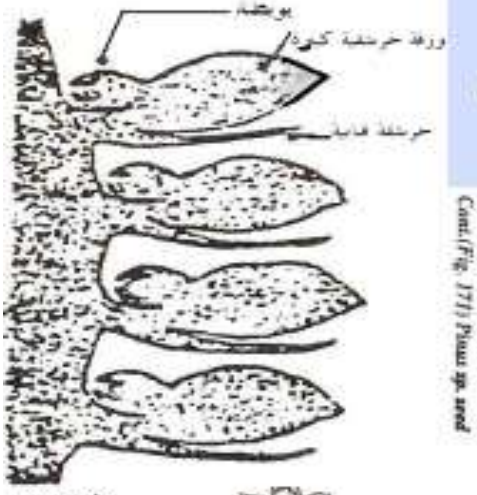


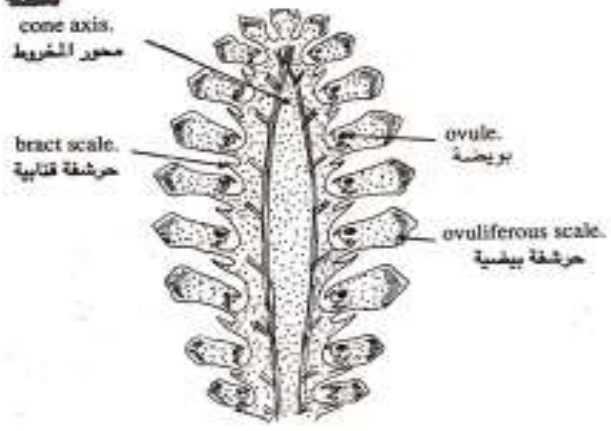


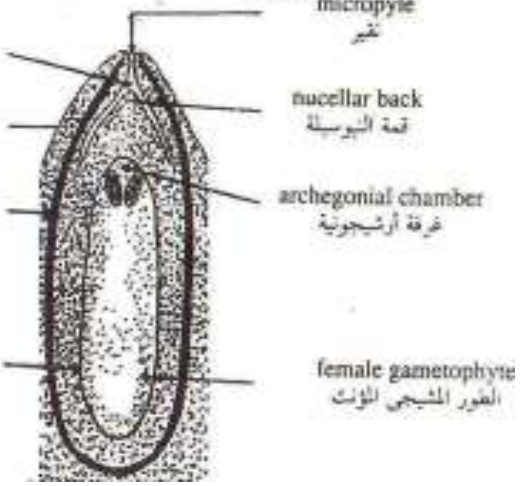
A female shoot of undimited growth showing two young female cones ($F.C_1$) of current year, two maturing female cones ($F.C_2$) of previous year

