Botany

2nd Term

1st year Biological sciences and Geology

Prepared by: Dr. Azza Misk

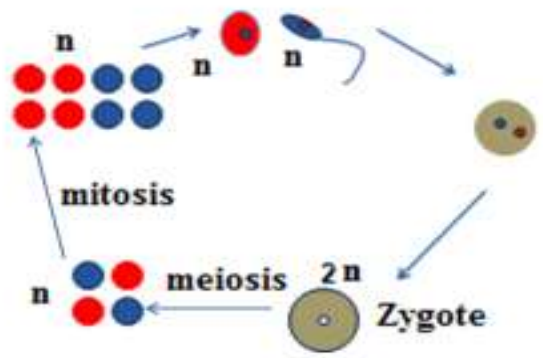
Part 1: Biodiversity II

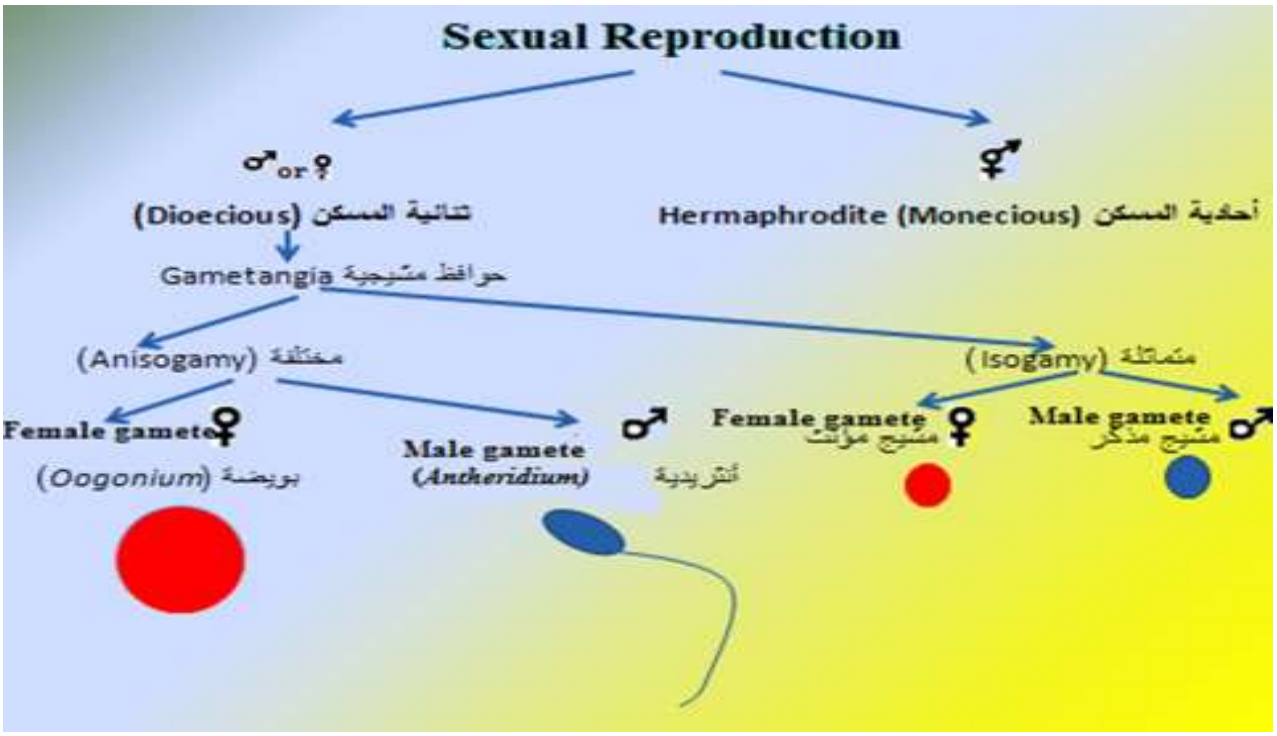
Kingdom: *Fungi*

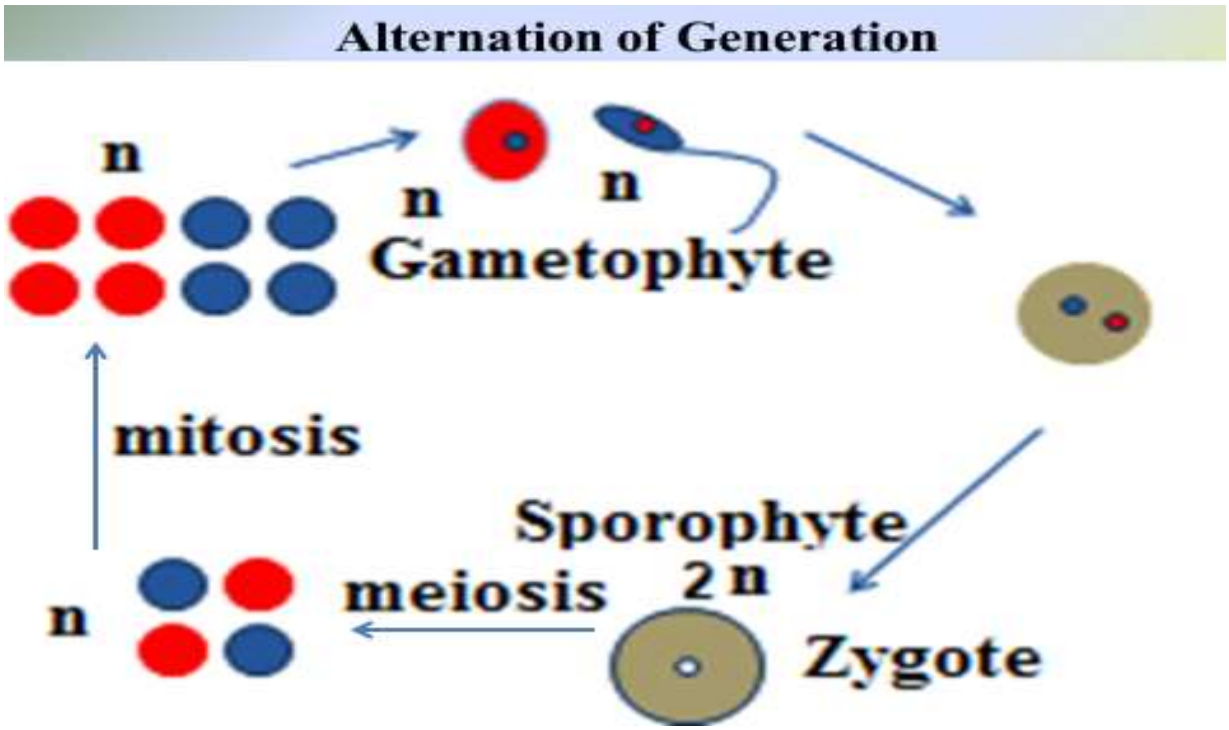
General Characteristics:

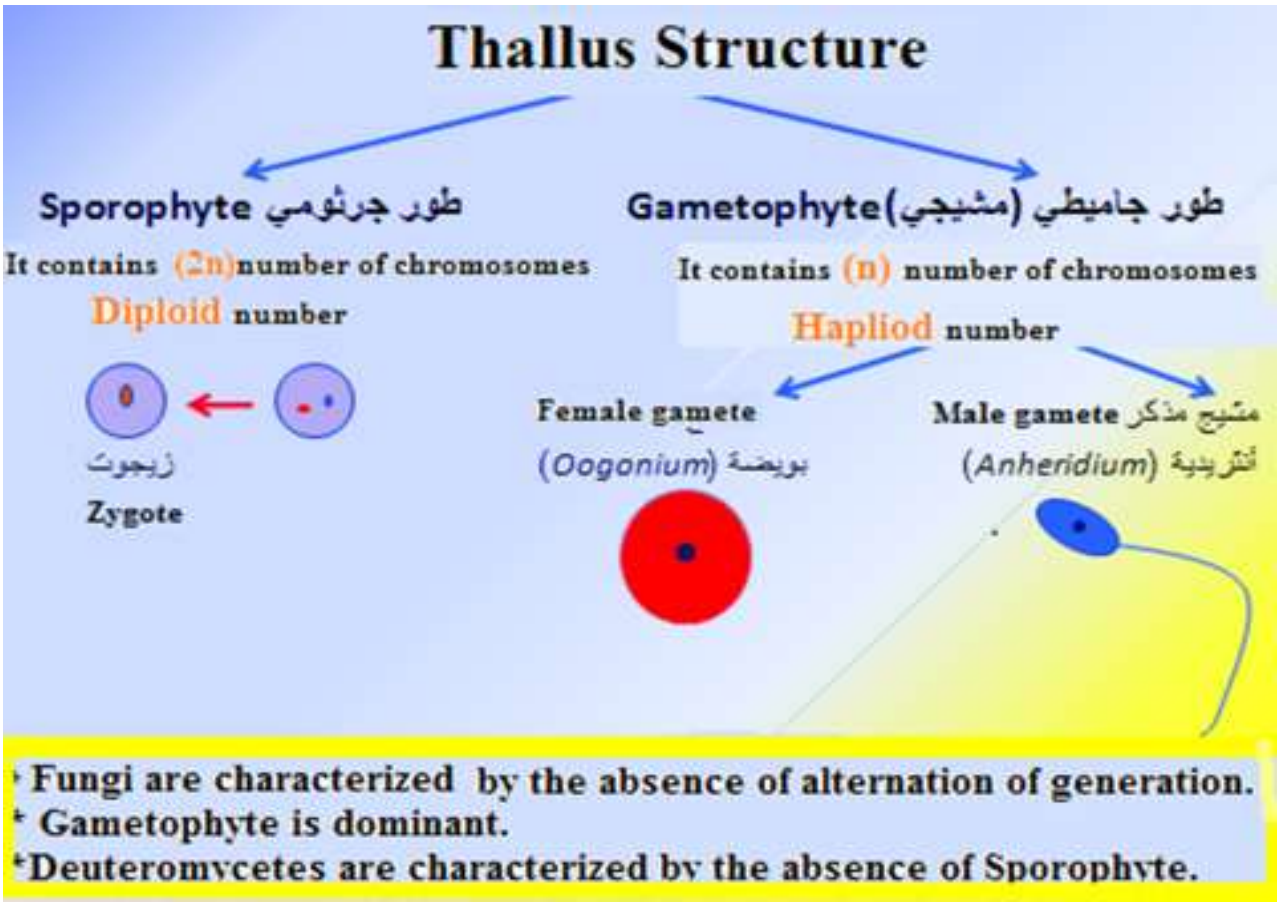
- They belong to *Eukaryota*. They are multicellular with no vascular system.
- ***Mycology***: is the science of studying *Fungi*. (***Mykes***: *Fungi*, ***logos***: science).
- They reproduce by binary fission, asexually by spores or sexually.
- They don't have chlorophyll thus they can't make their 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
2 n
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

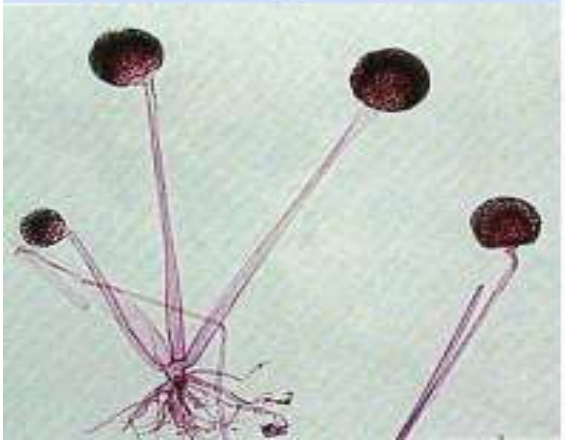
Class 9: *Deuteromycetes*

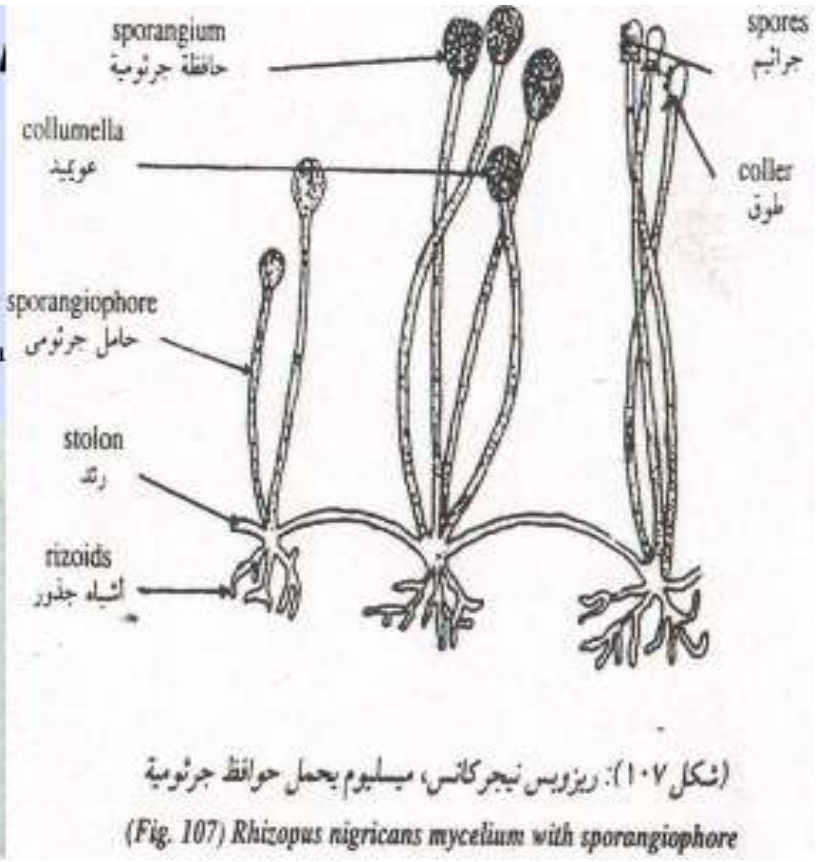
Phylla	Motility	Reproduction	Other Characters
Chytridiomycetes	By one back flagella	Sexually & Asexually	Of variable *Thallus*
Hyphochytridiomycetes	By one front flagella	Sexually & Asexually	Aquatic *Fungi*
Oomycetes	Amphitrichous	Sexually & Asexually ,Producing a fertile non motile Oogonium	Unseptated *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 *Ascus* 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

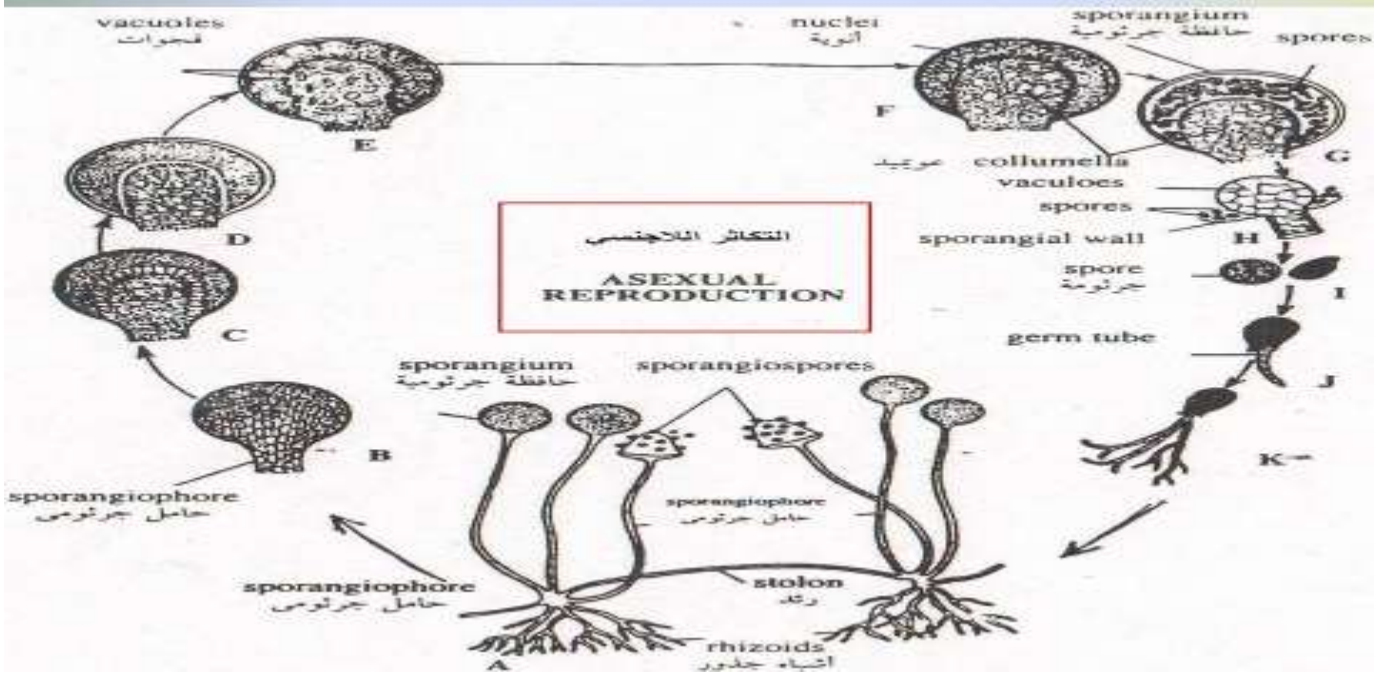




(شكل ١٠٧): ريزوبس نيجركانس، ميسليوم يحمل حوافظ جرثومية

(Fig. 107) Rhizopus nigricans mycelium with sporangiophore

Asexual reproduction in *Rhizopus sp.*



Asexual reproduction:

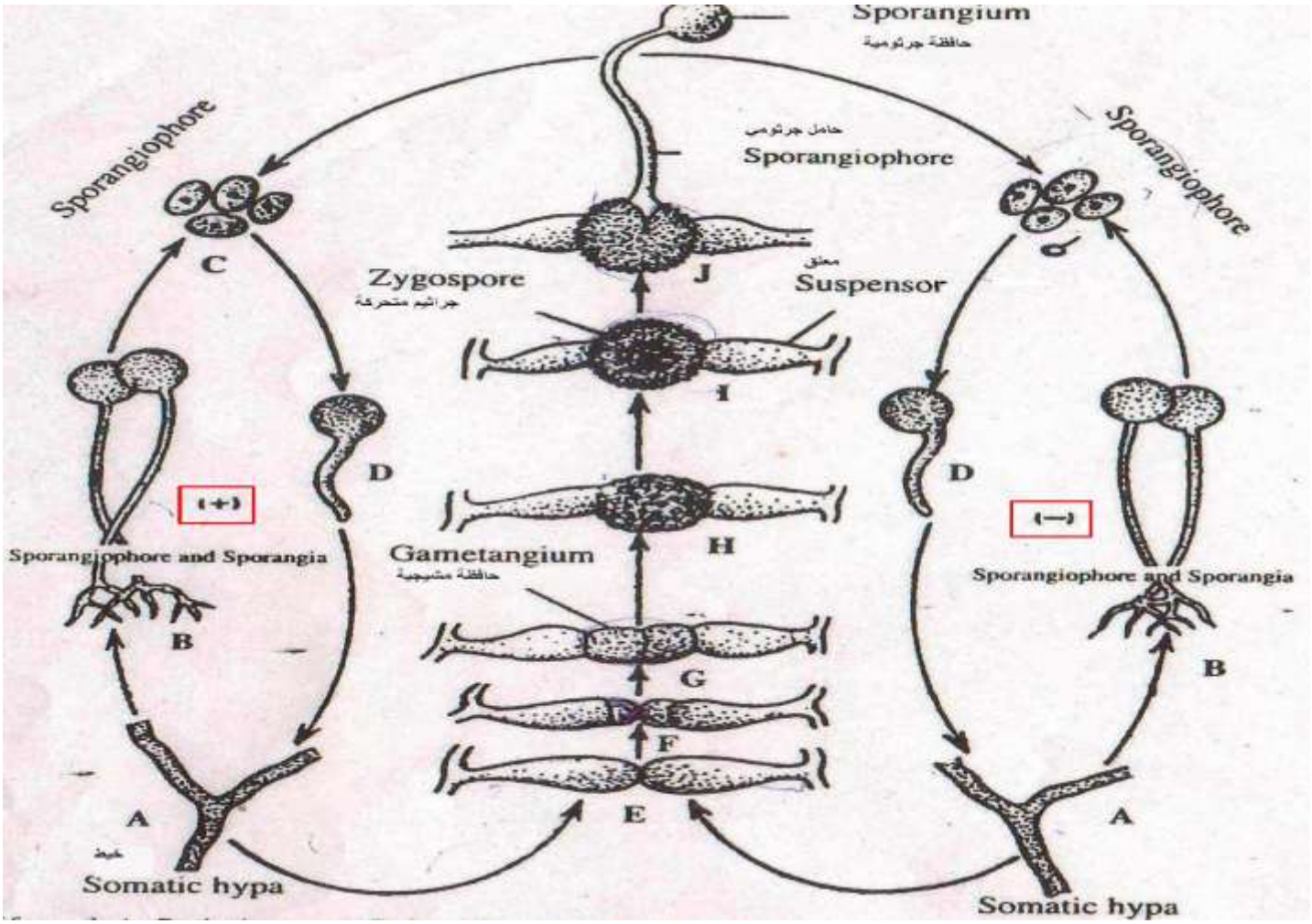
1- The tip of the sporangiophore becomes swollen, forming a sporangium in which a part of the protoplasm containing nuclei and food flows and accumulates at the periphery of the sporangium.
2- The inner area of the sporangium is poor in cytoplasm and nuclei.
3- A dome-shaped layer of vacuoles appears 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.

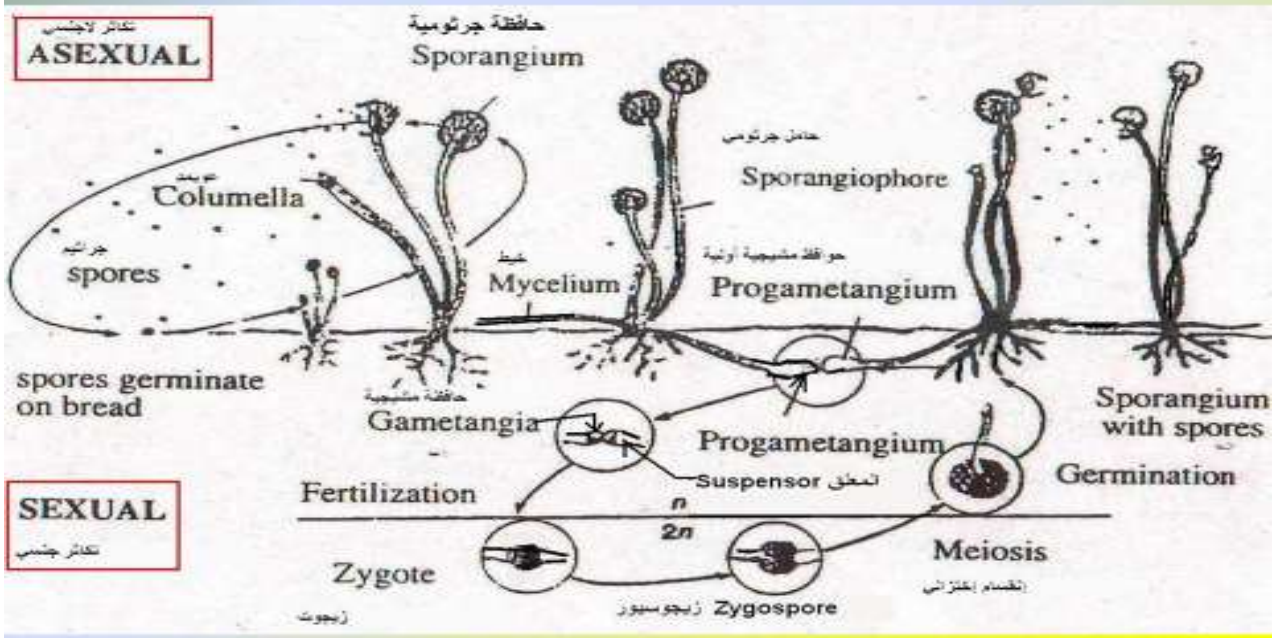


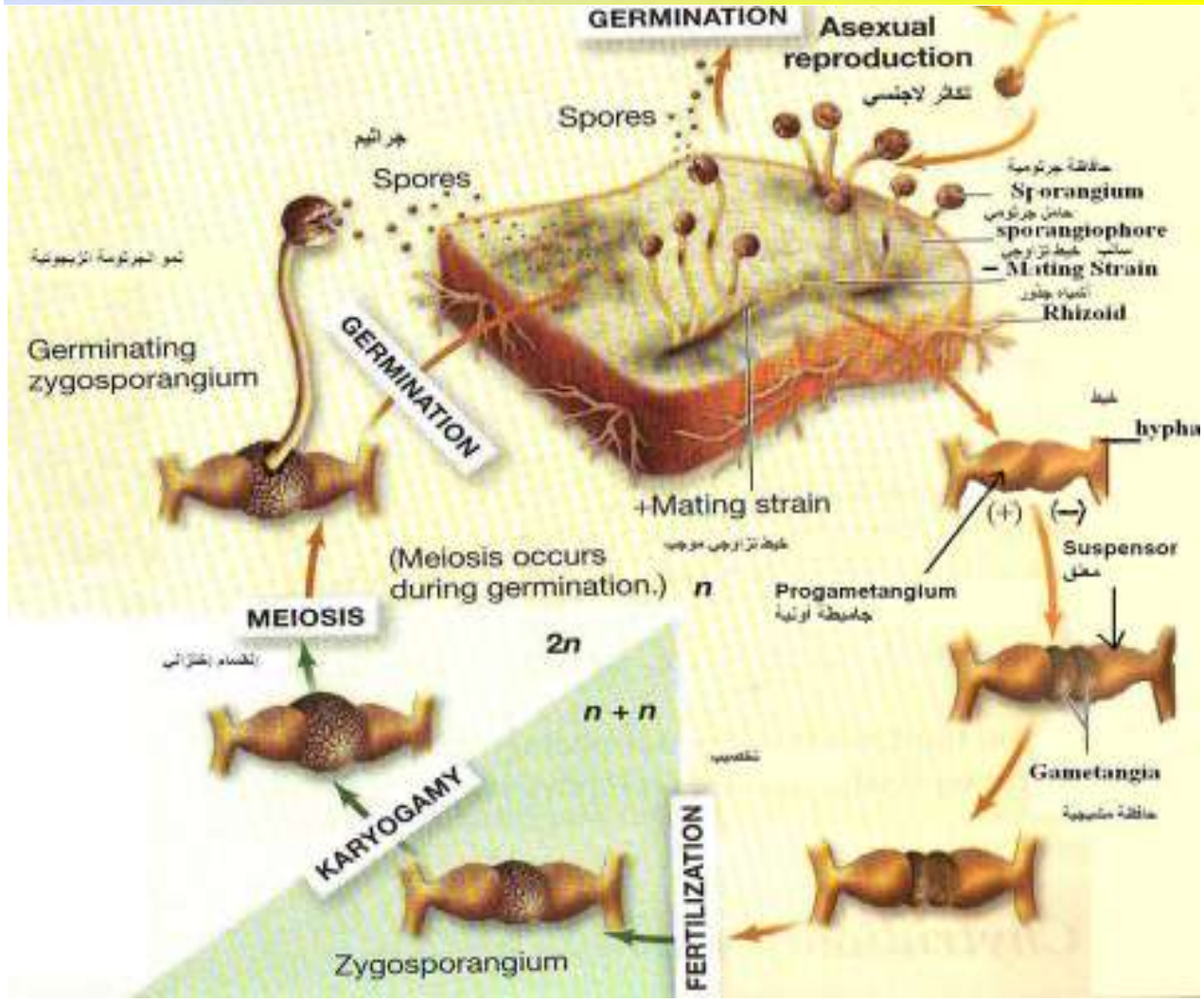
By the return of favourable conditions, the zygospore germinates to give a tube which ends with a sporangium. Meanwhile the diploid nuclei of the zygospore divide many divisions, the first of which is meiotic. This reduction division results in the segregation of genes for sex, and accordingly half of 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.*