فرع مؤنث ذات نمو غير محدود ويحمل المخاريط المؤنثة

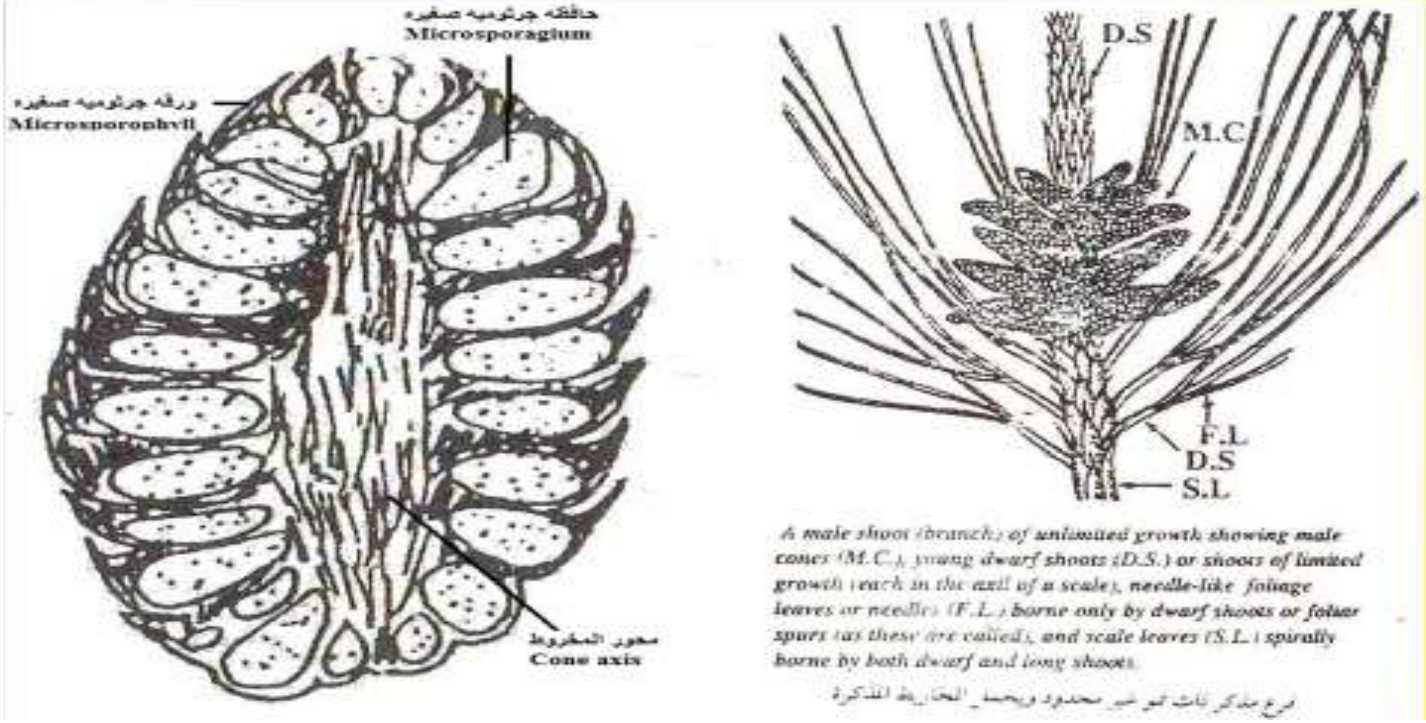
Pinus
L.S. in Female Cone of *Pinus*





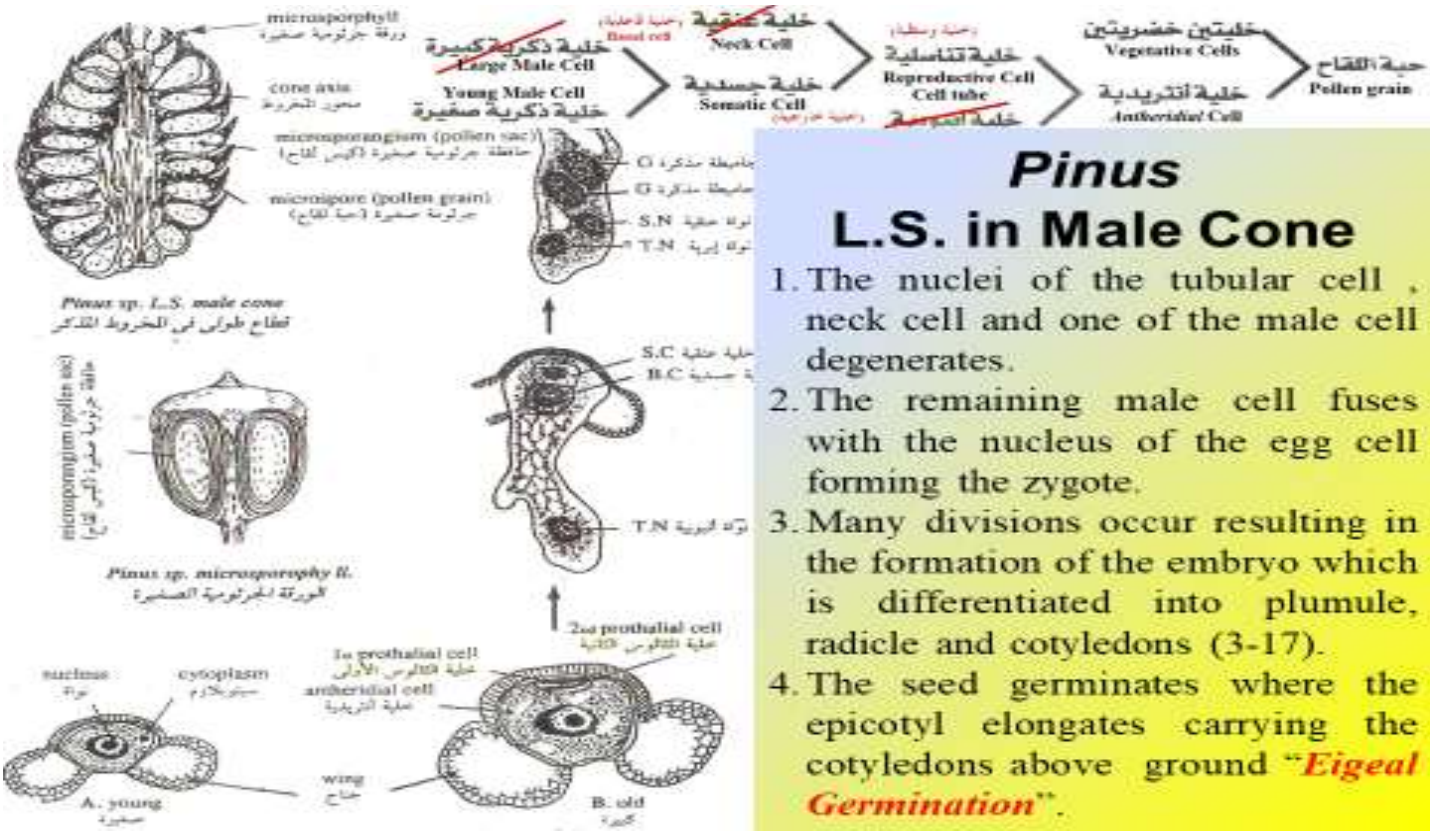


Pinus
L.S. in Male Cone of *Pinus*



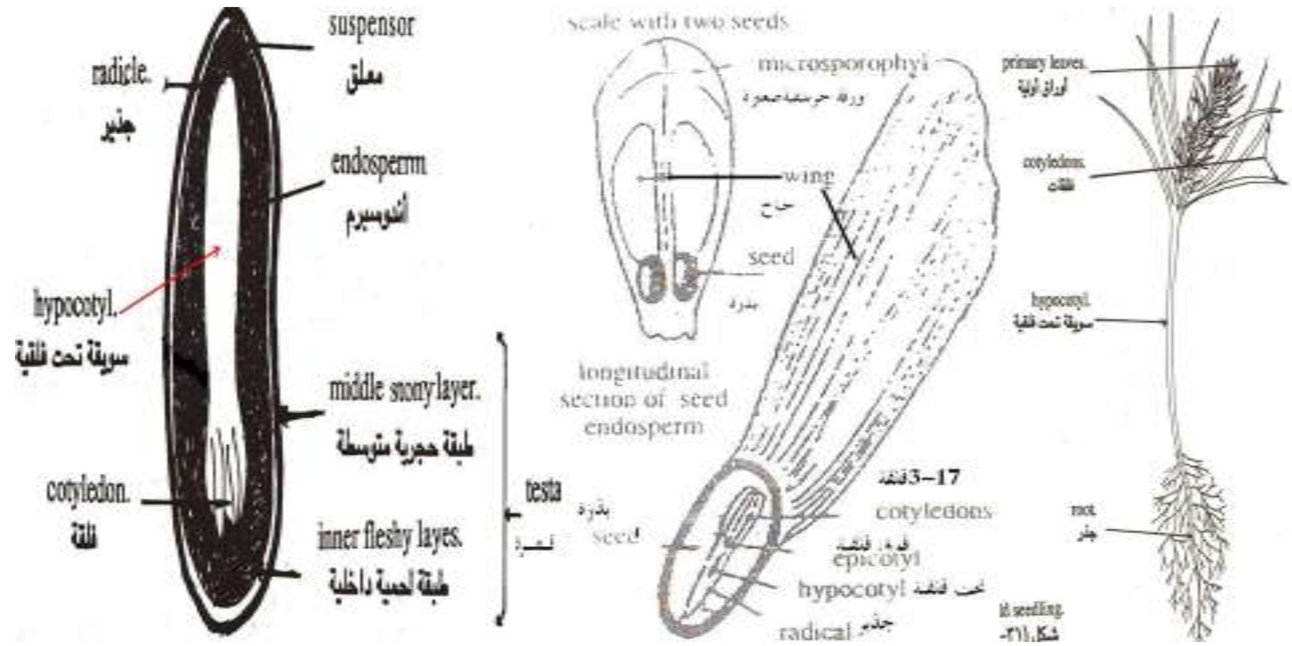
A male shoot (branch) of unlimited growth showing male cones (M.C.), young dwarf shoots (D.S.) or shoots of limited growth (each in the axil of a scale), needle-like foliage leaves or needles (F.L.) borne only by dwarf shoots or foliar spurs (as these are called), and scale leaves (S.L.) spirally borne by both dwarf and long shoots.

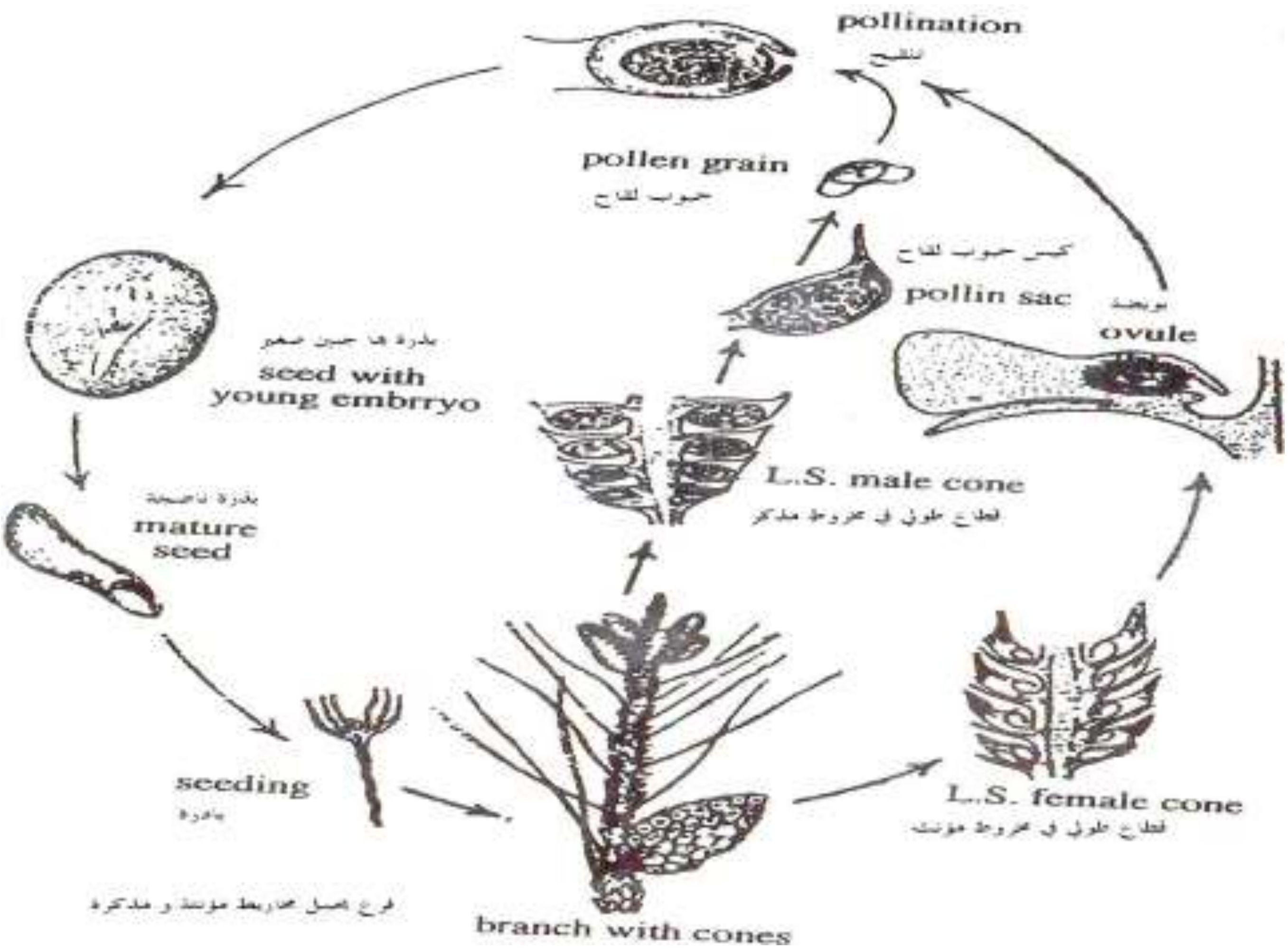
فرع مذكر نباتة ذو نمو محدود ويحمل المخاريط المذكرة