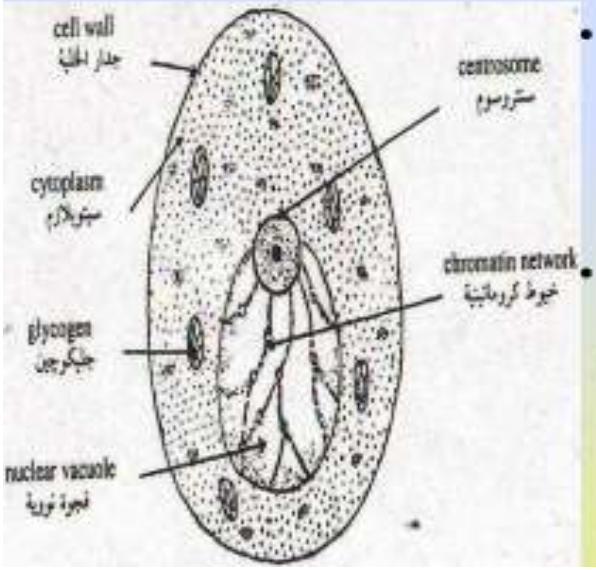




Saccharomyces cerevisiae

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:**

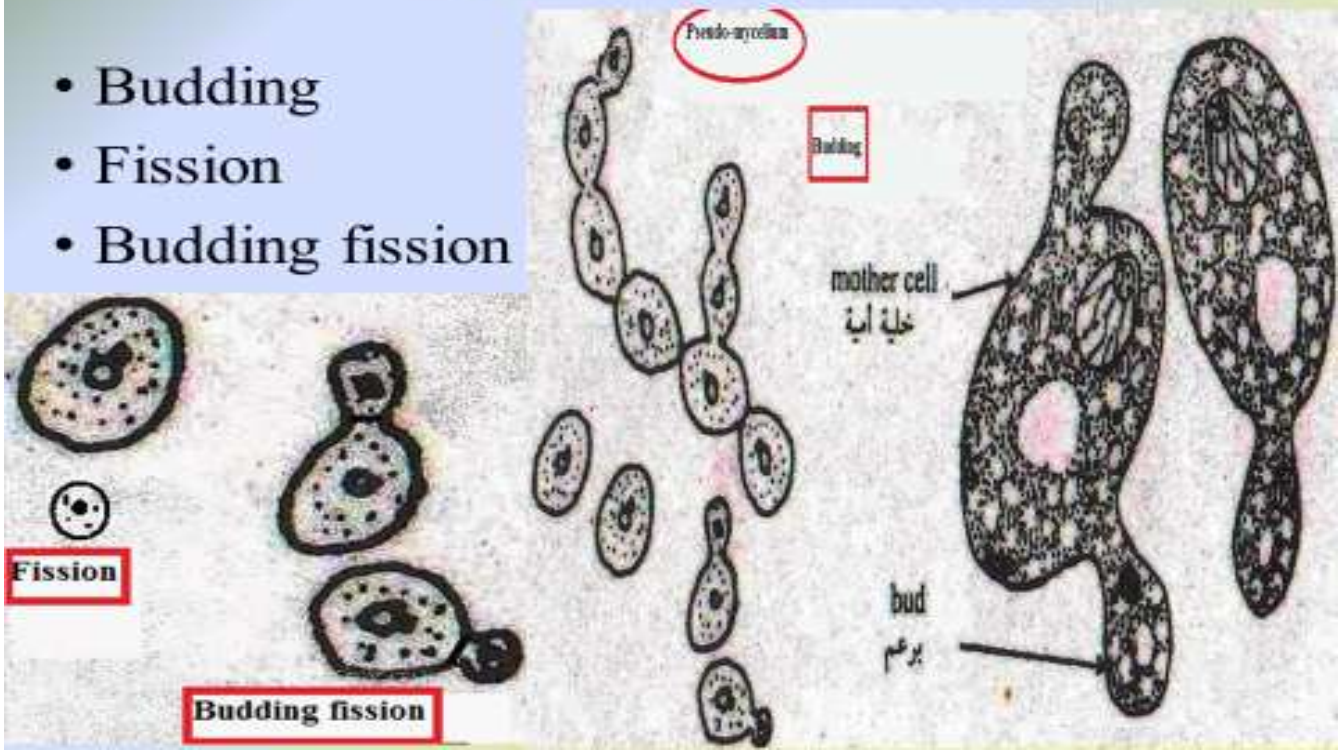
1. **Vegetatively**:
   - Budding - Fission -Budding fission
2. **Sexually**

- **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



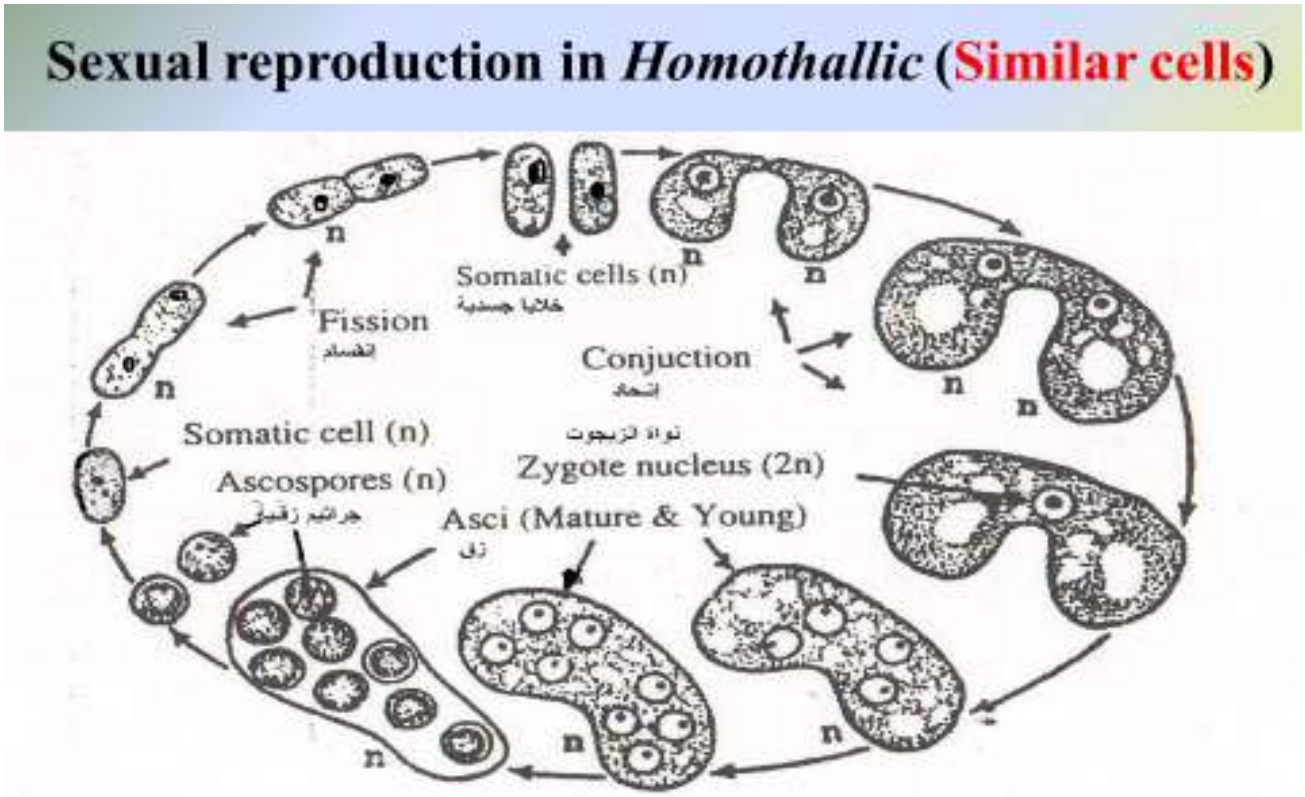
1. Vegetative reproduction:

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*.

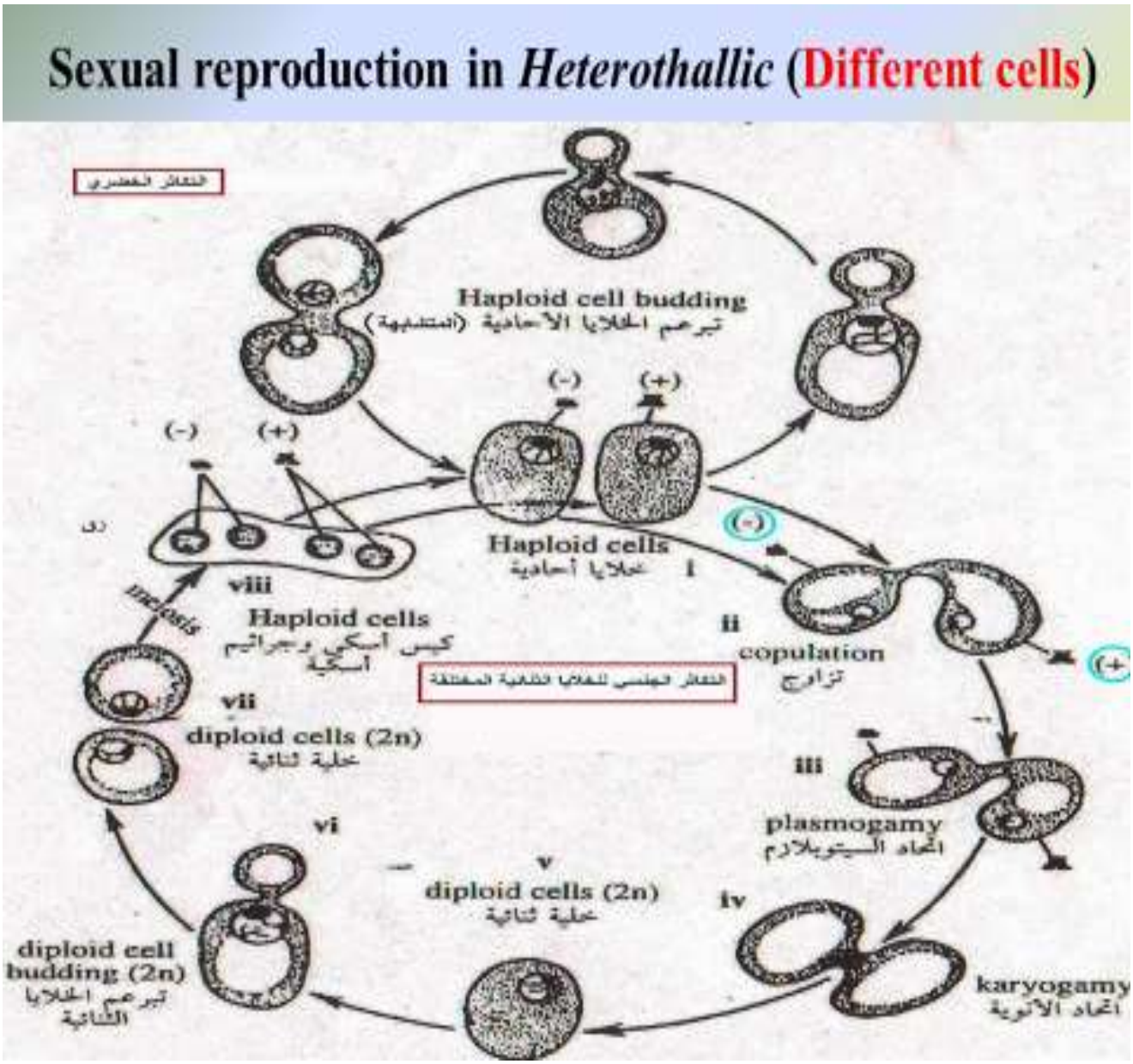
B. Fission: It occurs in a way similar to that found in bacteria. The cell elongates, the nucleus divides mitotically into two and a transverse wall or septum is formed in the middle, dividing the mother cell into two unincleated daughter cells which become separated. *Schizosccharomyces octosporus*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

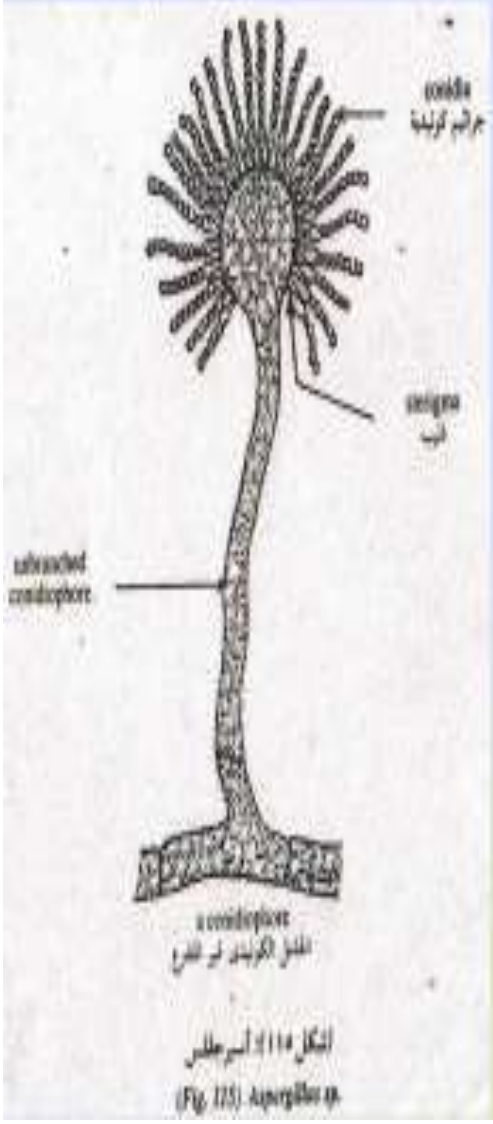
Division: *Eumycota*

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*

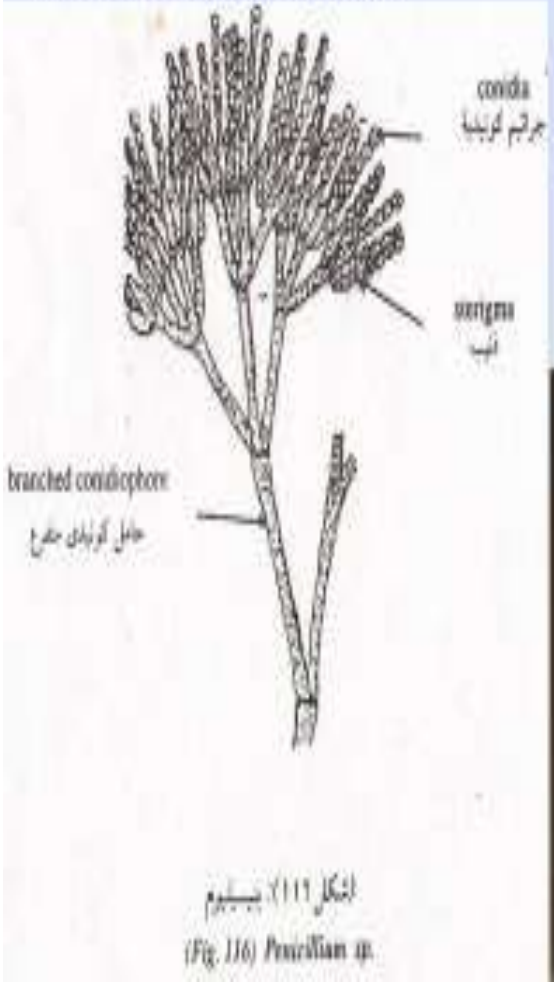
Division: *Eumycota*

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.

Peziza

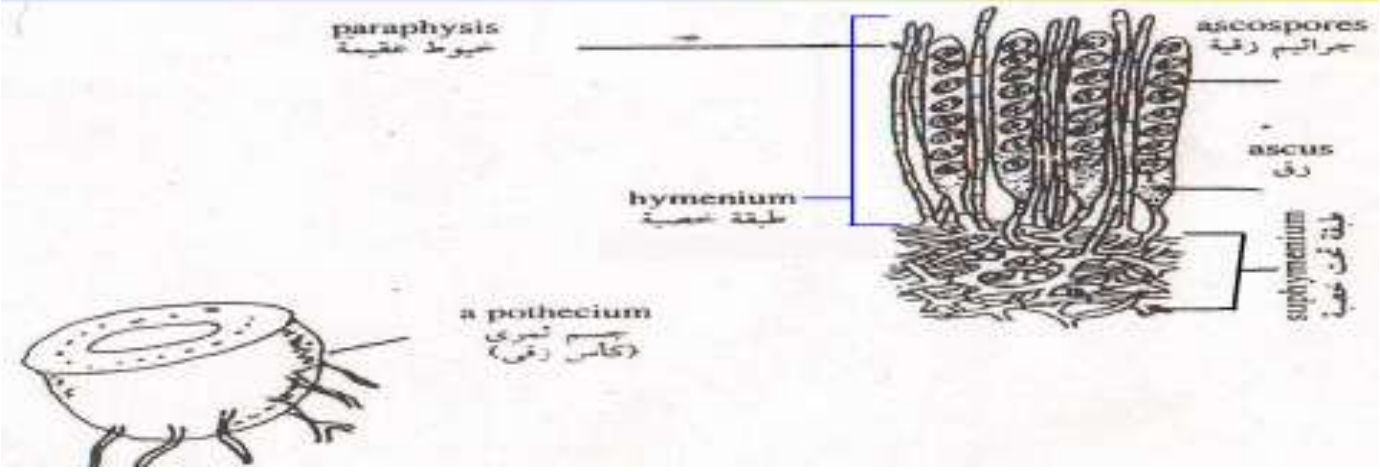
Kingdom: *Fungi*

Division: *Eumycota*

Class : *Ascomycetes*

i.e.: Peziza

1. It grows saprophytically on the organic matter in the soil, rotten wood or animal manures.
2. It is one of the disc-shaped *Ascomycetes*, looking like a cup where the *Ascospores* are arranged.
3. Each *Asci* has 8 *Ascospores*.



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:**

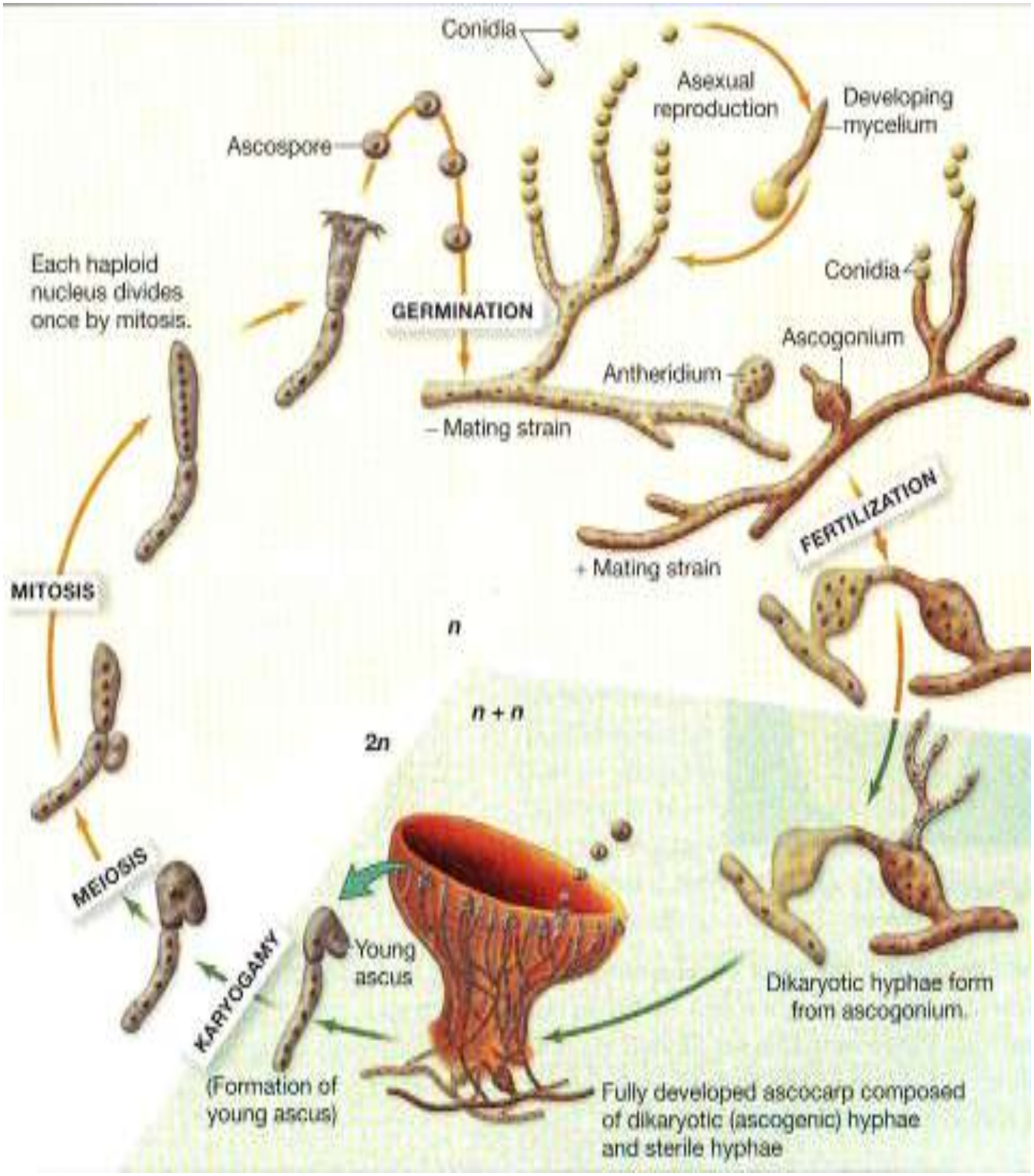
   It takes place by the formation of conidia and chlamydospores. The conidia are exogenously formed spores. They are abstricted from the tips of conidiophores. Each conidium germinates to form a new mycelium.

   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

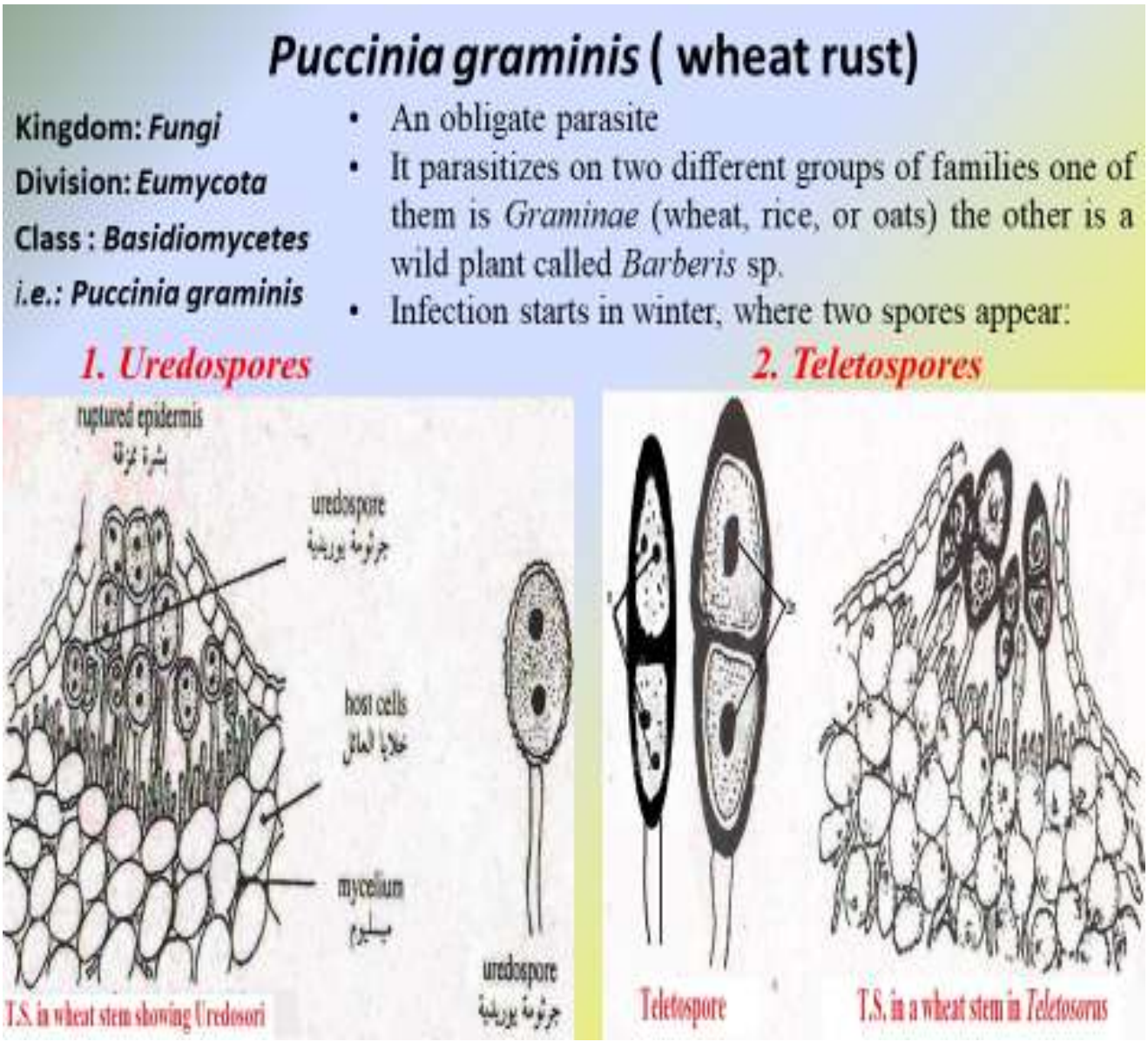
two purely vegetative nuclei in a pair. The adult mycelium consists of a tangled mass of hyphae. Certain vegetative cells in the center of the tangled hyphal mass have been seen to possess nuclei which become associated in pairs.



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)

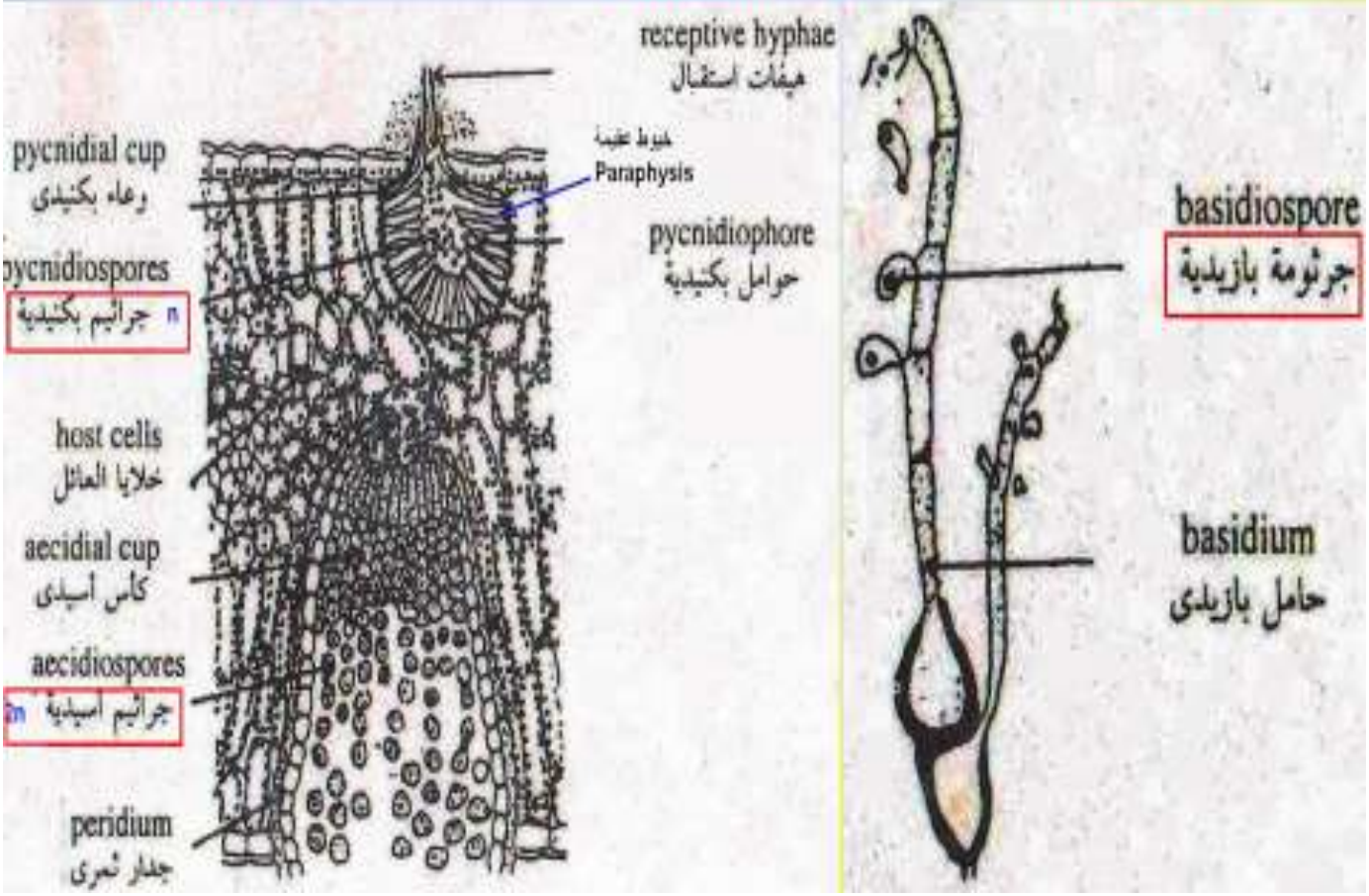
Points of Comparisons	Uredospores	Teletospores
Shape	Unicellular, binucleated spore with haploid number of chromosomes. The outer membrane is thick and dentate, while the inner one is thin and	Bicellular with one nucleus in each cell with a diploid number of chromosome. The outer membrane is thick while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

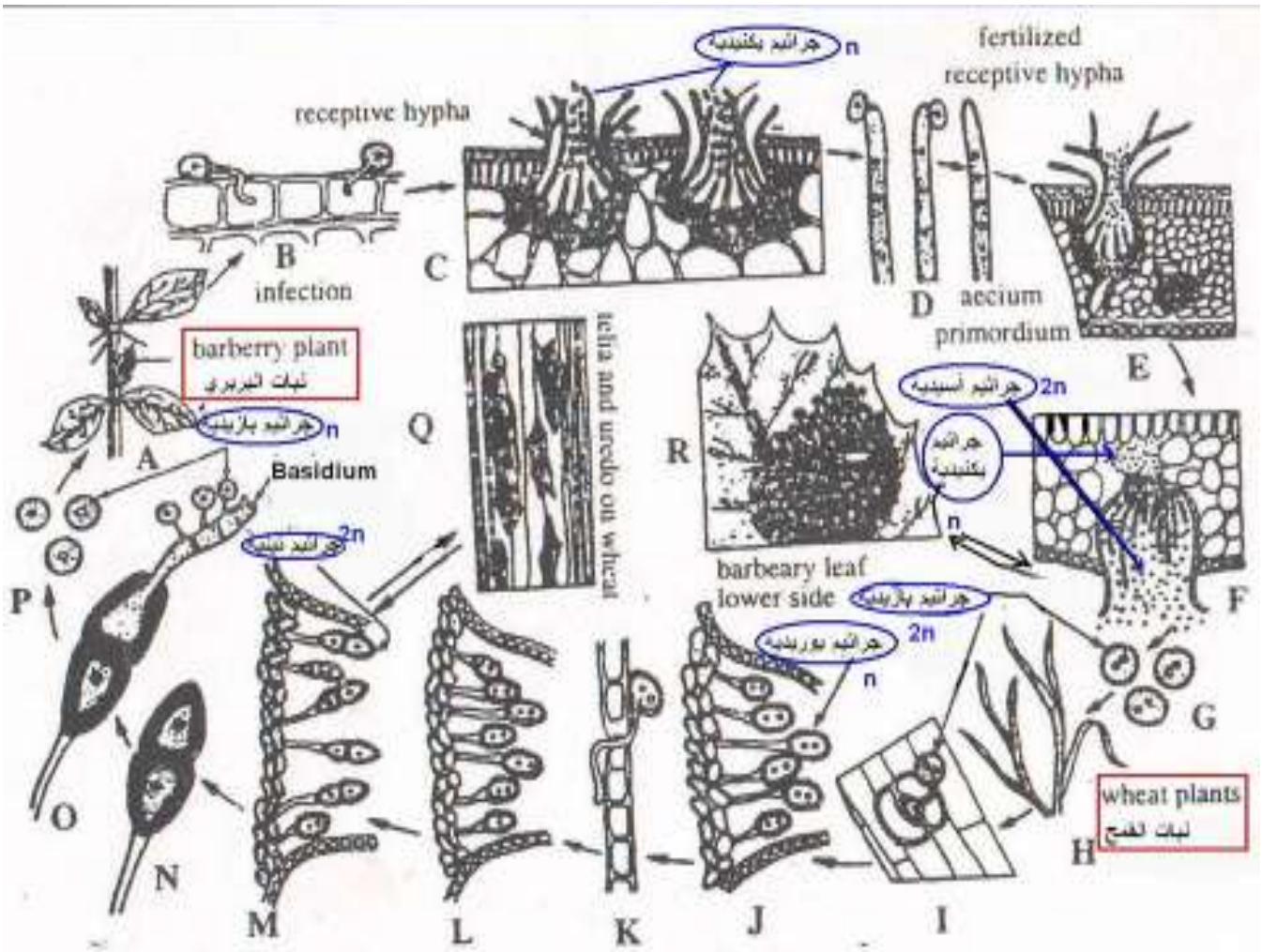
Puccinia graminis (wheat rust)

- 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.

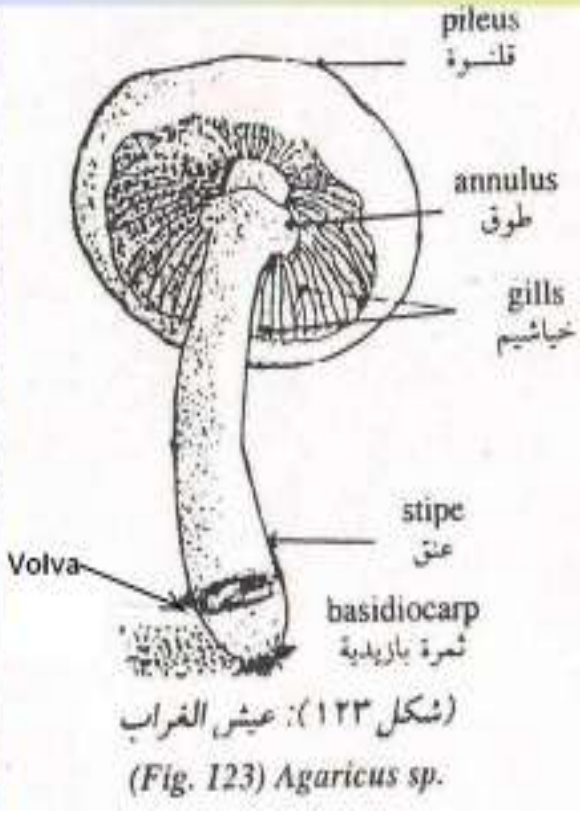
All these hyphae and pycniospores in one pycnidium are either of the positive or negative strain according to the type of the infecting basidiospore.

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.

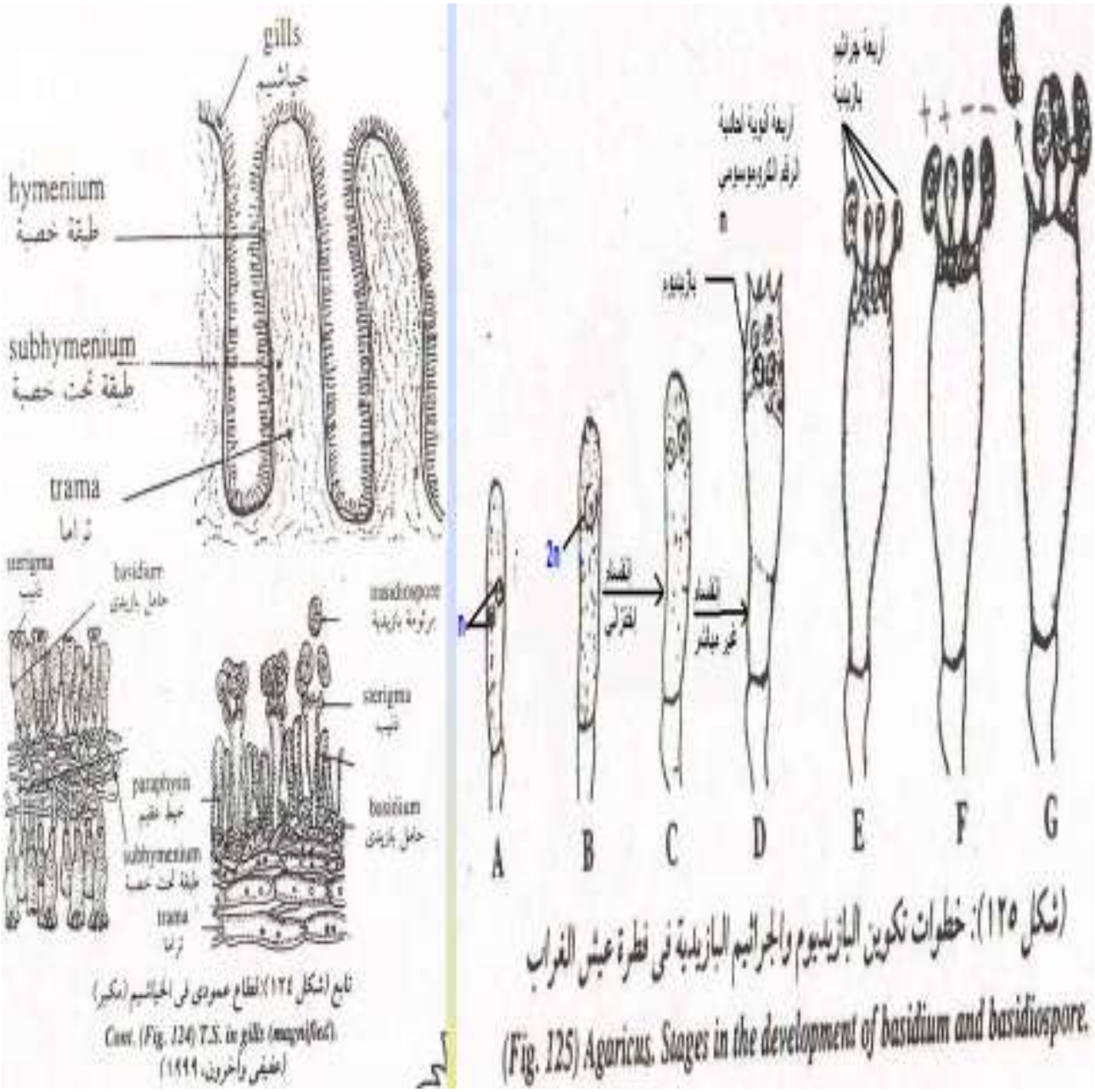


(شكل ١٢٣): عيش الغراب

(Fig. 123) Agaricus sp.

Life cycle:

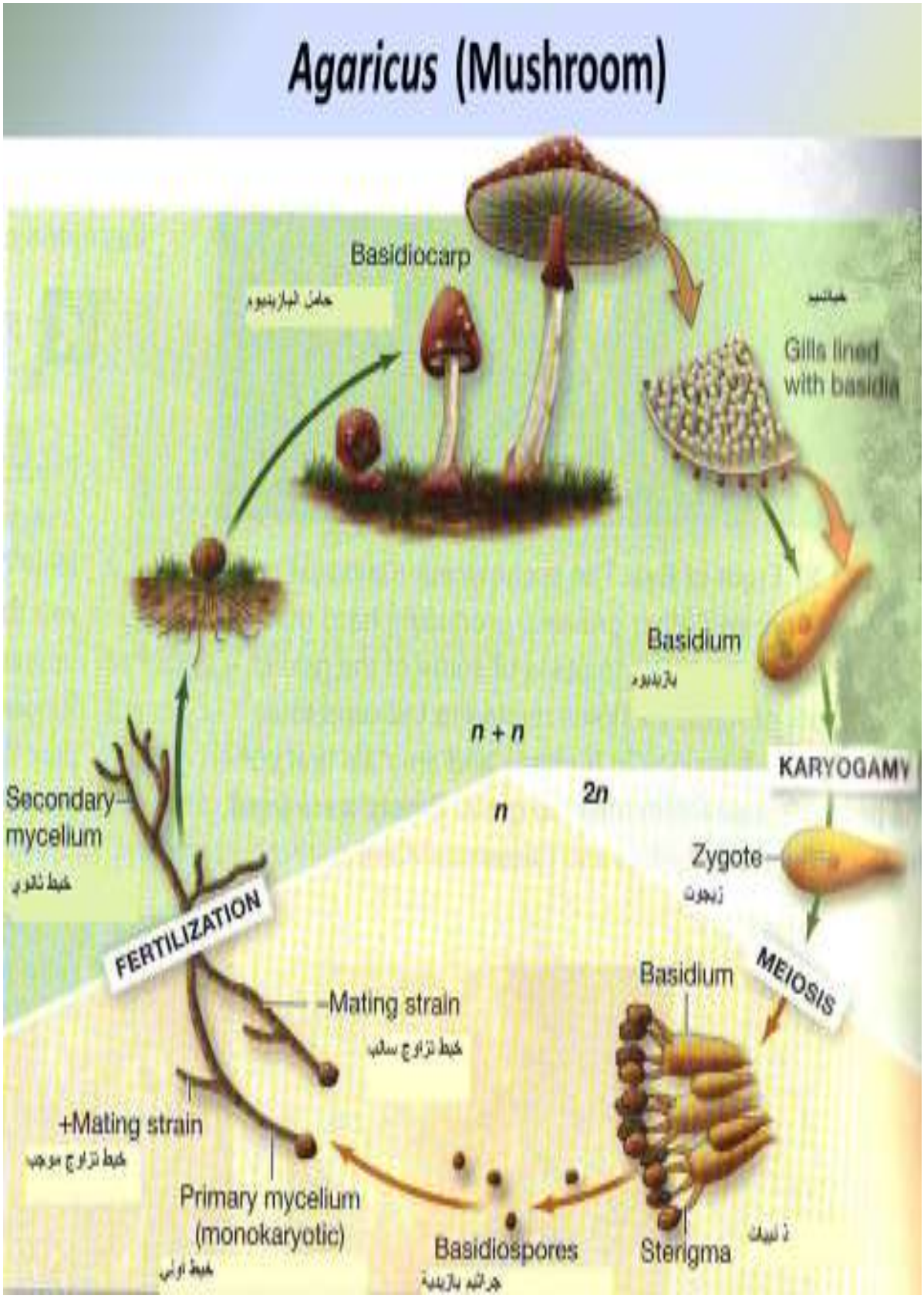
The basidiospores, after dissemination from gills, germinate in the soil to give uninucleated hyphae. These hyphae (primary mycelium) are sexually differentiated. Hayphae of opposite surains conjugate to form binucleated cells. It is these cells that form the secondary mycelium which develops into the 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.

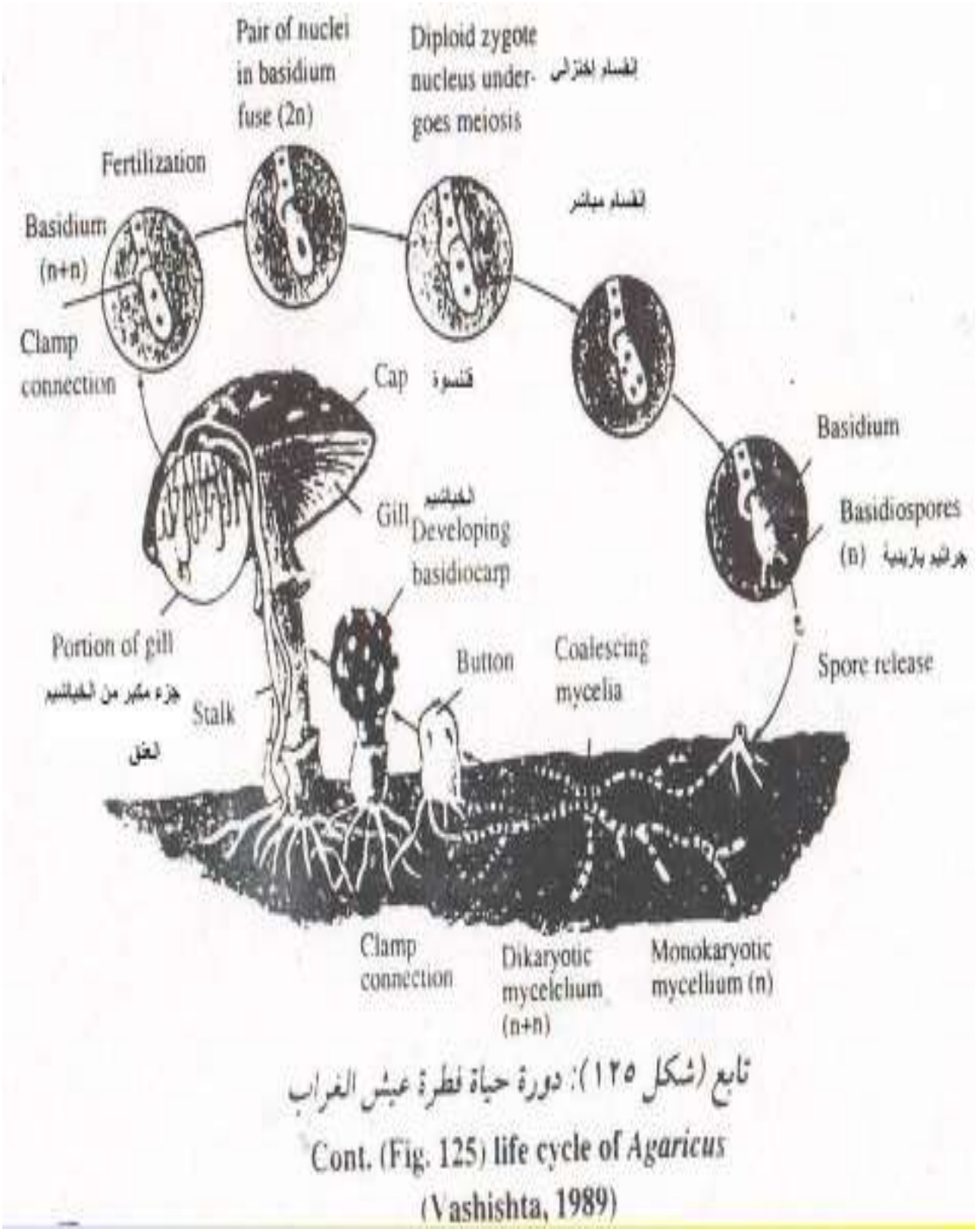


These uninucleated lobes, form the basidiospores carried on short sterigmata. Meiosis of the diploid nuçleus results in segregation of sex characters, thus two basidiospores give, on germination, hyphae a the +ve strain while the two other spores give hyphae of the

-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:





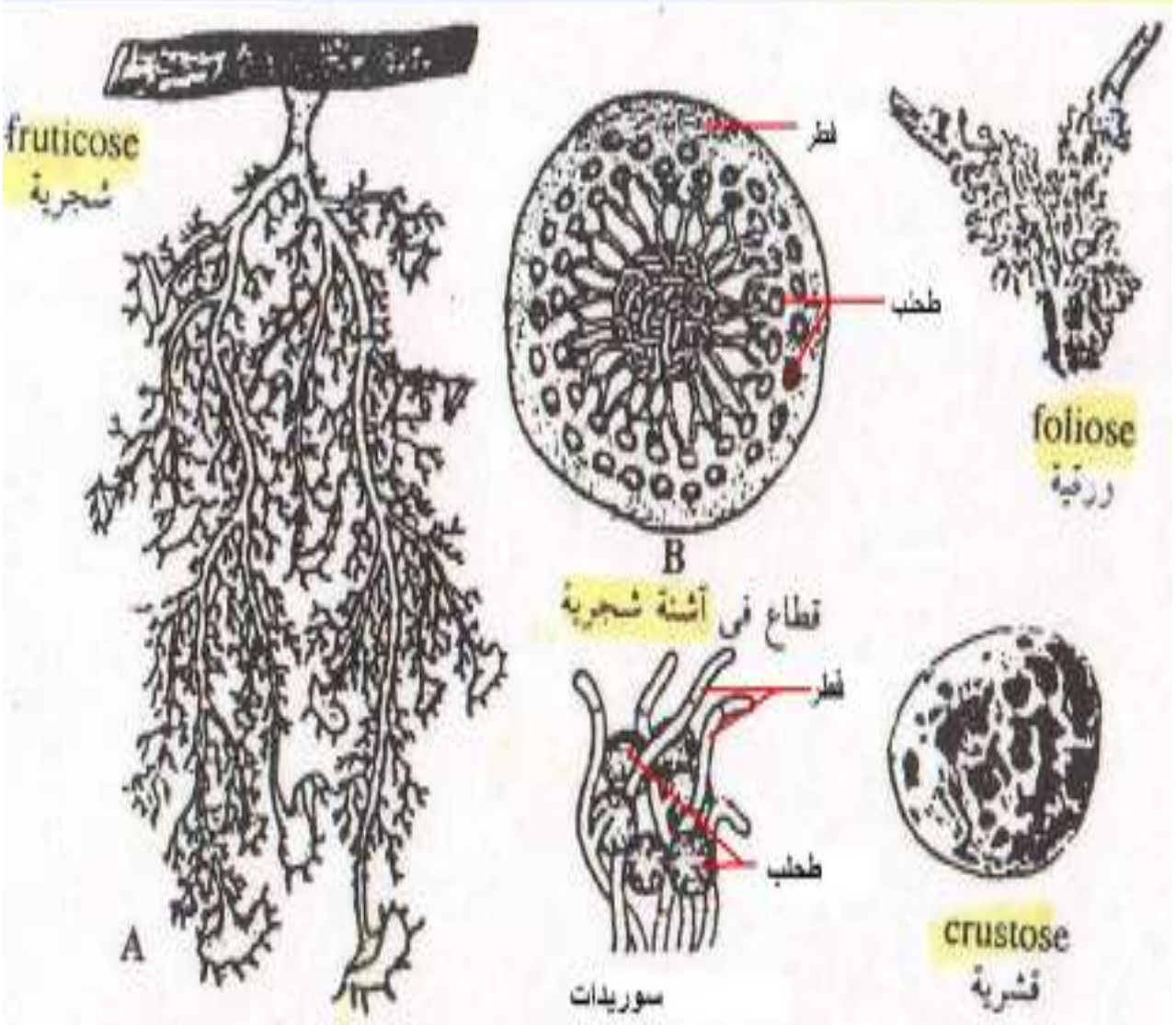
تابع (شكل ١٢٥): دورة حياة فطرة عيش الغراب