Pinus
L.S. in Male Cone

1. The nuclei of the tubular cell , neck cell and one of the male cell degenerates.
2. The remaining male cell fuses with the nucleus of the egg cell forming the zygote.
3. Many divisions occur resulting in the formation of the embryo which is differentiated into plumule, radicle and cotyledons (3-17).
4. The seed germinates where the epicotyl elongates carrying the cotyledons above ground "***Eigeal Germination***".

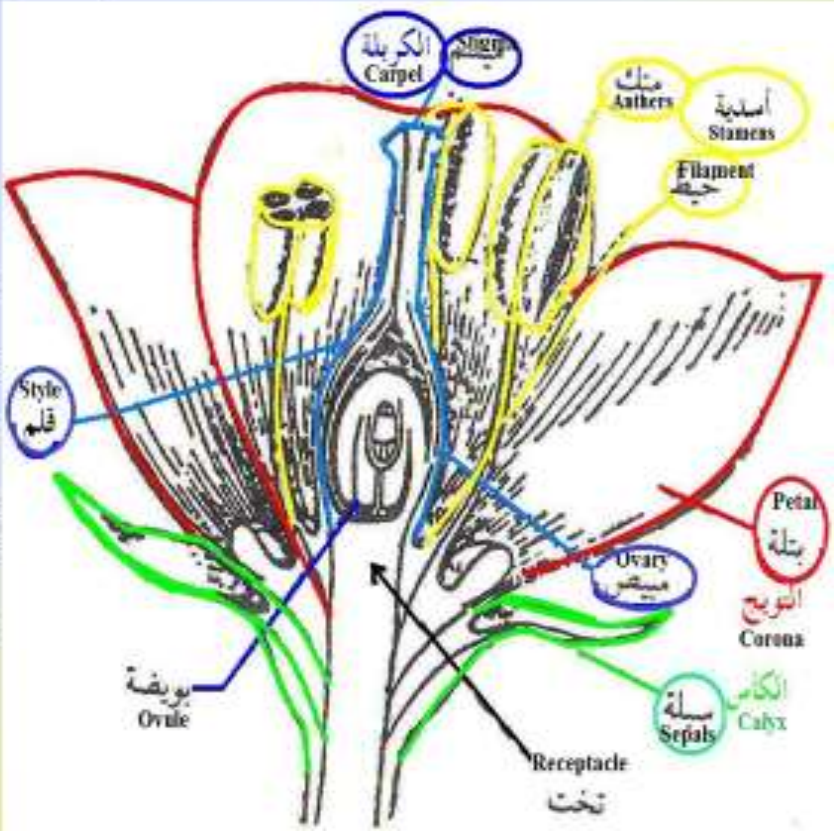

suspensor
معلق
radicle.
جذير
endosperm.
أندوسبيرم
hypocotyl.
سويقة تحت فلقية
middle stony layer.
طبقة حجرية متوسطة
cotyledon.
فلقة
inner fleshy layes.
طبقة لحمية داخلية
testa
scale with two seeds
microsporophyl
wing
seed
longitudinal section of seed endosperm
3-17
cotyledons
epicotyl
hypocotyl
radical
primary leaves.
أوراق أولية
cotyledons.
فلقات
hypocotyl.
سويقة تحت فلقية
root
جذر


pollination
تلقيح
pollen grain
حبوب لقاح
كيس حبوب لقاح
pollin sac
ovule
بذرة بها جنين صغير
seed with young embrryo
بذرة ناضجة
mature seed
L.S. male cone
قطاع طولي في مخروط مذكر
seeding
بادرة
فرع يحمل مخاريط مؤنثة و مذكرة
branch with cones
L.S. female cone
قطاع طولي في مخروط مؤنث