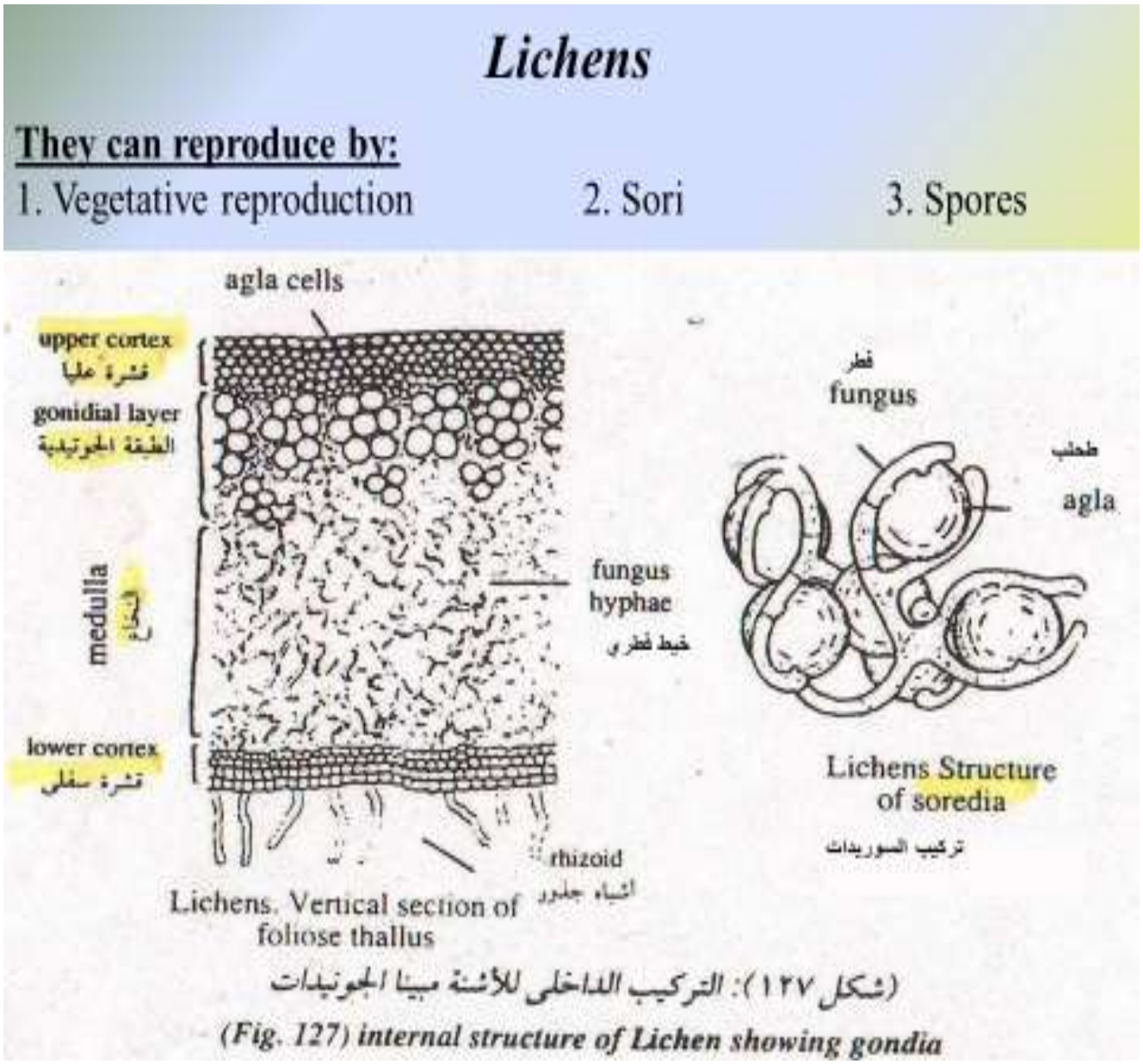
Cont. (Fig. 125) life cycle of *Agaricus*

(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.

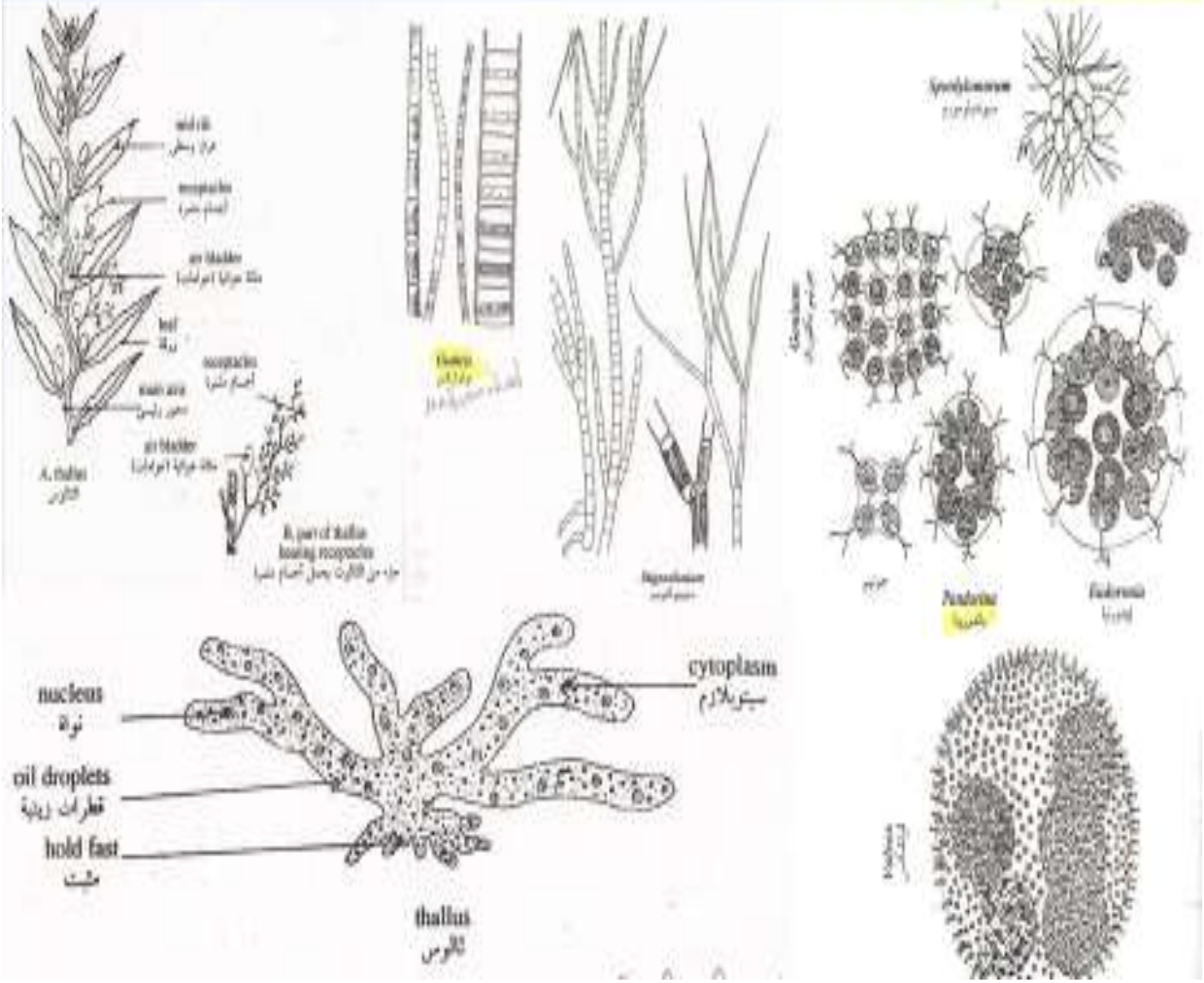
Algae

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*.

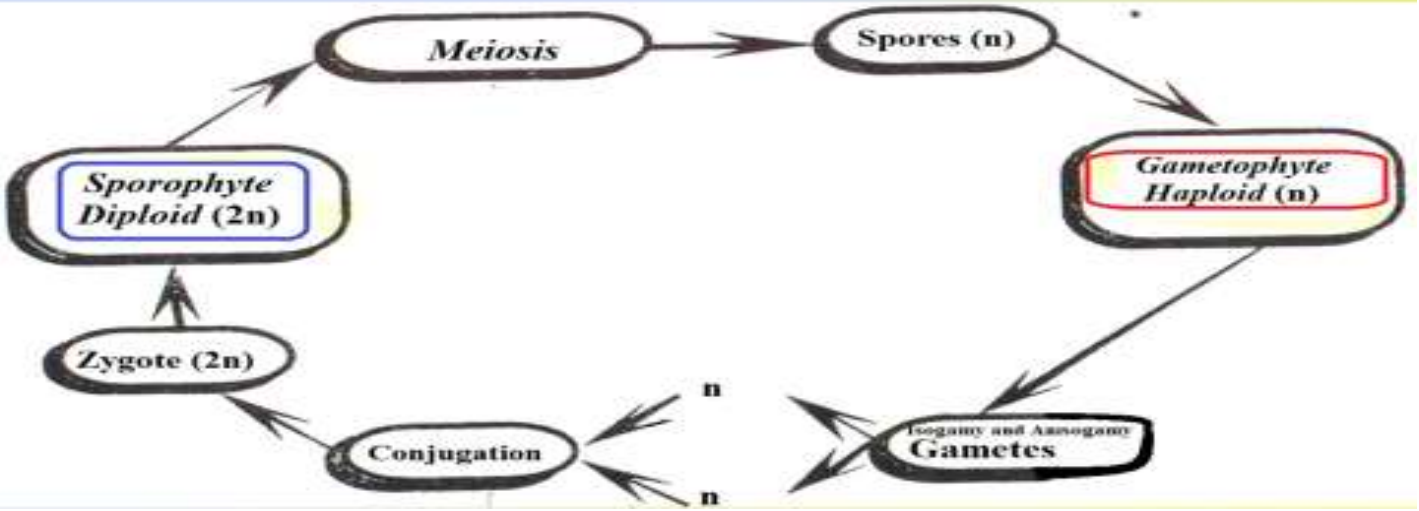
Algae

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.

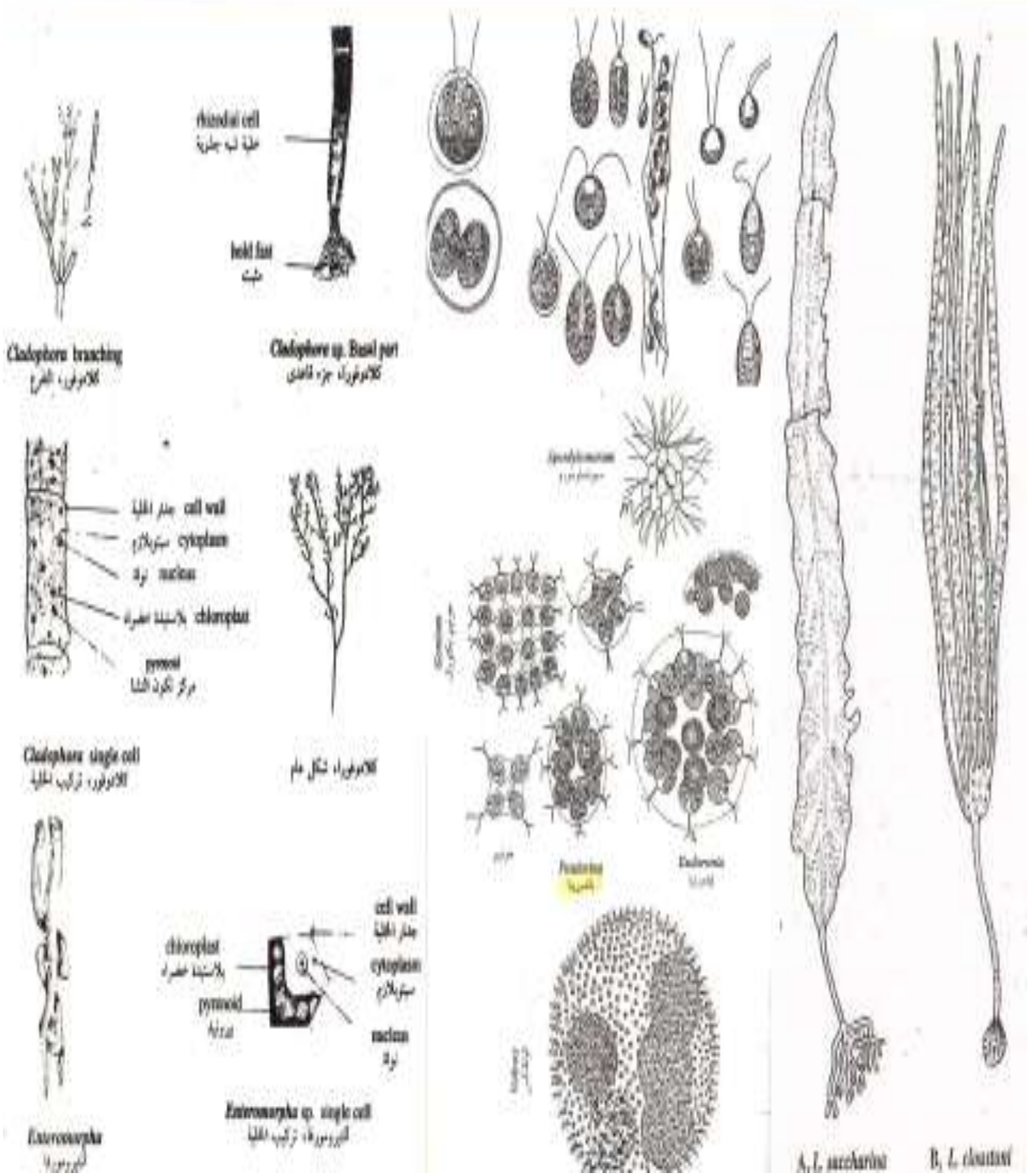
الأسواط، تركيب الجدار الخلوي والمادة الغذائية المدخرة

عدد الأنواع تقريبا	الأسواط	أصباغ البناء الضوئي	مكونات الجدار الخلوي	المادة المدخرة	الموطن البيئة	القسم أو المجموعة
٢٠٠٠٠	أحيانا لا يوجد أو يوجد ١-٨ كرباجية	كلوروفيل أ، ب كاروتونيدات	سكريات عديدة مع سليلوز	نشا	معظمها تقطن المياه العذبة، بعضها في المياه البحرية أو أرضية أو هوائية	الطحالب الخضراء Chlorophyta
١٥٠٠	٢ جانبية كرباجية أمامية أحيانا	كلوروفيل أ، ج فيكوكزانثين كاروتونيدات	سليلوز مع حامض الألجين سكريات عديدة مع كبريتات	لامينارين مانيتول	كلها غالبا في المياه البحرية - قلة قليلة للغاية في المياه العذبة	الطحالب البنية Phaeophyta
٣٩٠٠٠	لا يوجد	كلوروفيل أ، د كاروتونيدات فيكوبيلينات كلوروفيل أ-ج	سليلوز مع بكتين وأملاح كالسيوم سليلوز+ سيليكاة	نشا فلوريدى	معظمها بحرية، البعض منها في المياه العذبة	الطحالب الحمراء Rhodophyta
٦٠٠٠	لا يوجد، أو يوجد أحيانا واحد أو اثنان كرباجية ١-٣	فيكوكزانثين كاروتونيدات	أحيانا غير موجودة	كريزو لامينارين	مياه عذبة مياه مالحة أرضية -هوائية	الطحالب العصوية (الدياتومات) Bacillariophyta
٧٠٠	لا يوجد	كلوروفيل أ،ب كاروتونيدات	لا يوجد جدار	أجسام باراميلونية	مياه عذبة أو مالحة بعضها هوائية.	الطحالب اليوجلينية Euglenophyta
		كلوروفيل أ،ب كاروتونيدات	سليلوز	نشا	مياه عذبة أو ضارية للملوحة	الطحالب الكارية Charophyta
٢٥٠	لا يوجد	كلوروفيل أ،ج كاروتونيدات	لا يوجد	نشا	غالبا مياه عذبة بعض منها بحرية	الطحالب الكريبتية
١١٠٠	اثنين	كلوروفيل أ، ج بيريدينين كاروتونيدات	سليلوز أحيانا غير موجود	نشا	مياه عذبة ومالحة هوائية	الطحالب النارية ثنائيات 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).

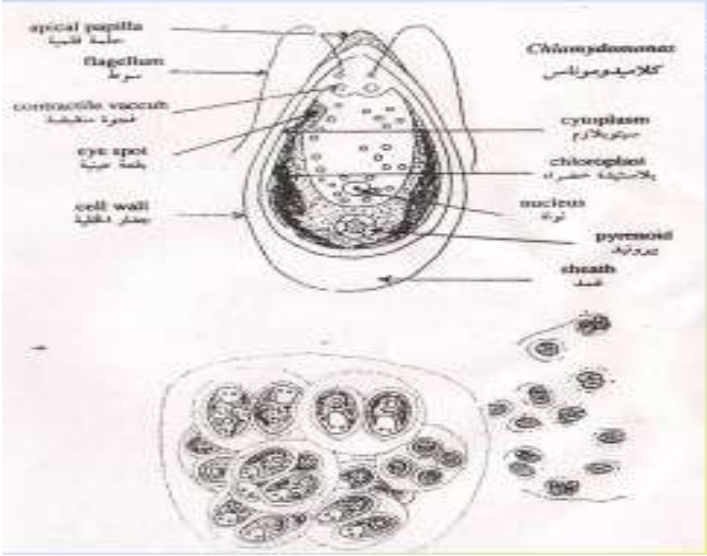
Chloropyta


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
Prasiola
cell wall
chloroplast
cytoplasm
pyrenoid
nucleus
Enteromorpha sp. single cell
أنتيروموربا، تركيب خلية
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.

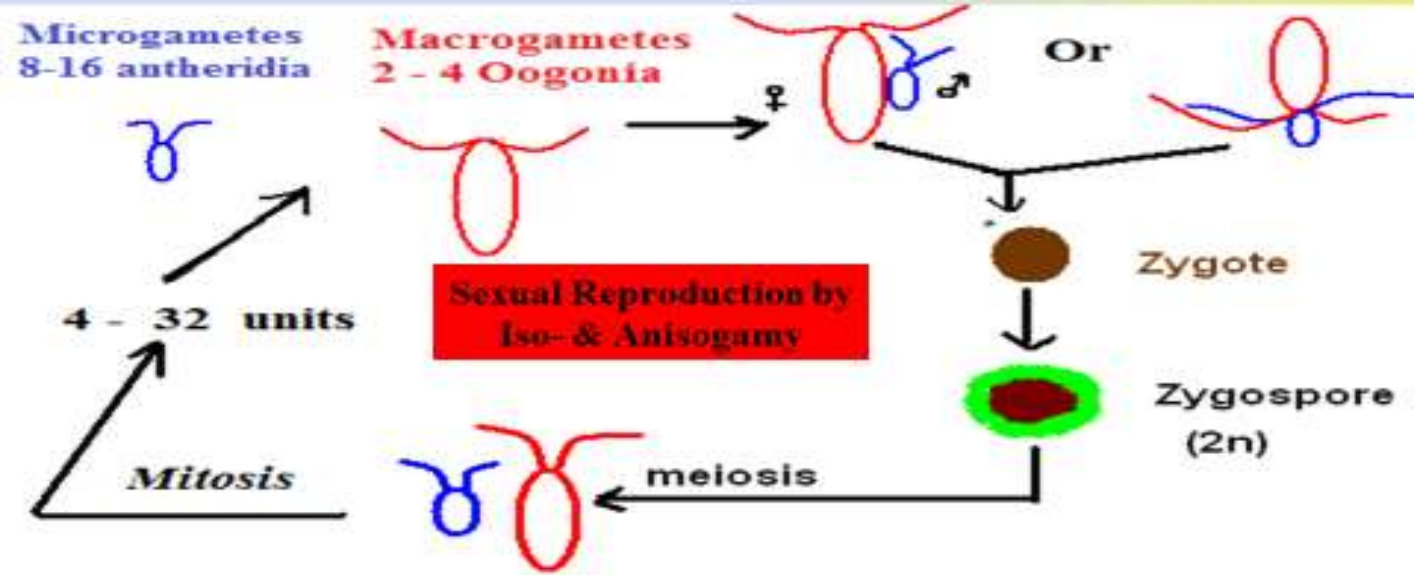


Reproduction:

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.

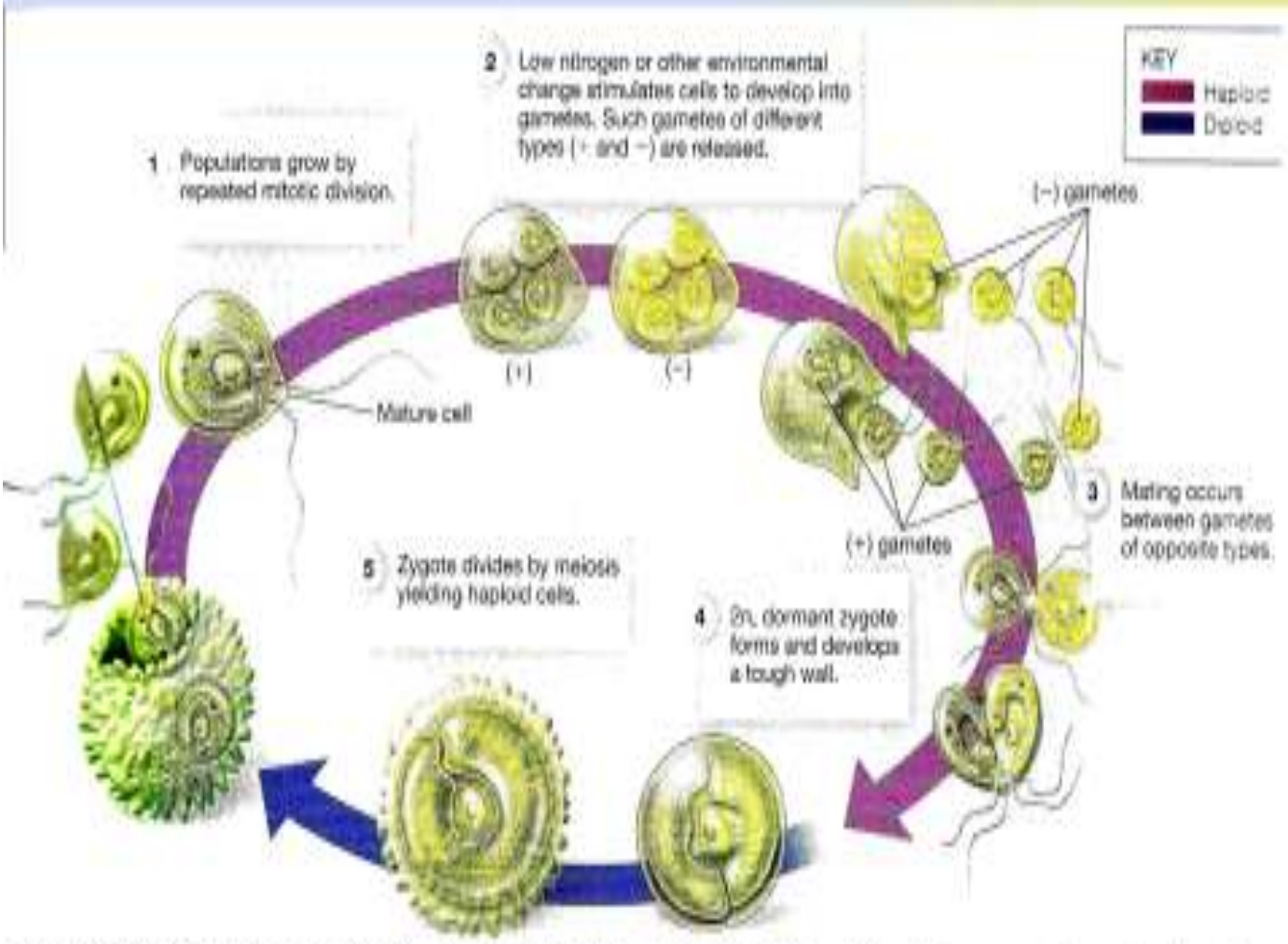


FIGURE 23.20 *Chlamydomonas*: **The Structure and Life Cycle of This Motile Green Alga.** During asexual reproduction, all structures are haploid; during reproduction, only the zygote is diploid.