Angiospermae

Kingdom: *Plantae*
Division: *Tracheophyta*
Subdivision : *Spermatophyta*
Class: *Angiospermae*

1. It is characterized into *Xylem* and *Phloem*.
2. The ovule is completely covered by the *Megasporophyll* forming the carpel.
3. The carpels (stigma, style and ovary) are surrounded by the stamens.
4. The perianth (Calyx and Corona) then surrounds them.



Pollination and Fertilization

- **Pollination:** The transfer of pollen from the anther to the stigma of the same or other flower.

  - **Types of pollination:**
    1. **Self pollination:** It occurs from the anther of one flower to the stigma of the same flower.
    2. **Cross pollination:** It occurs from the anther of one flower to the stigma of another flower.
       It takes place by:
       a. Insects **b. Wind**

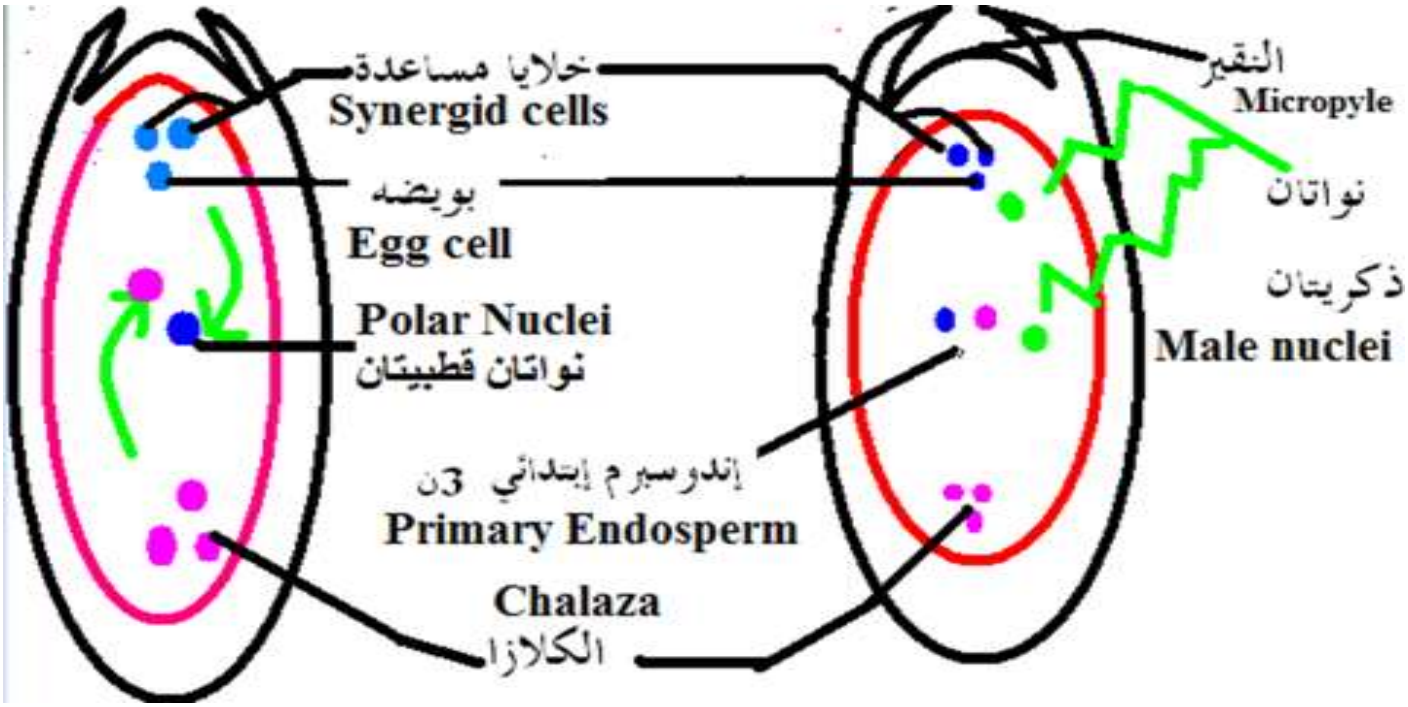
- **Fertilization:** The conjugation between the male nucleus and the female nucleus (egg) inside the embryo sac.