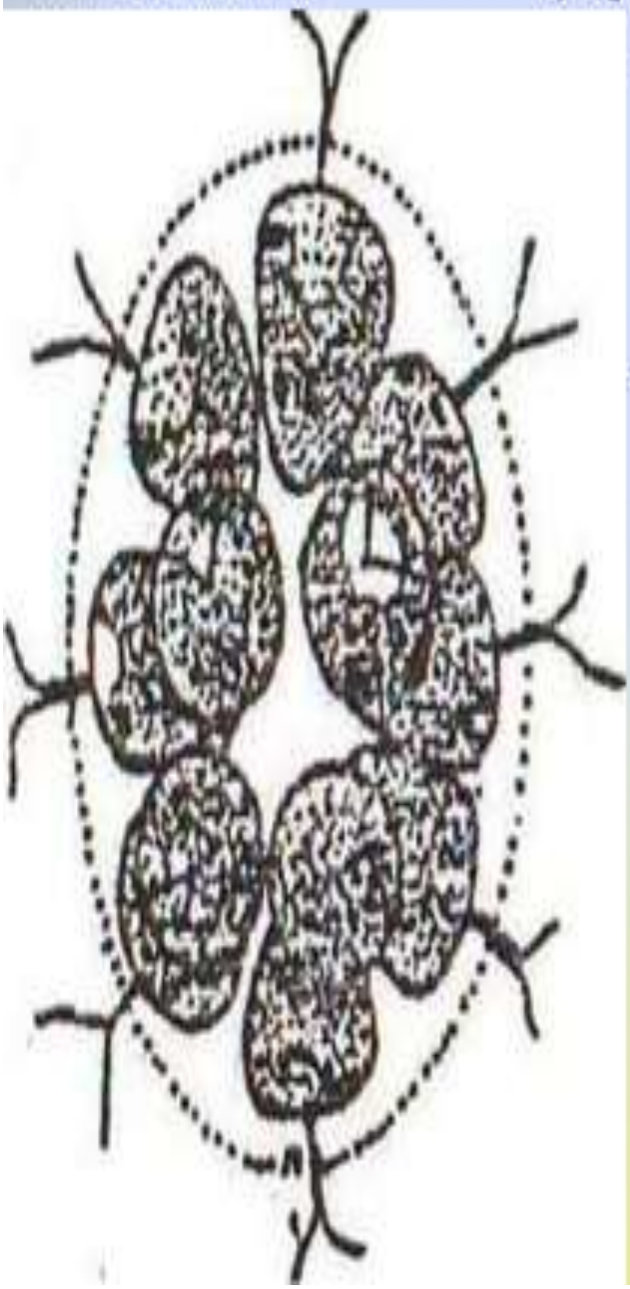
Pandorina

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.

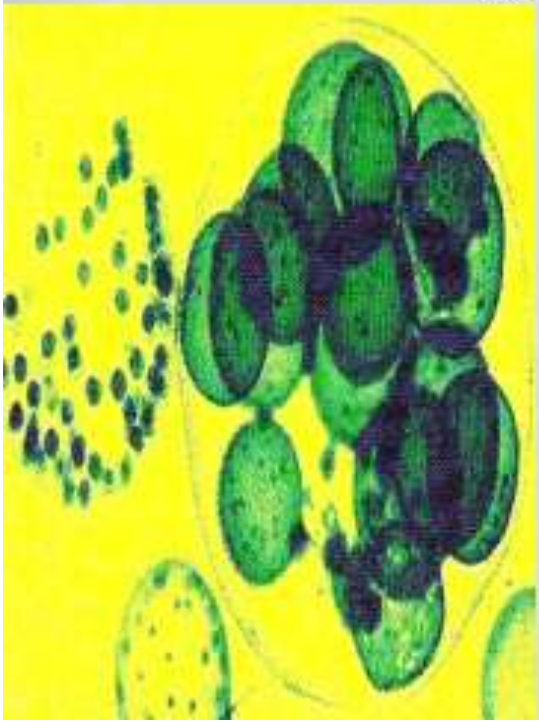
Volvox

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.

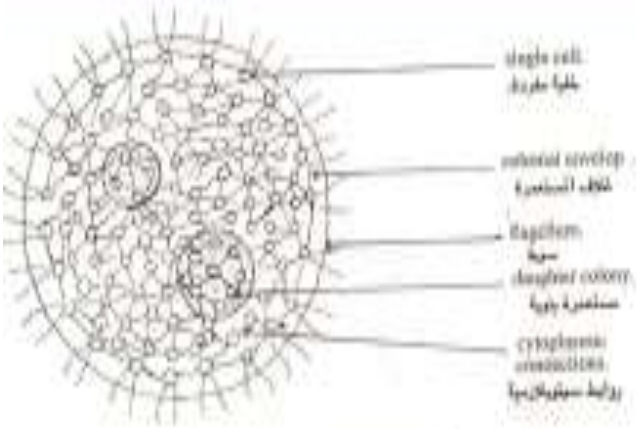


Fig. 12.1, *Volvox* sp. parent colony with daughter colonies
شكل (١٢-١) فولفوكس : مستعمرة أبوية بها مستعمرات بنوية

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

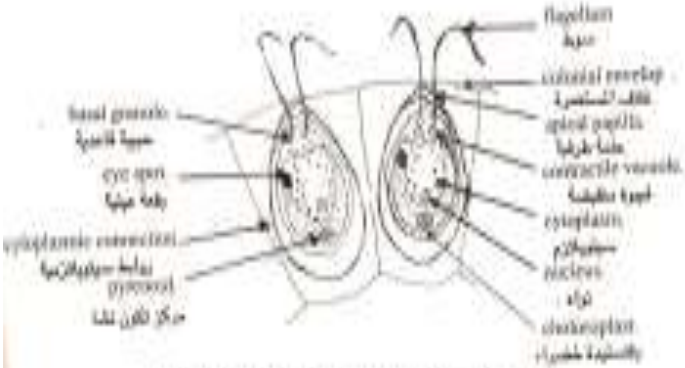


Fig. 12.2, *Volvox* sp. cell arrangement and structure
شكل (١٢-٢) فولفوكس : ترتيب وتركيب خلايا المستعمرة

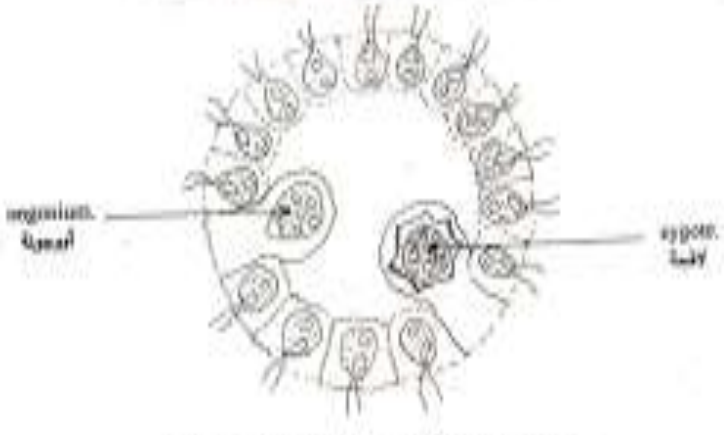
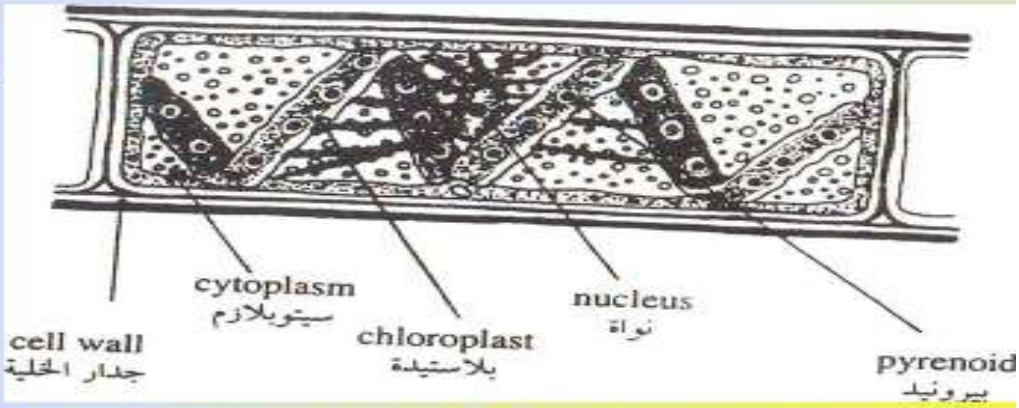
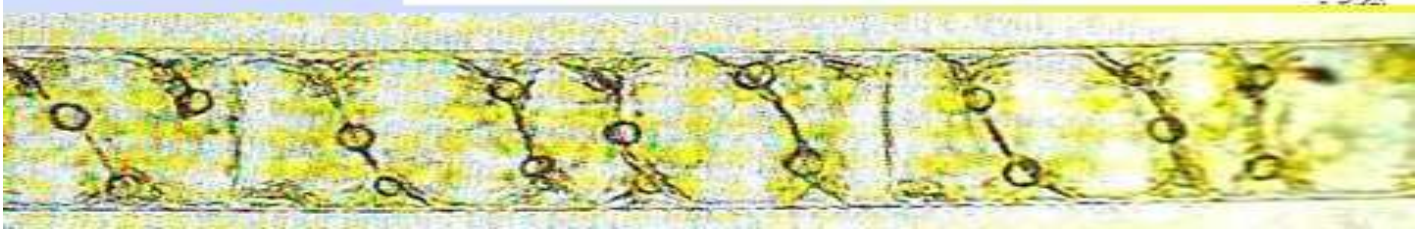


Fig. 12.4, *Volvox* sp. a colony with a zygote
شكل (١٢-٤) فولفكس : مستعمرة يتضح بها اللاقحة

Spirogyra

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





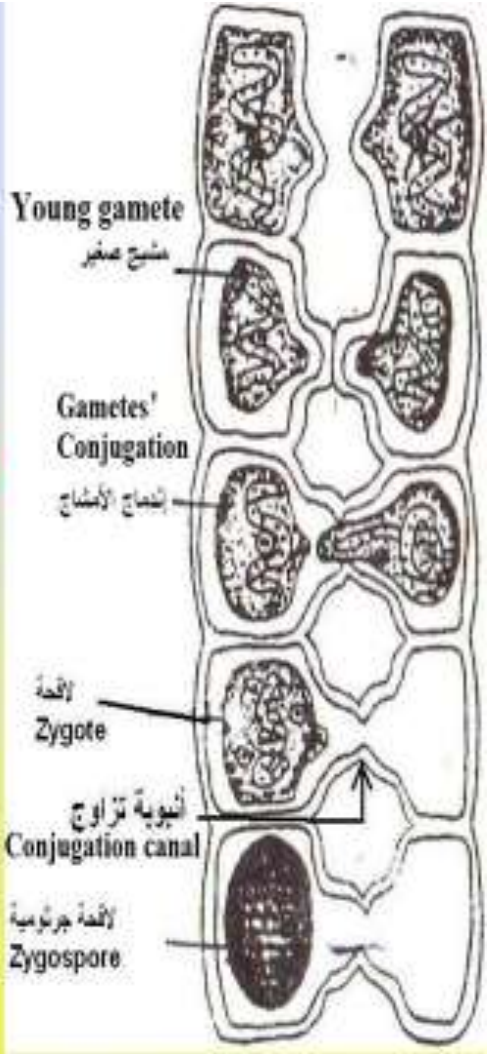
Kingdom: *Protista*

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.

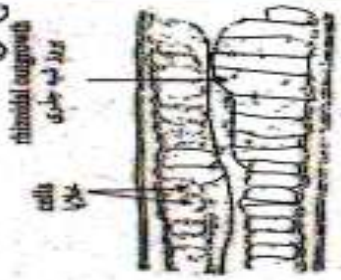


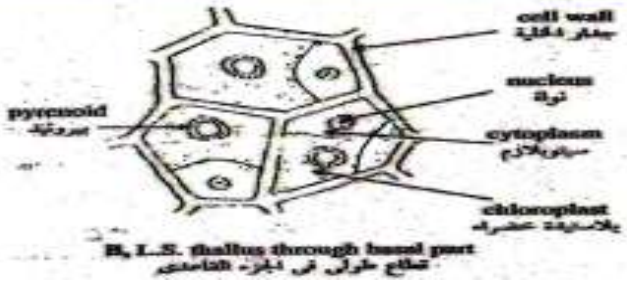
Ulva

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.

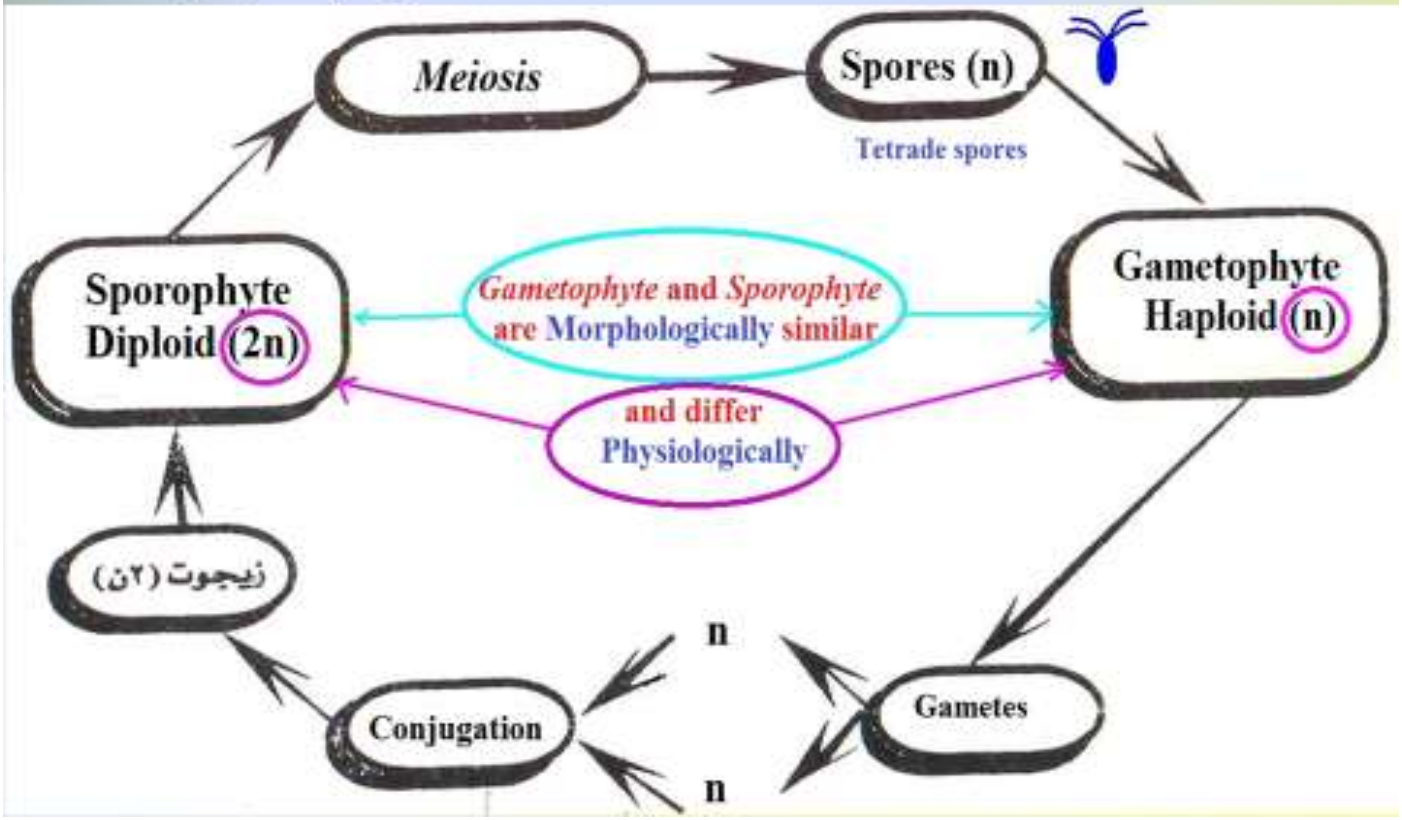
- **Reproduction:**
  1. **Vegetatively:** by budding
  2. **Asexually:** by *Zoospores*
     - Each cell turns into sporangium divides mitotically into 4 – 8 *Zoospores.*





B. L.S. thallus through basal part

3. Sexually: by isogamy

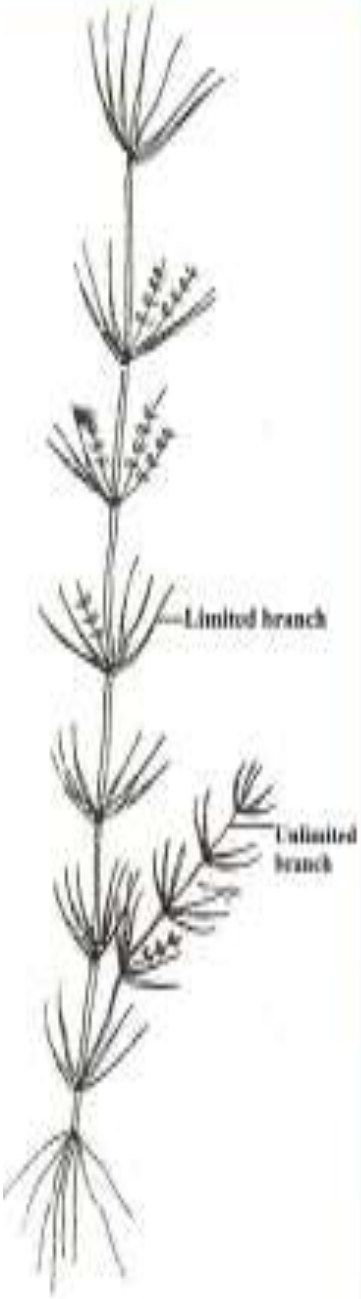


Chara

Kingdom: ***Protista***

Class : ***Charphyta***

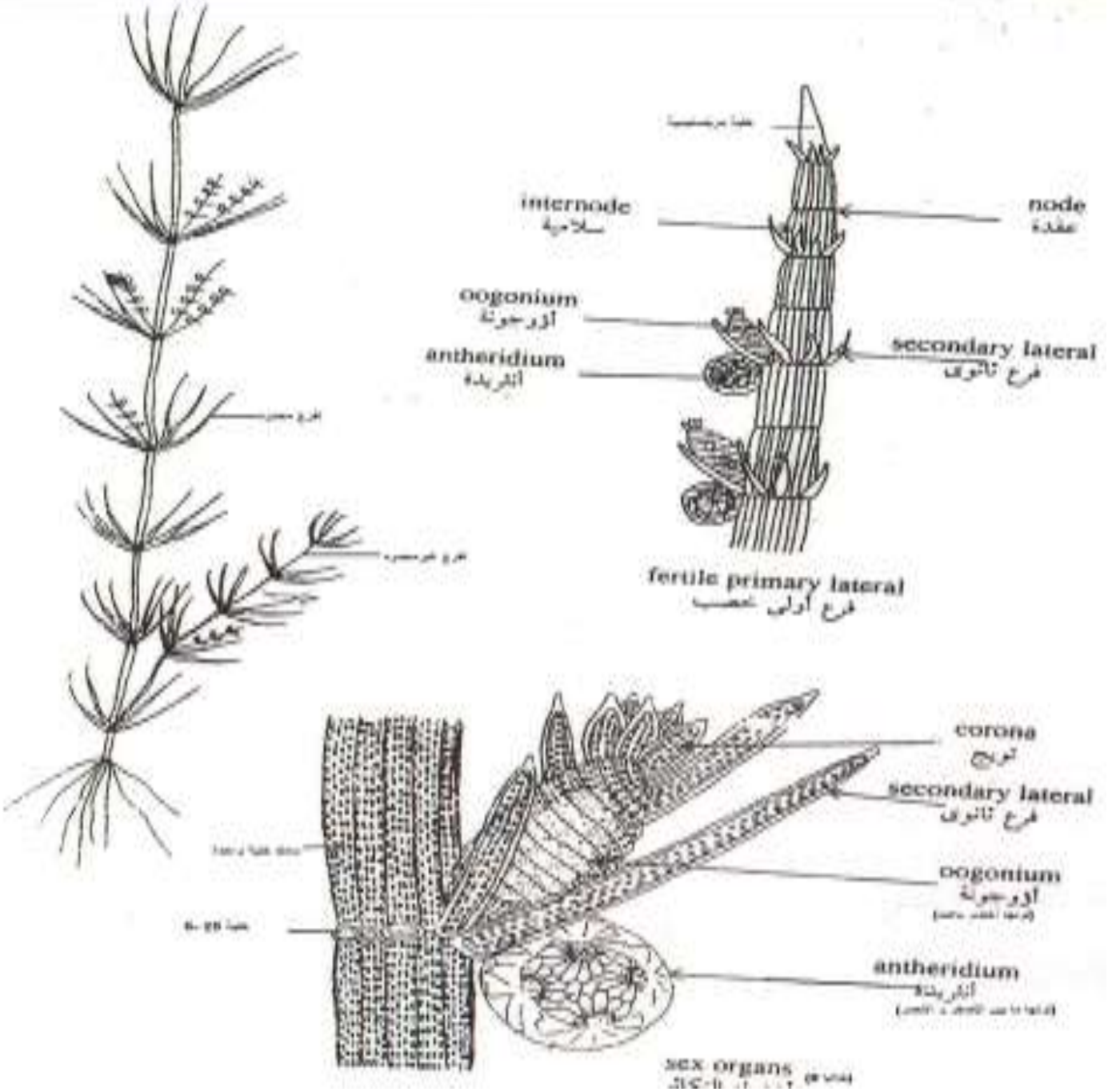
i.e.: Chara



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.

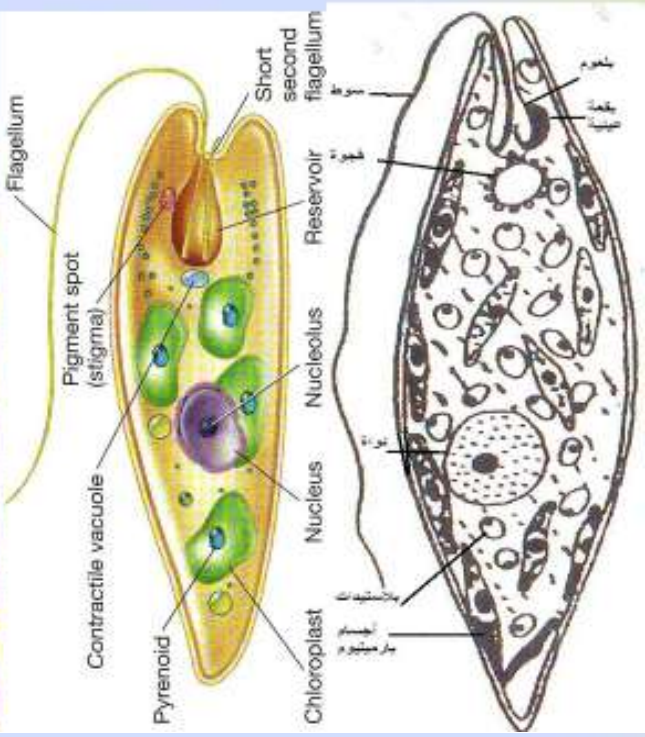
- **Reproduction:**
  1. **Asexually:** There is no asexual spores.
  2. **Sexually:** by Oogamy, where:
     - *Antheridia* mature to form 8 cells, each contain *Antherizoids*.
     - One of the *Antherizoids* fertilize the egg by a canal under the Corona, forming the *Zygote*.
     - The zygote divides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

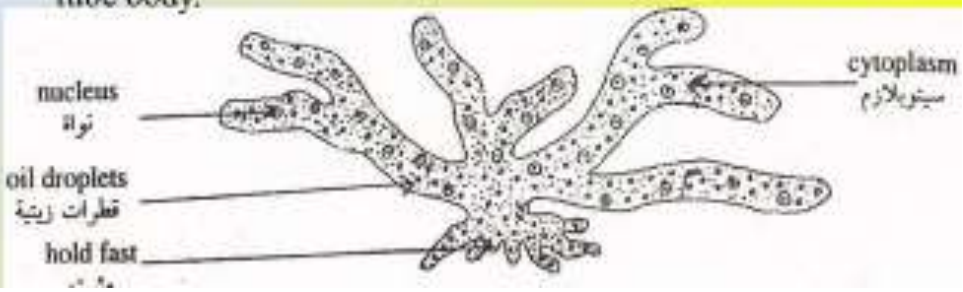
Kingdom: ***Protista***
Class : *Xanthophyta*
i.e.: Vaucheria

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.

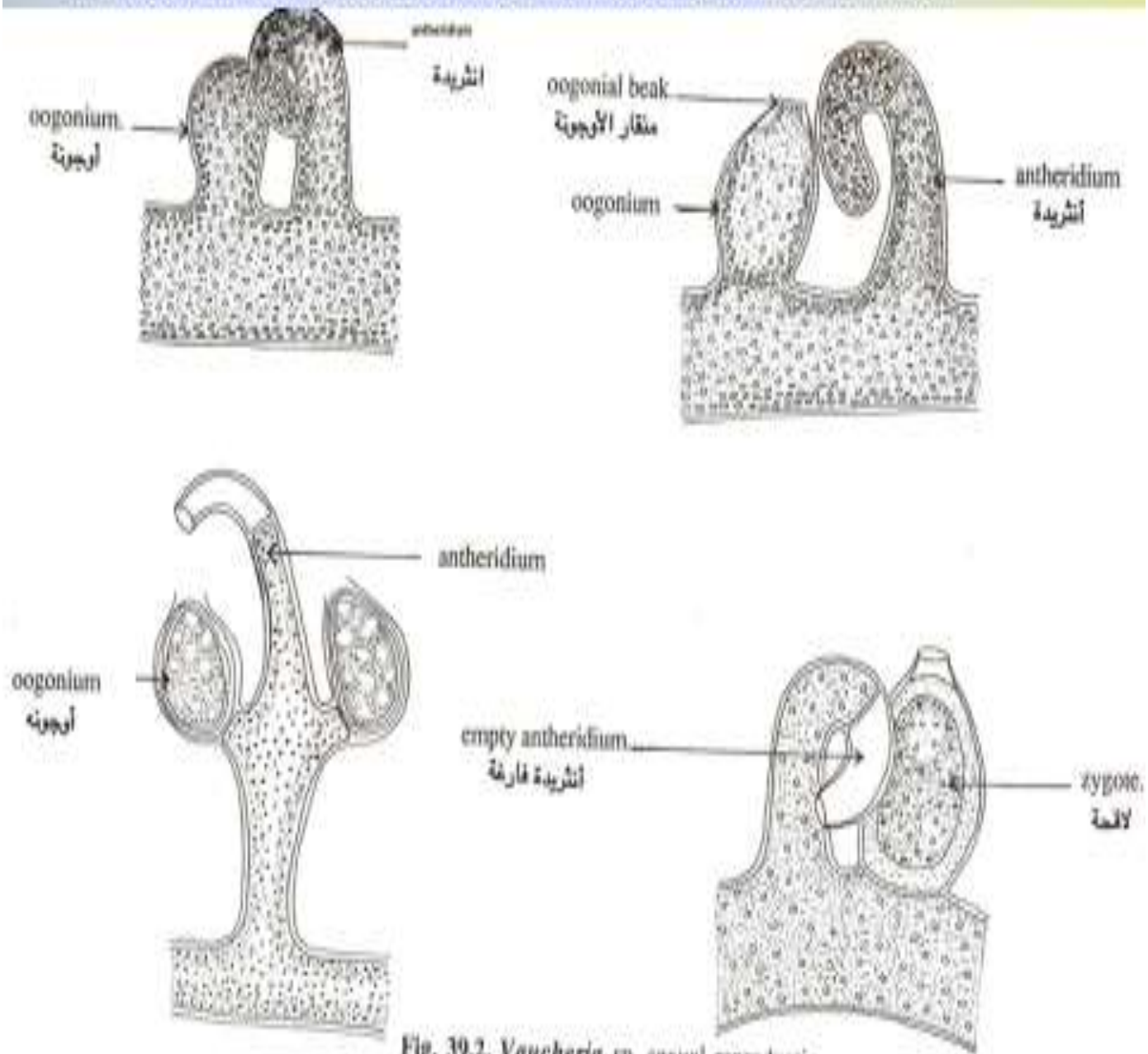
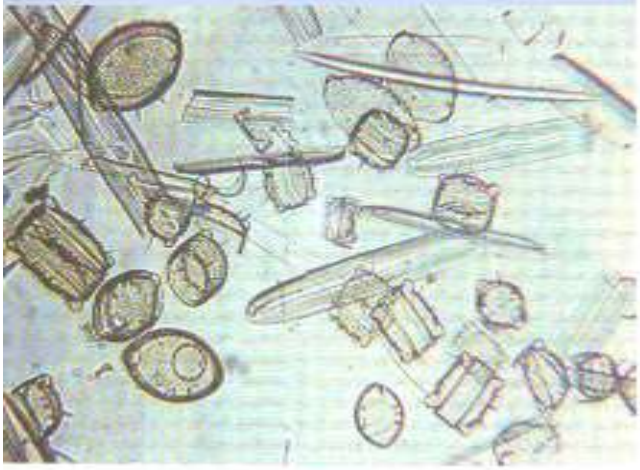


Fig. 39.2, *Vaucheria* sp. sexual reproduction.

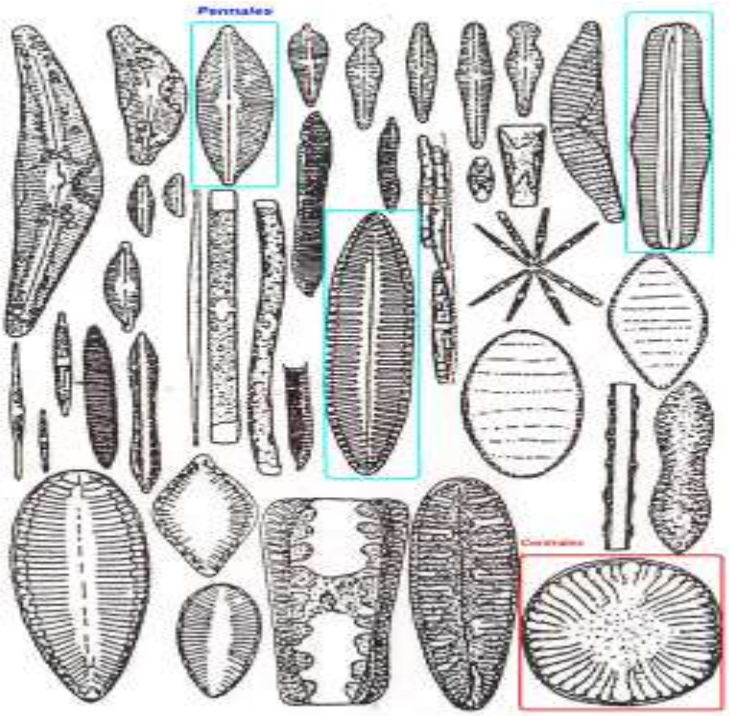
شكل (٣٩ - ٢) فيوشيريا . التكاثر الجنسي

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.

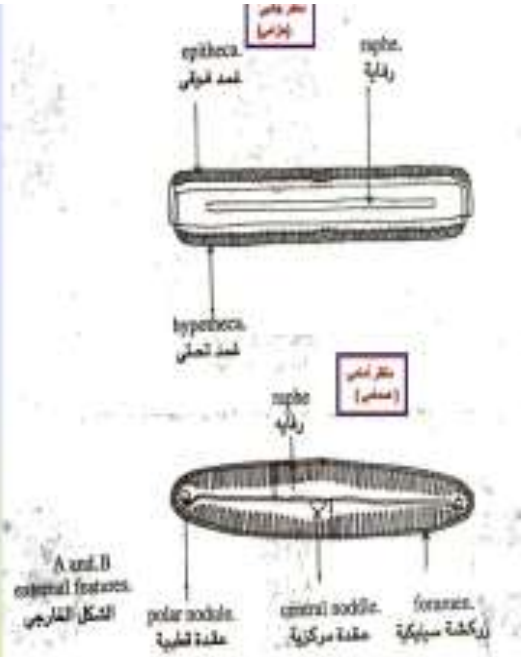
- **Reproduction:**

  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.



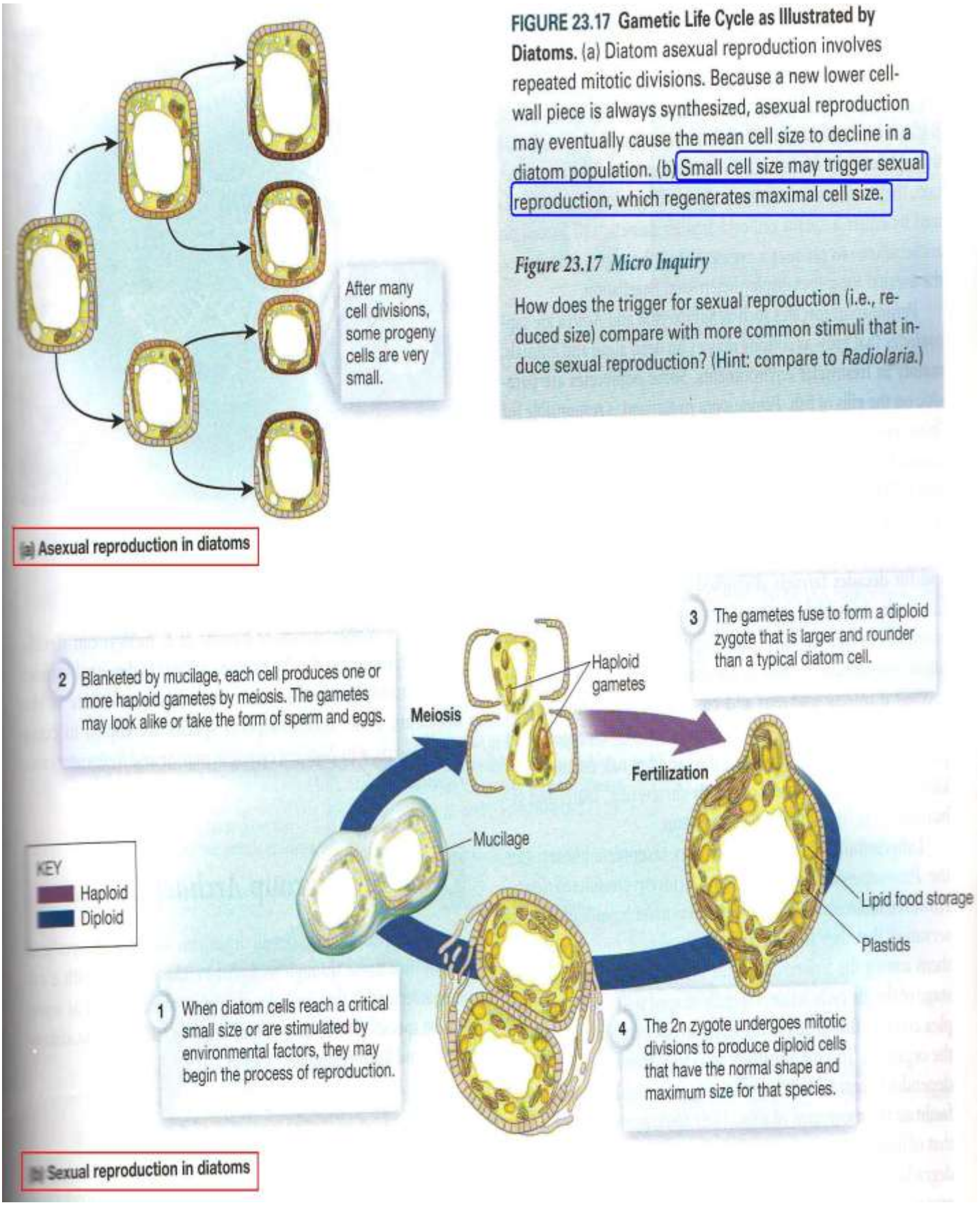


FIGURE 23.17 Gametic Life Cycle as Illustrated by Diatoms. (a) Diatom asexual reproduction involves repeated mitotic divisions. Because a new lower cell-wall piece is always synthesized, asexual reproduction may eventually cause the mean cell size to decline in a diatom population. (b) Small cell size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

Figure 23.17 Micro Inquiry

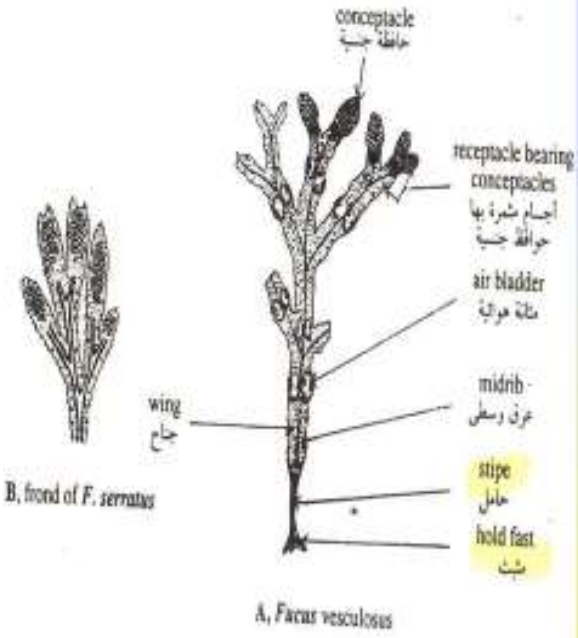
How does the trigger for sexual reproduction (i.e., reduced size) compare with more common stimuli that induce sexual reproduction? (Hint: compare to *Radiolaria*.)

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.



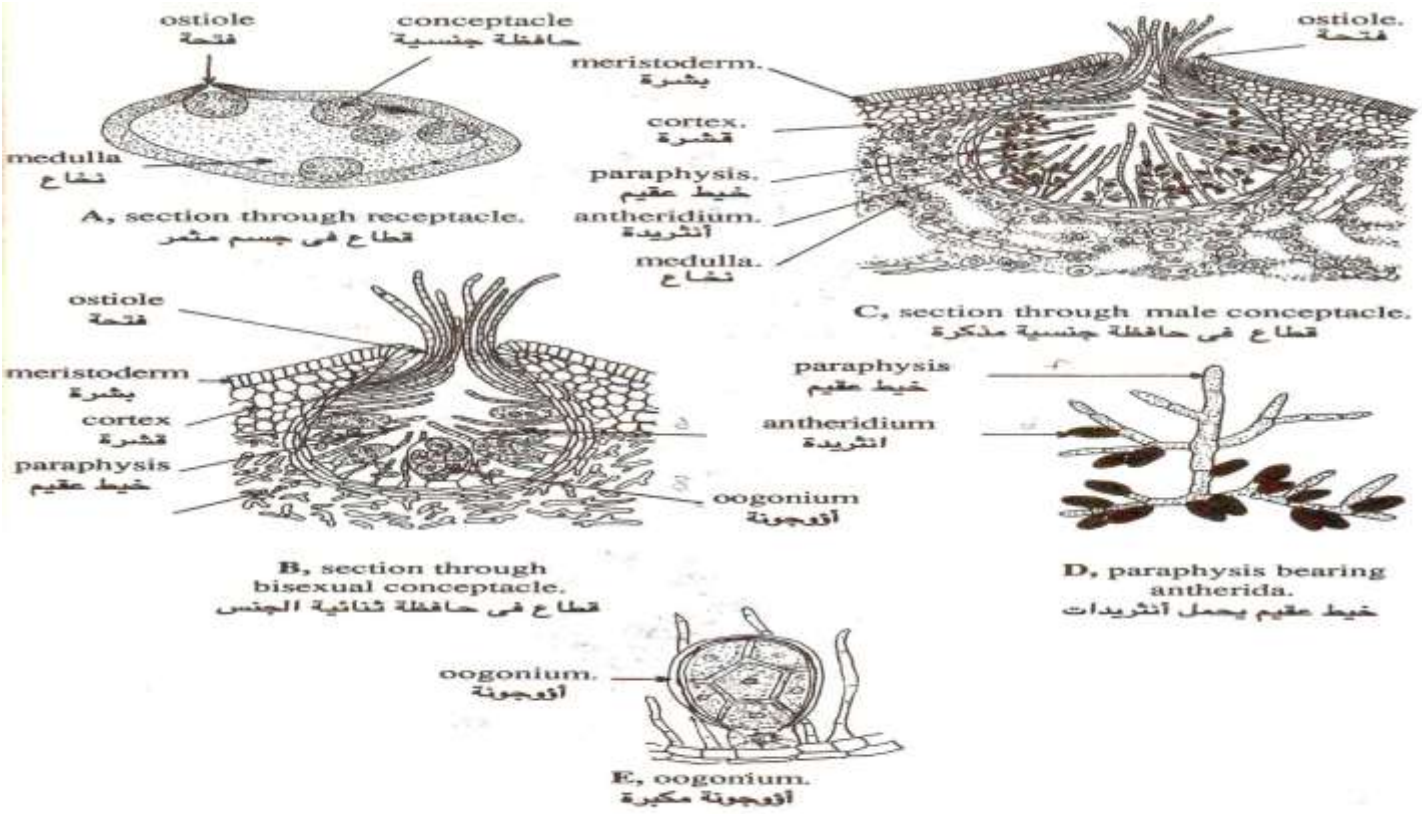


Fig. 46.2. *Fucus* sp.
شكل (٤٦-٢) فيوكس .

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.

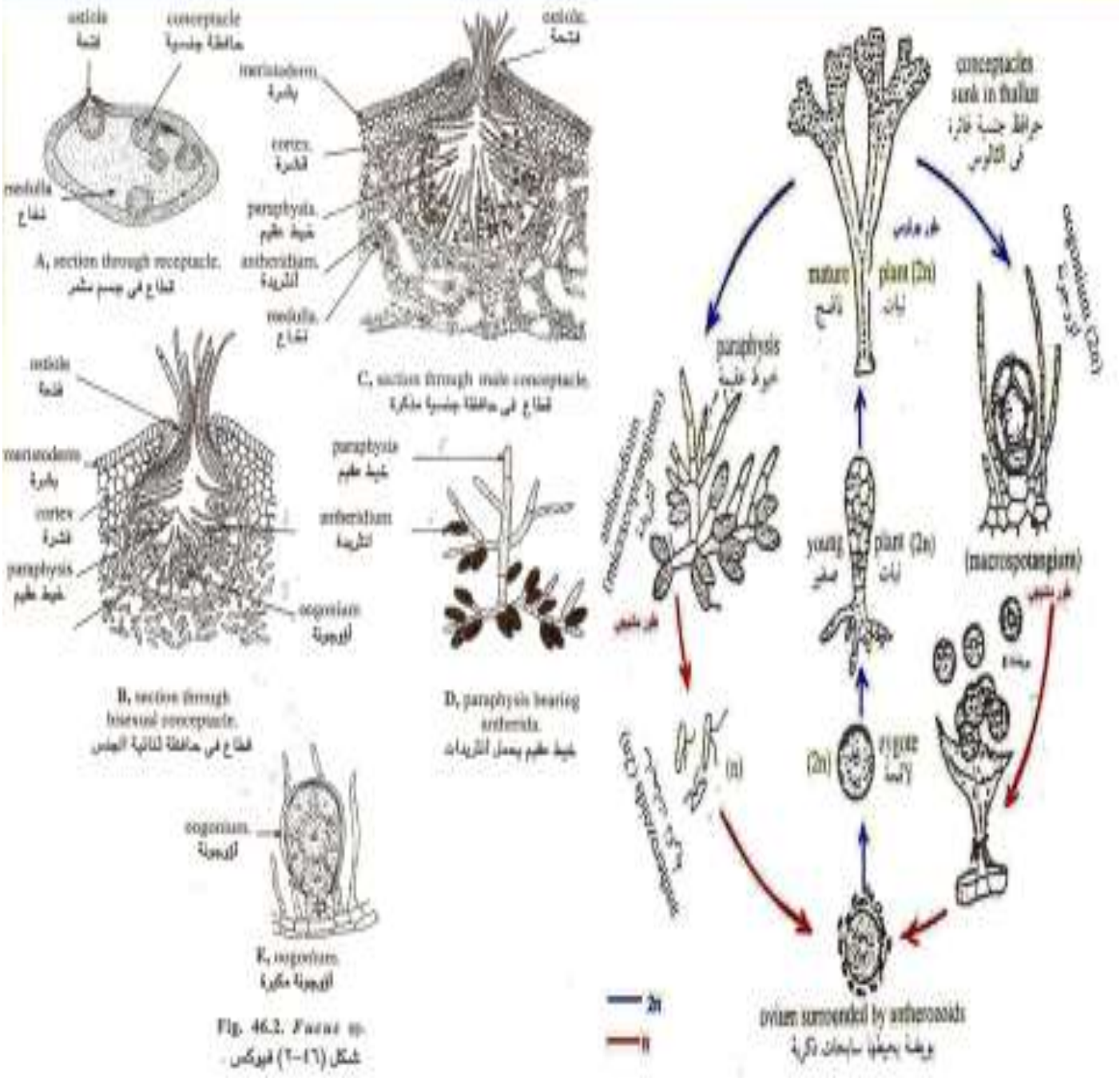


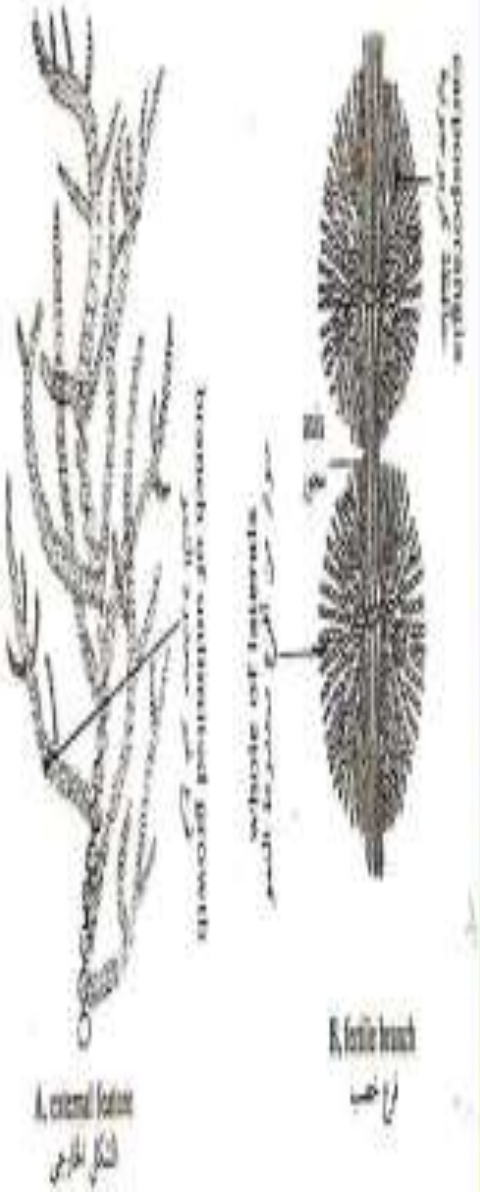
Fig. 46.2. *Fucus* sp.
شكل (١٦-٢) فيوكس

Batrachospermum

Kingdom: *Protista*

Class : *Rhodophyta*

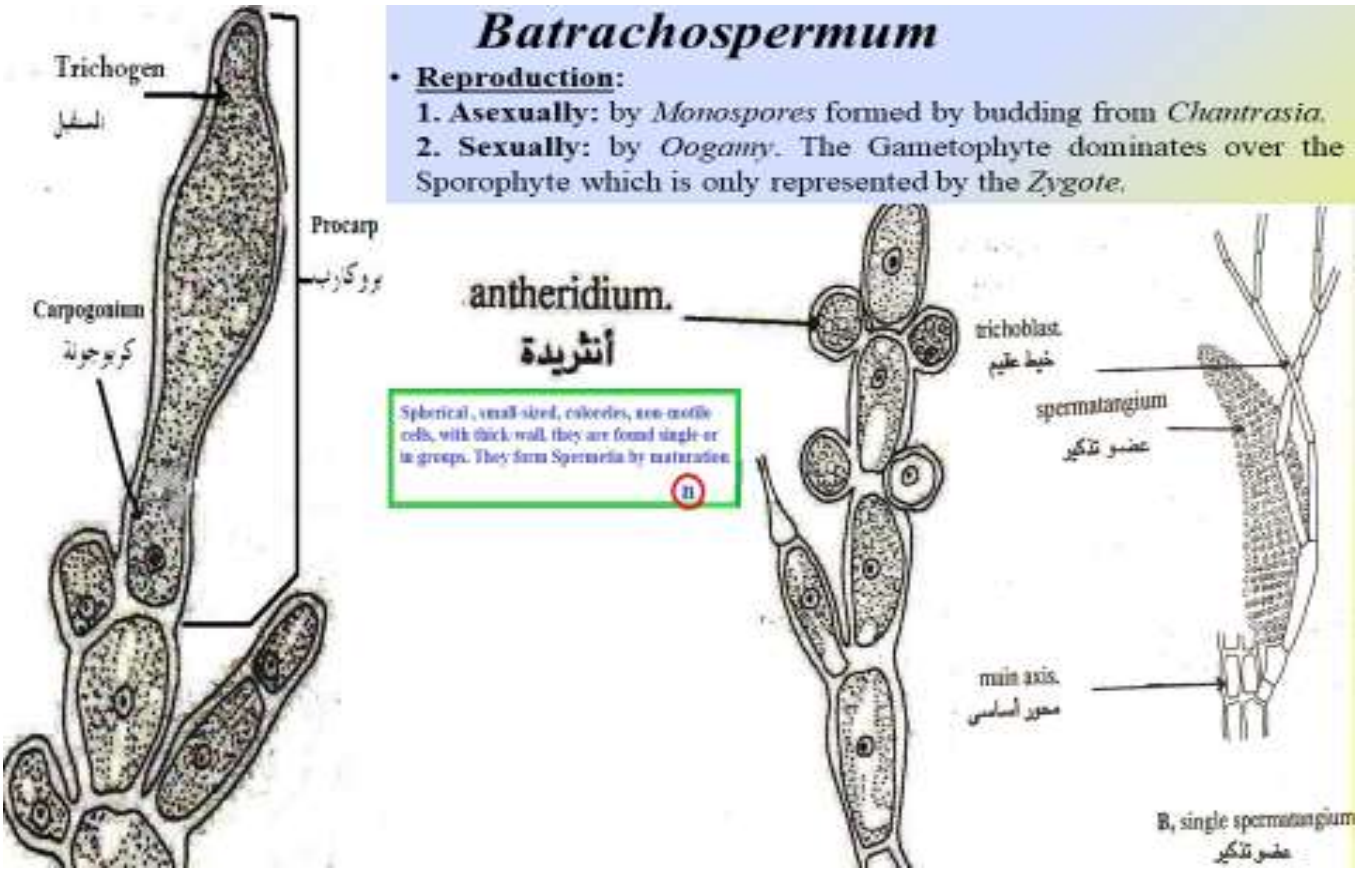
i.e.:



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 plant is developed from the Chantransia stage.