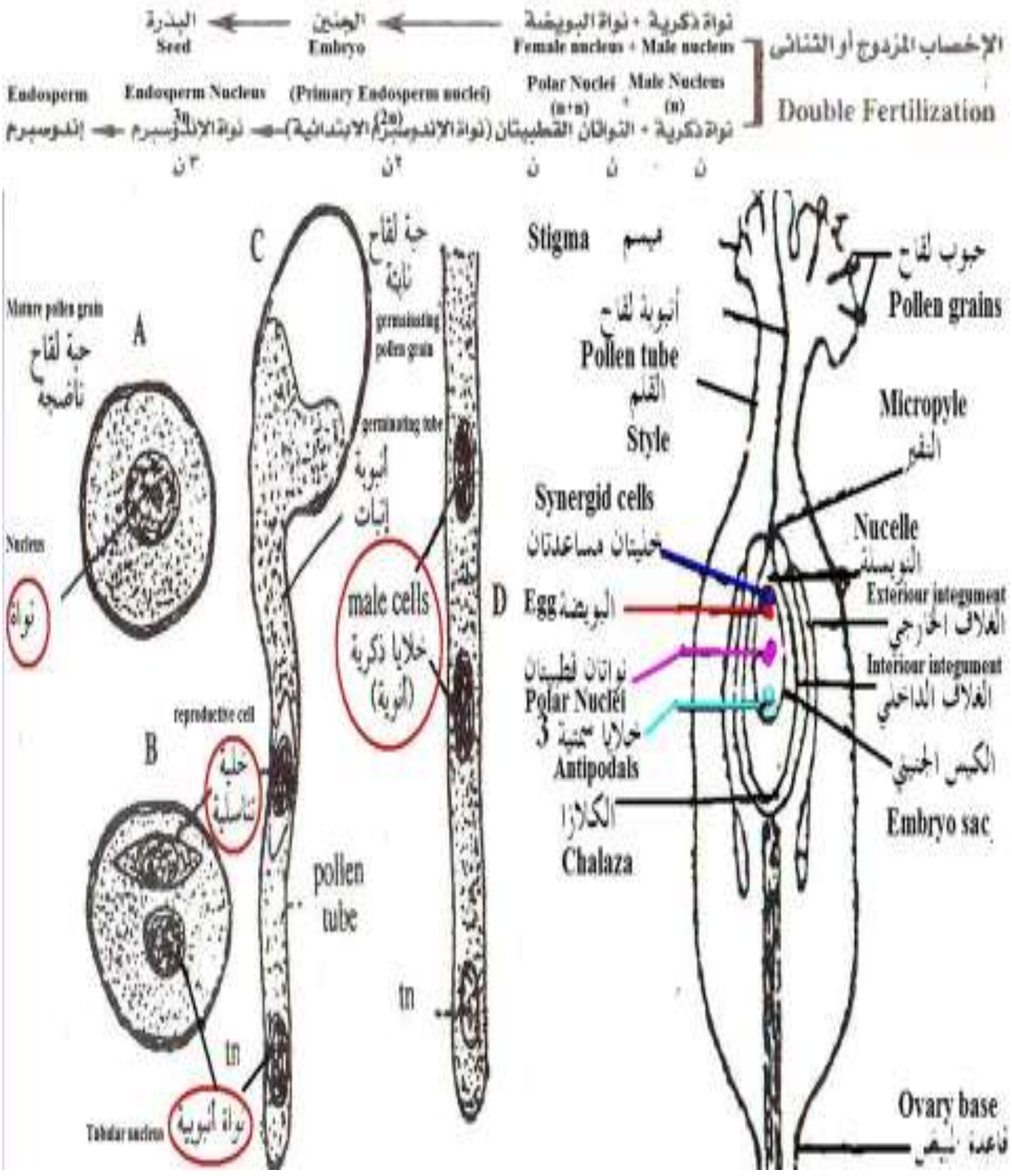
Double Fertilization in Plants

Angiosperms undergo two fertilization events where a zygote and endosperm are both formed.