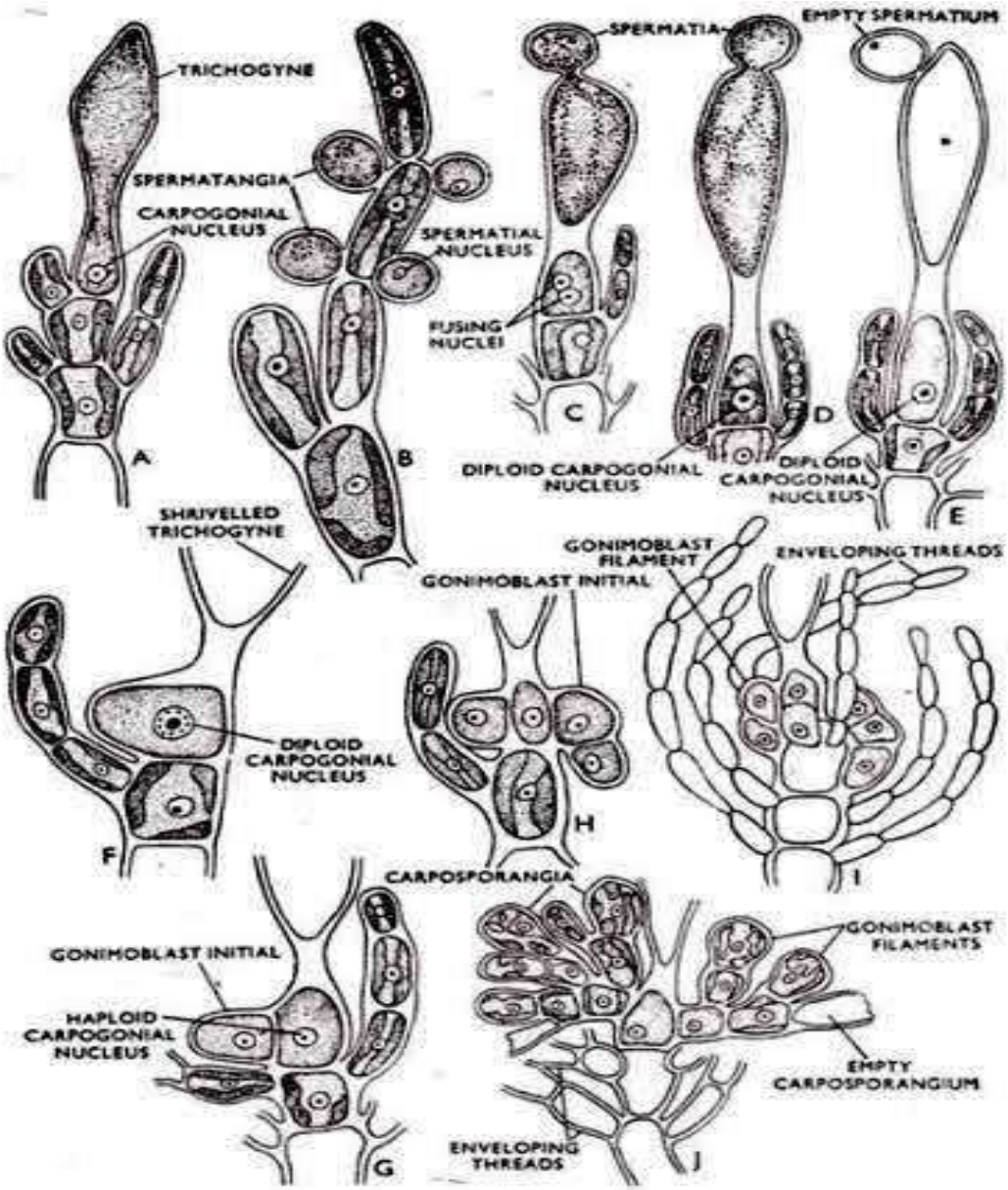


Fig. 120. *Batrachospermum* sp. A. Mature carpogonium. B. Spermatangial branch bearing spermatangia. C–F. Stages in fertilization. G–H. Development of gonimoblast initial. I. Development of gonimoblast filament and enveloping threads. J. Mature gonimoblast filaments, carposporangia and enveloping threads.

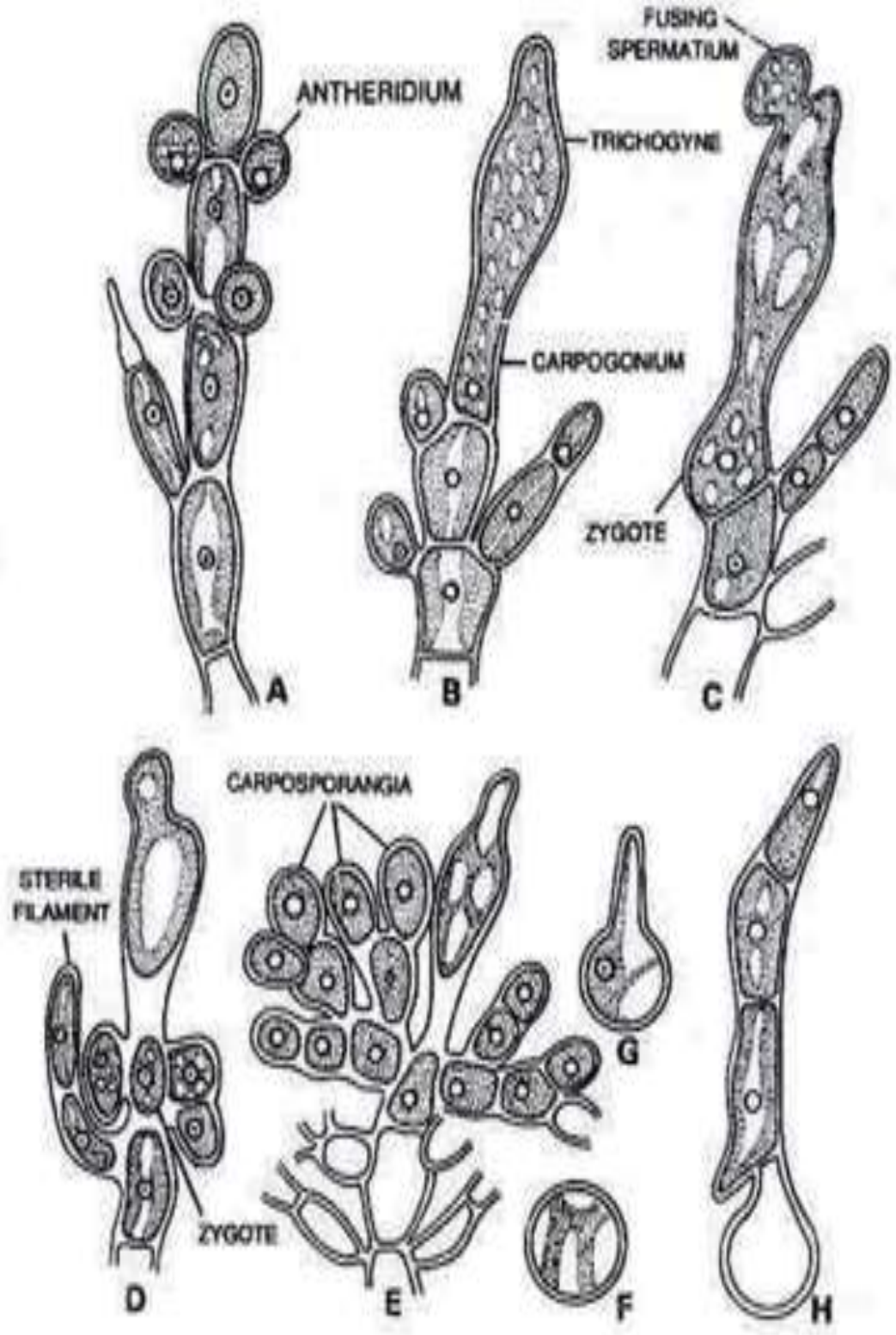
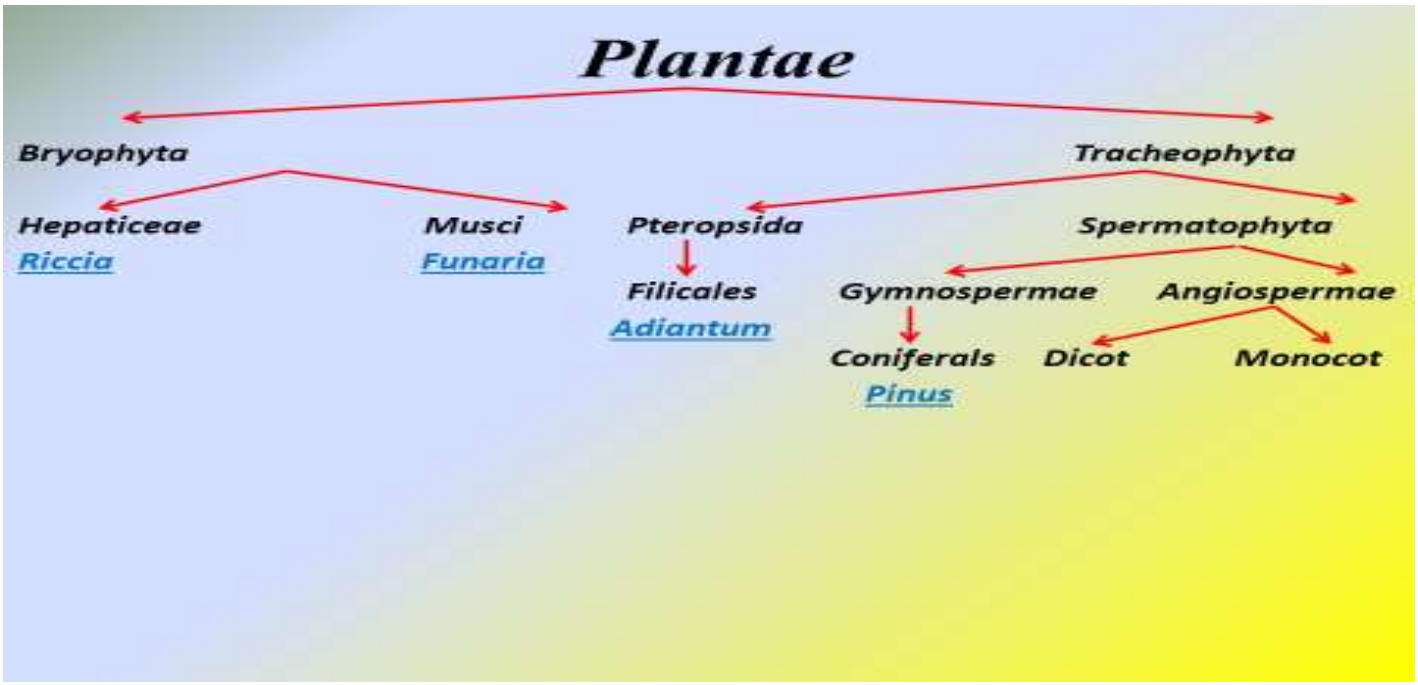


Fig. 7.8. *Batrachospermum*, A, antheridial branch with globular antheridia; B, carpogonial branch with carpogonium; C, fusion of trichogyne with spermatium; D and E, germination of zygote and formation of carposporangia; F, carpospore; G,germination of carpospore; H. *Chantransia* Stage.

Economic Importance of *Algae*

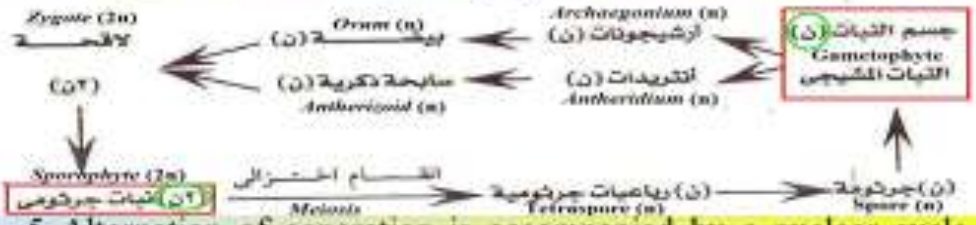
1. It is the basis of food chain.
2. Keeps the ecological balance in aquatic environments.
3. Absorption of Carbon dioxide CO_2.
4. It is used as food in certain countries. *i.e.* Japan
5. It increases soil fertility and it has been used as a bio-fertilizer.
6. It is used as pollution indicators.
7. 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

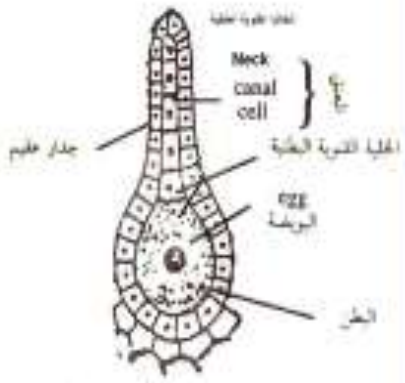
Plantae (Embryophyta)

- **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.

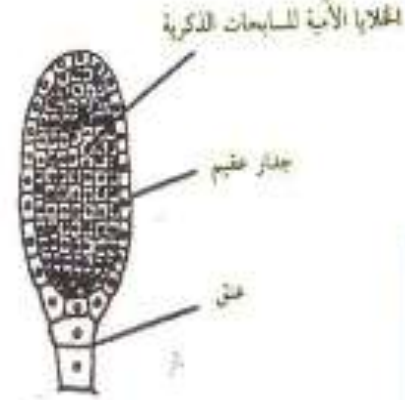


5. Alternation of generation is accompanied by a nuclear cycle, alternating between haploid (n) and diploid (2n).
6. *Embryophyta* includes green plants.
7. Dominancy of Sporophyte and Gametophyte varies.
8. The more dominant the Sporophyte is on the Gametophyte the more developed the organism is.



(شكل ١٥٤): تركيب الأرشيجونة

(Fig. 154) structure of archegonium



(شكل ١٥٥): تركيب الأنثريدة

(Fig. 155) structure of Antheridium

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

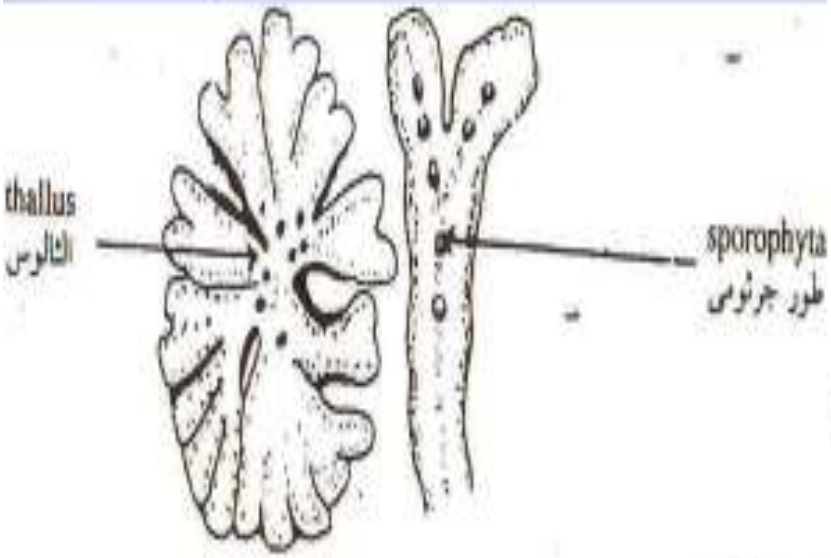
Kingdom: *Plantae*

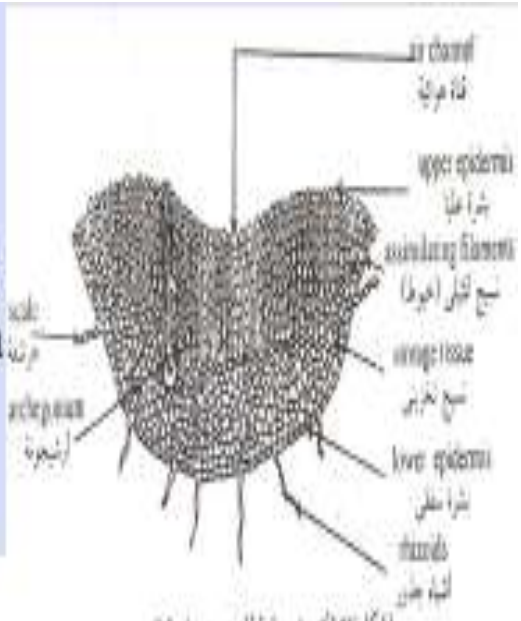
Division: *Bryophyta*

Class : *Hepaticeae*

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

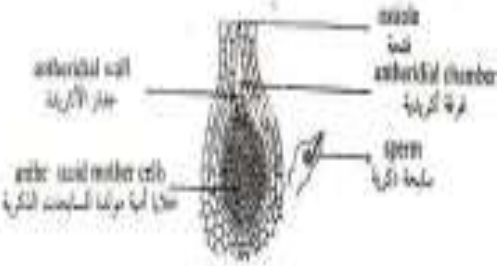
1. Green broad thallus.
2. Dichotomously branched.
3. The **midrib** is swollen where the rhizoids arise.





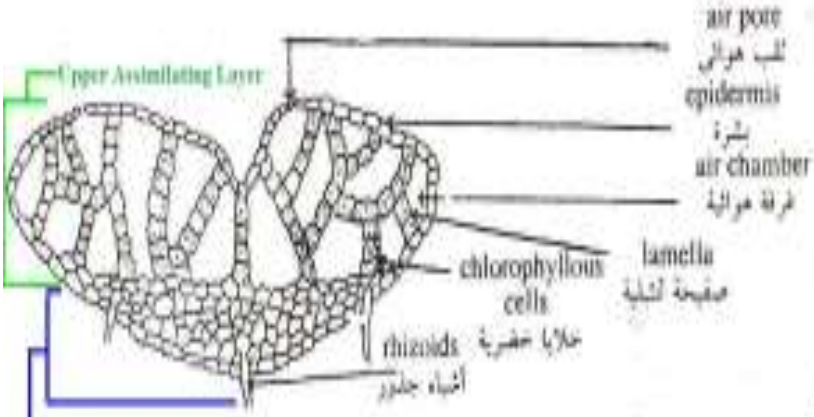
(شكل ١٥٦): ريشيا قطاع عرضي في الثالوس

(Fig. 156) Riccia sp. T.S. of the thallus



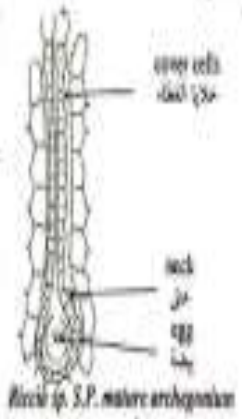
Riccia sp. S.P. antheridium showing structure

ريشيا تركيب الأنثريدة



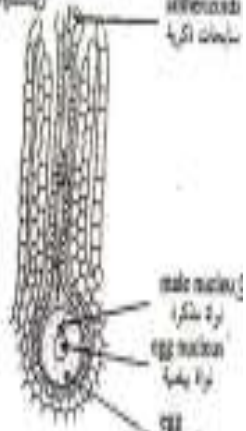
تابع (شكل ١٥٧): ريشيا فلبانس، قطاع عرضي في الثالوس

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



Riccia sp. S.P. mature archegonium

ريشيا أرشيجونة ناضجة



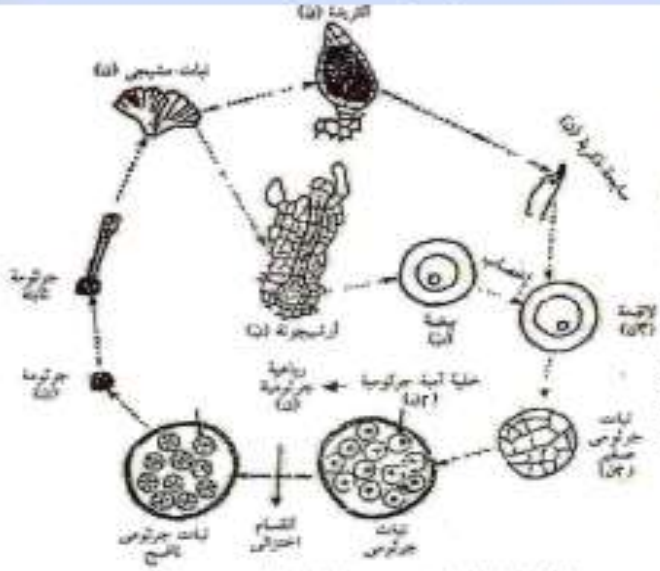
Riccia sp. S.P. fertilized egg

ريشيا بيضة مخصبة

Riccia

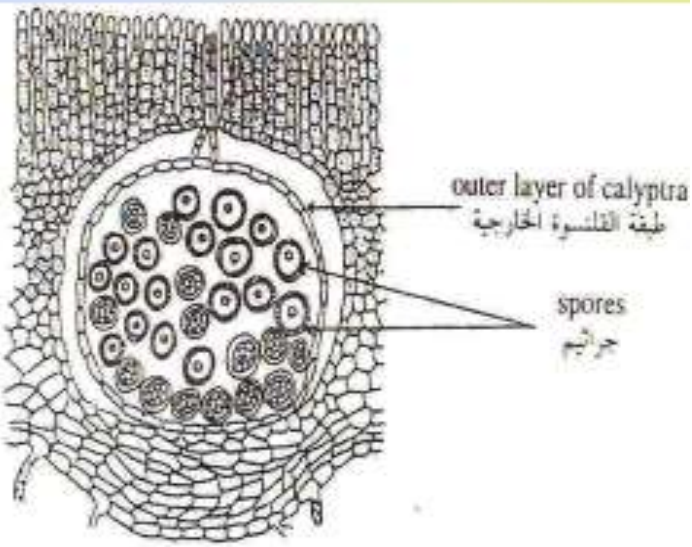
- **Sexually:**

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

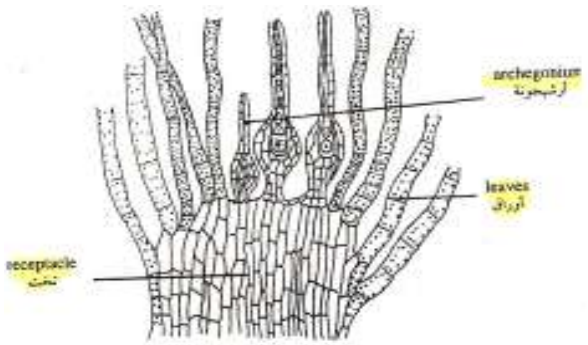
شـــا، قطاع عمودي في الطور الجرثومي

Funaria

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

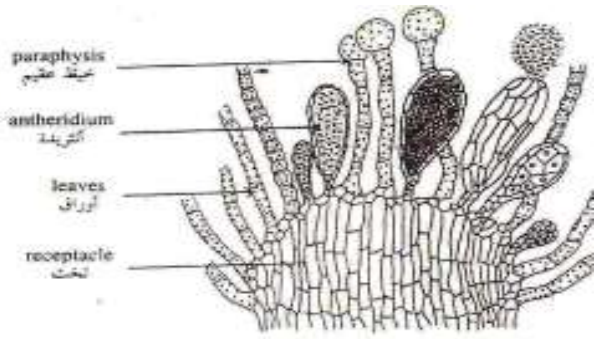
1. It blooms in Egypt in wet places.
2. Gametophytes dominates
3. Moss flowers are either *Monecious* or *Dioecious*.

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



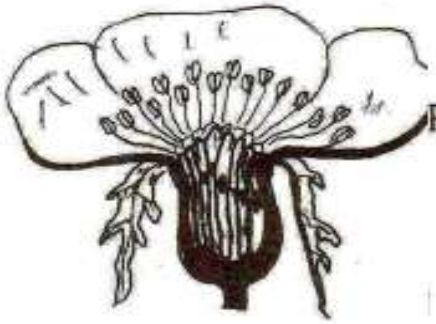
(شكل ١٦٠): فيوناريا، ق. ط. في زهرة حزازية مؤنثة

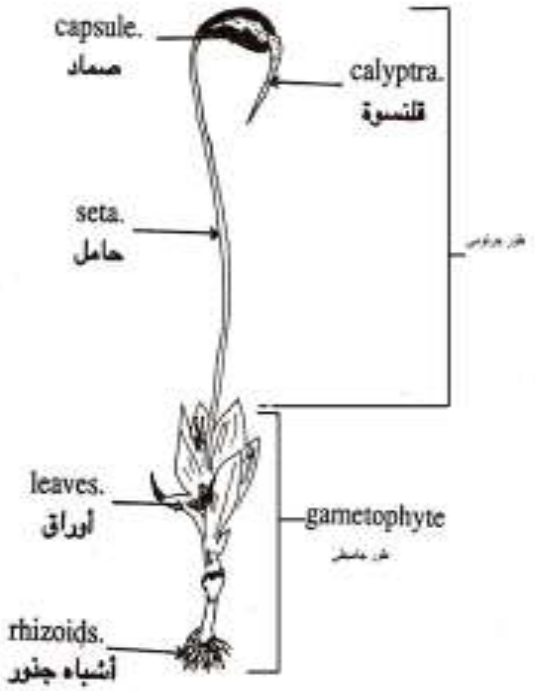
(Fig. 160) Funaria sp. L.S. of female moss)



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

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





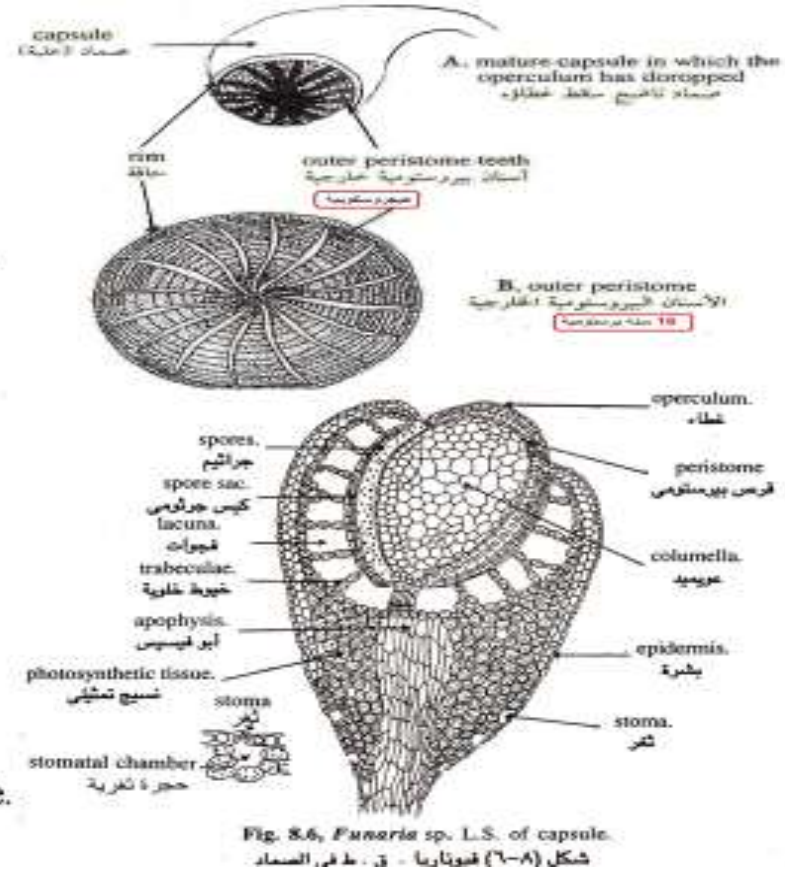


Fig. 8.1, ***Funaria*** sp. gametophyte bearing sporophyte.