Double Fertilization

After pollen is deposited on the stigma, it must germinate and grow through the style to reach the ovule. The microspores, or the pollen, contain two cells: the pollen tube cell and the generative cell. The pollen tube cell grows into a pollen tube through which the generative cell travels. The germination of the pollen tube requires water, oxygen, and certain chemical signals. As it travels through the style to reach the embryo sac, the pollen tube's growth is supported by the tissues of the style. During this process, if the generative cell has not already split into two cells, it now divides to form two sperm cells. The pollen tube is guided by the chemicals secreted by the synergids present in the embryo sac; it enters the ovule sac through the micropyle. Of the two sperm cells, one sperm fertilizes the egg cell, forming a diploid zygote; the other sperm fuses with the two polar nuclei, forming a triploid cell that develops into the endosperm. Together, these two fertilization events in angiosperms are known as double fertilization. After fertilization is complete, no other sperm can enter. The fertilized ovule forms the seed, whereas the tissues of the ovary become the fruit, usually enveloping the seed.


خلايا مساعدة
Synergid cells
بويضه
Egg cell
Polar Nuclei
نواتان قطبيتان
إندوسبرم إبتدائي 3ن
Primary Endosperm
Chalaza
الكلازا
النقير
Micropyle
نواتان
ذكريتان
Male nuclei


البذرة
Seed
الجنين
Embryo
نواة ذكرية + نواة البويضة
Female nucleus + Male nucleus
الإخصاب المزدوج أو الثنائي
Double Fertilization
Endosperm
إندوسبرم
Endosperm Nucleus
نواة الإندوسبرم
(Primary Endosperm nuclei)
(نواة الإندوسبرم الابتدائية)
Polar Nuclei
النواتان القطبيتان
Male Nucleus
نواة ذكرية
٣ن
٢ن
ن
ن
ن
A
حبة لقاح ناضجة
Mature pollen grain
Nucleus
نواة
B
reproductive cell
خلية تناسلية
tn
Tubular nucleus
نواة أنبوبية
C
حبة لقاح نابتة
germinating pollen grain
germinating tube
أنبوبة إنبات
male cells
خلايا ذكرية (أنبوبة)
pollen tube
tn
D
Egg البويضة
Stigma ميسم
أنبوبة لقاح
Pollen tube
القلم
Style
Synergid cells
خليتان مساعدتان
نواتان قطبيتان
Polar Nuclei
3 خلايا سمتية
Antipodals
الكلازا
Chalaza
حبوب لقاح
Pollen grains
Micropyle
النقير
Nucelle
النيوسيلة
Exterior integument
الغلاف الخارجي
Interior integument
الغلاف الداخلي
الكيس الجنيني
Embryo sac
Ovary base
قاعدة المبيض

REFERENCES

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3. **El Sahar, Kasem (1987). Systematic Botany. Mediterranean Sea Publication house. 1st edition.**
4. **Eskarous *et al.*(1987). Practical Botany. Cairo Univ. Press.**
5. **Megahed *et al.*(1996). General Botany. Anglo Press. 7th edition.**
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7. **Kamel *et al.* (2005). Basics of Plant Sciences. Dar El Fikr El Araby Pub. 2nd edition.**
8. **Kumar (2010). Microbiology and Nanobiology. Daya Publishing, Delhi, India.**
9. **Plant Atlas (2010).**
10. **Willey *et al.* (2011). Prescott's Microbiology. Mc Graw Hill 8th edition**

GRADING

1. **Practical exam: 10 marks**
2. **Final written exam: 40**

TEACHING HOURS

1. **Lectures: 2 hours**
2. **Lab: 2 hours**