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:

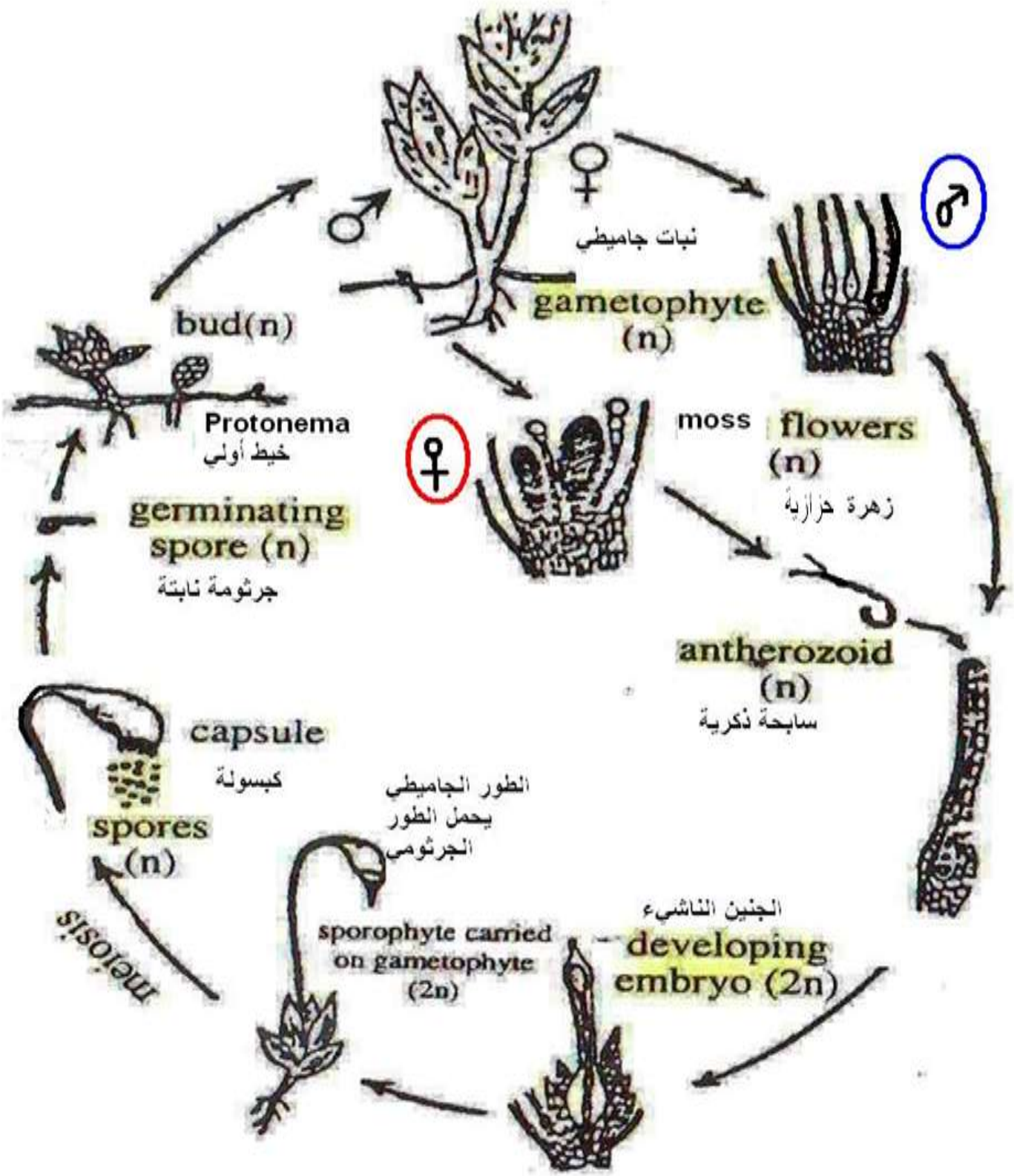
Sexual reproduction is oogamous. Male reproductive structure is known as antheridium and female as archegonium. Funaria is monoecious (having male and female sex organs on the same thallus) and autoicous (antheridia and archegonia develop on separate branches of the same thallus).

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.

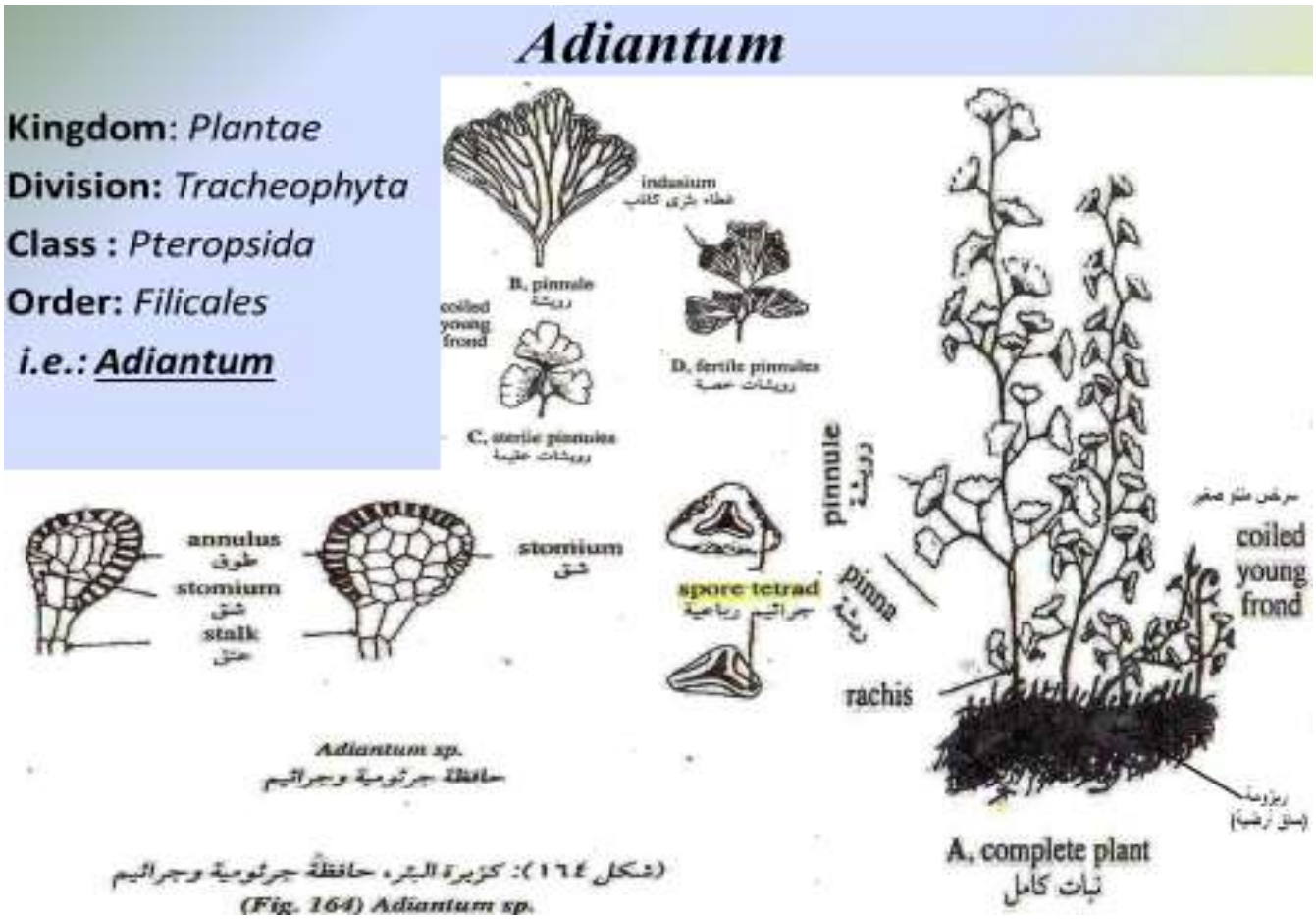
The capsule is made up of three parts: the basal apophysis, the central theca, and the terminal operculum. Annulus is a ring-like cell that separates the operculum from the Theca. From the center to the outside, the middle fertile theca is made up of a sterile columella surrounded by a barrel-shaped 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

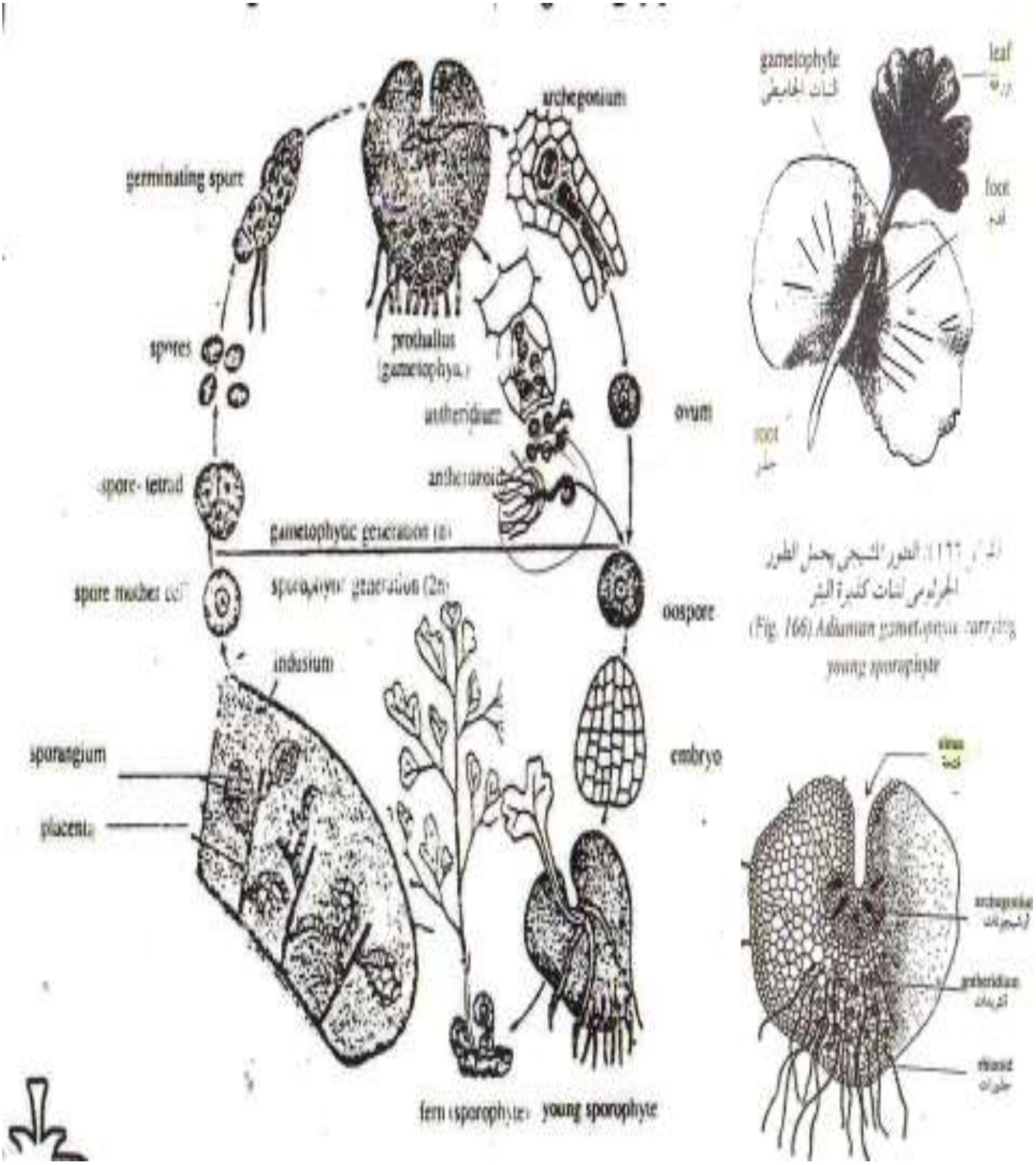


Reproduction:

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*

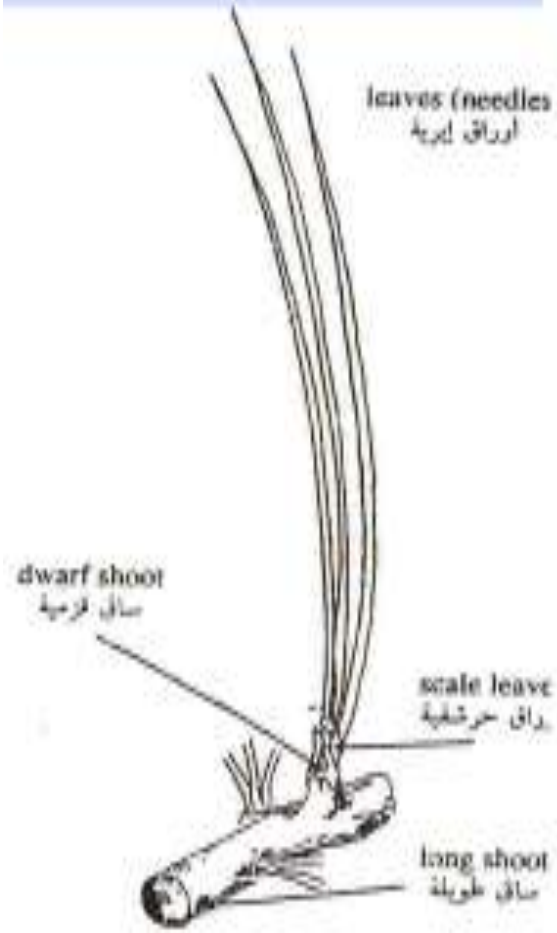
Subdivision : *Spermatophyta*

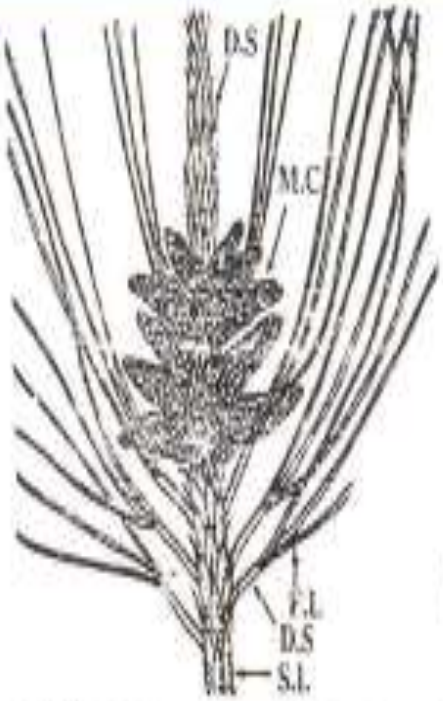
Class: *Gymnospermae*

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.

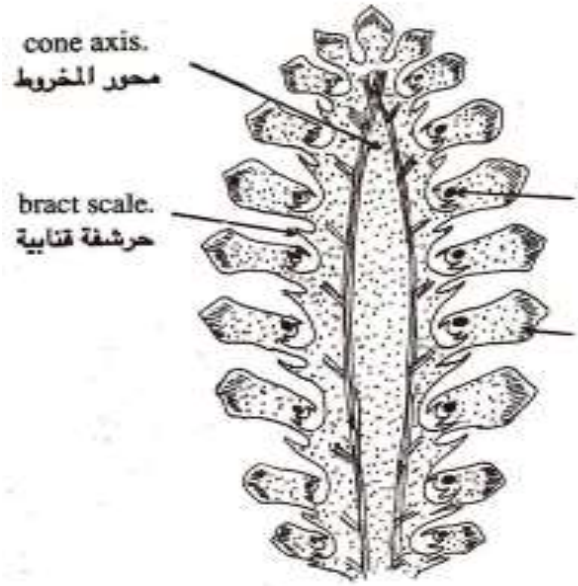


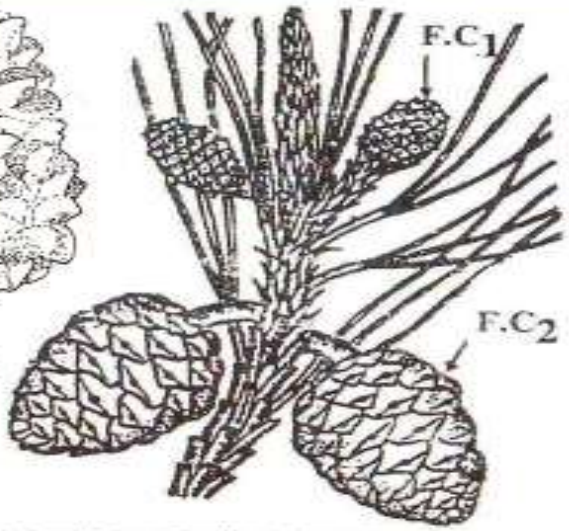


A male shoot (branch) of unlimited growth showing male cones (M.C.), young dwarf shoots (D.S.) or shoots of limited growth each in the axil of a scale, needle-like foliage leaves or needles (F.L.) borne only by dwarf shoots or false spurs on these are called, and scale leaves (S.L.) spirally borne by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

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

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

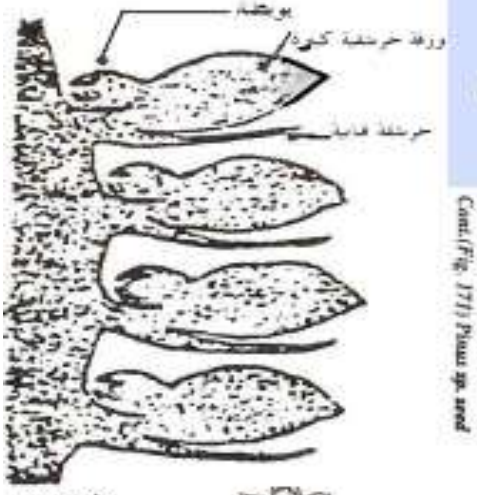


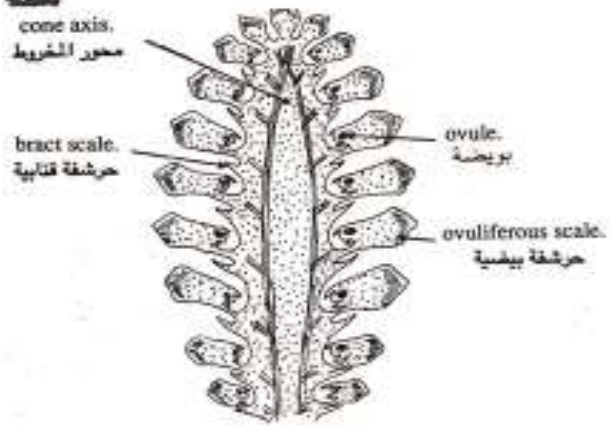


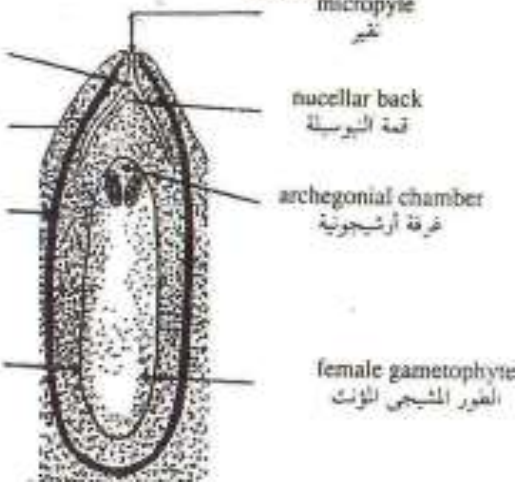
A female shoot of undimited growth showing two young female cones ($F.C_1$) of current year, two maturing female cones ($F.C_2$) of previous year

فرع مؤنث ذات نمو غير محدود ويحمل المخاريط المؤنثة

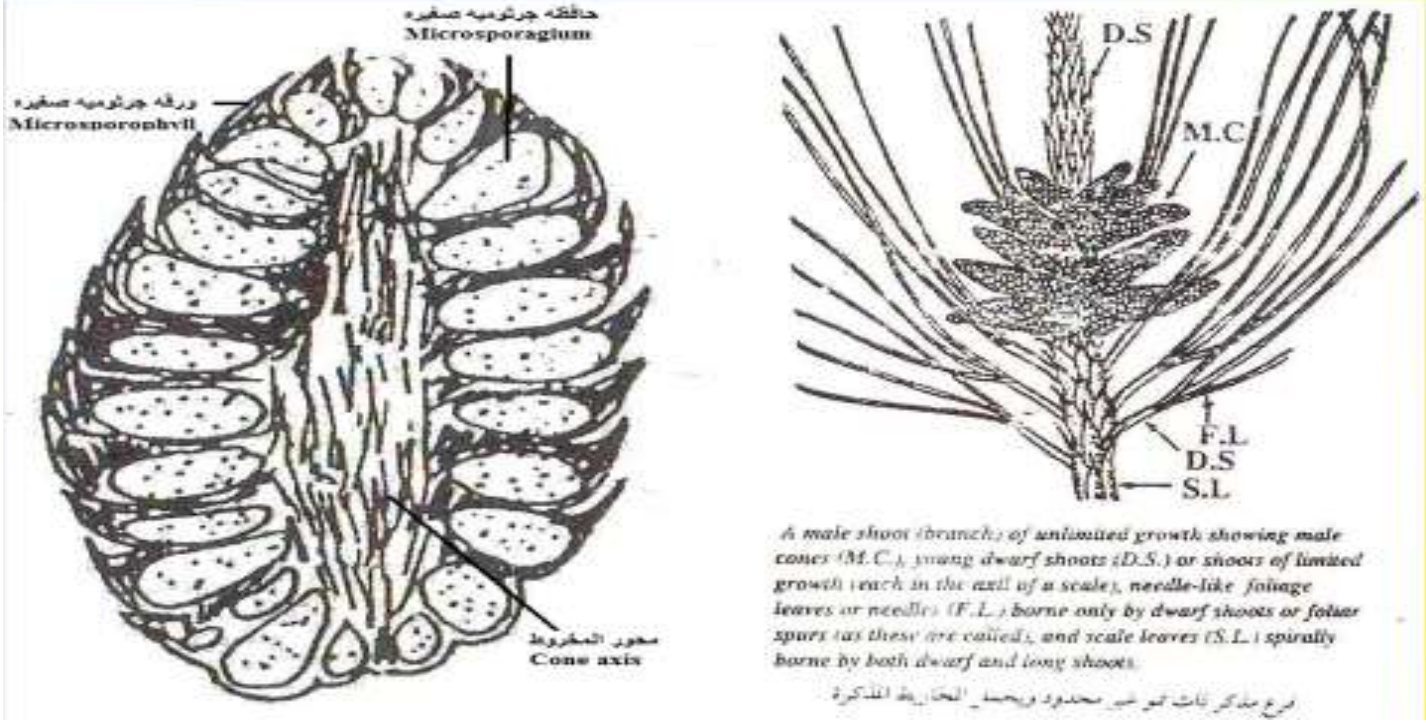
Pinus
L.S. in Female Cone of *Pinus*

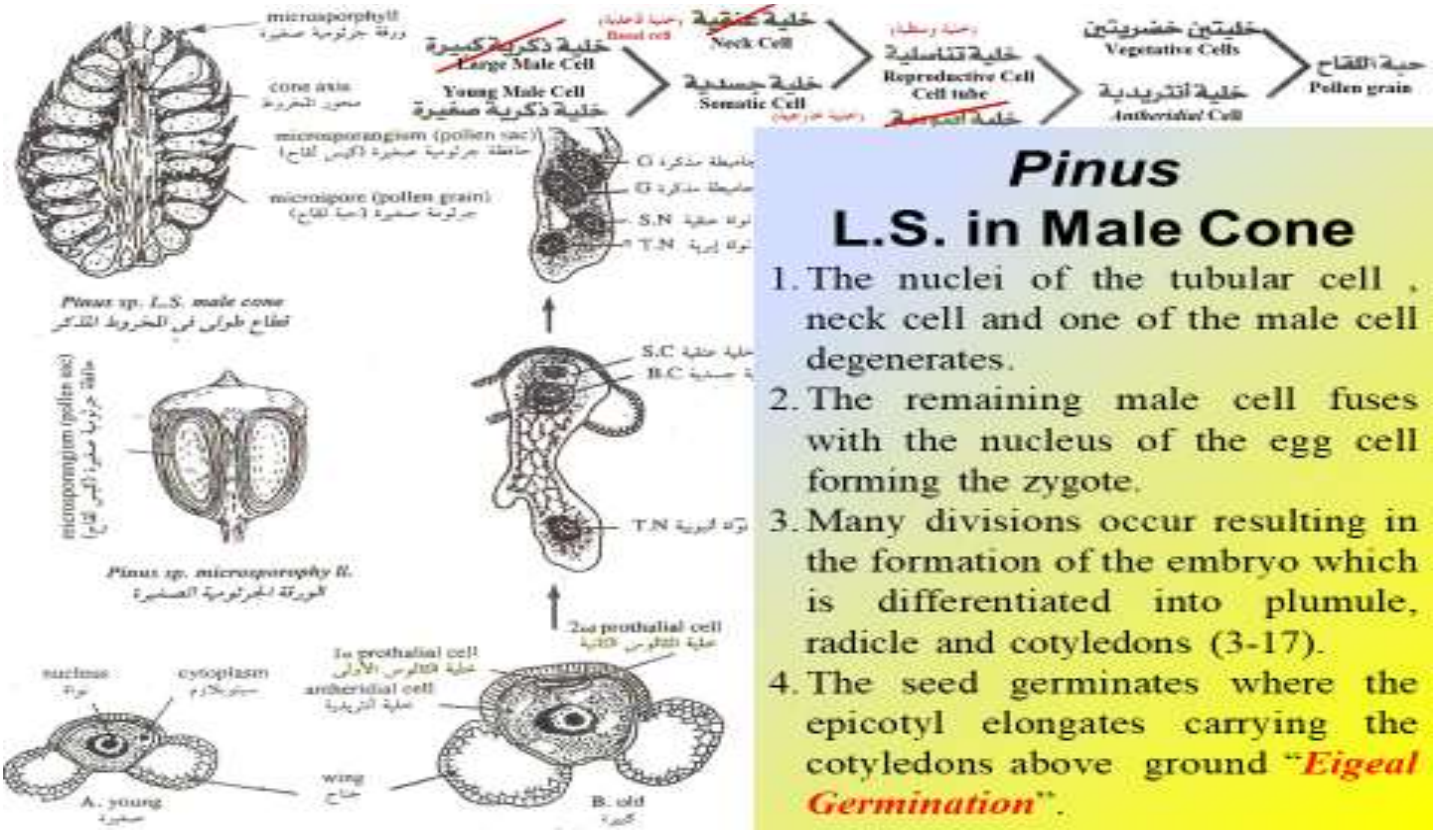






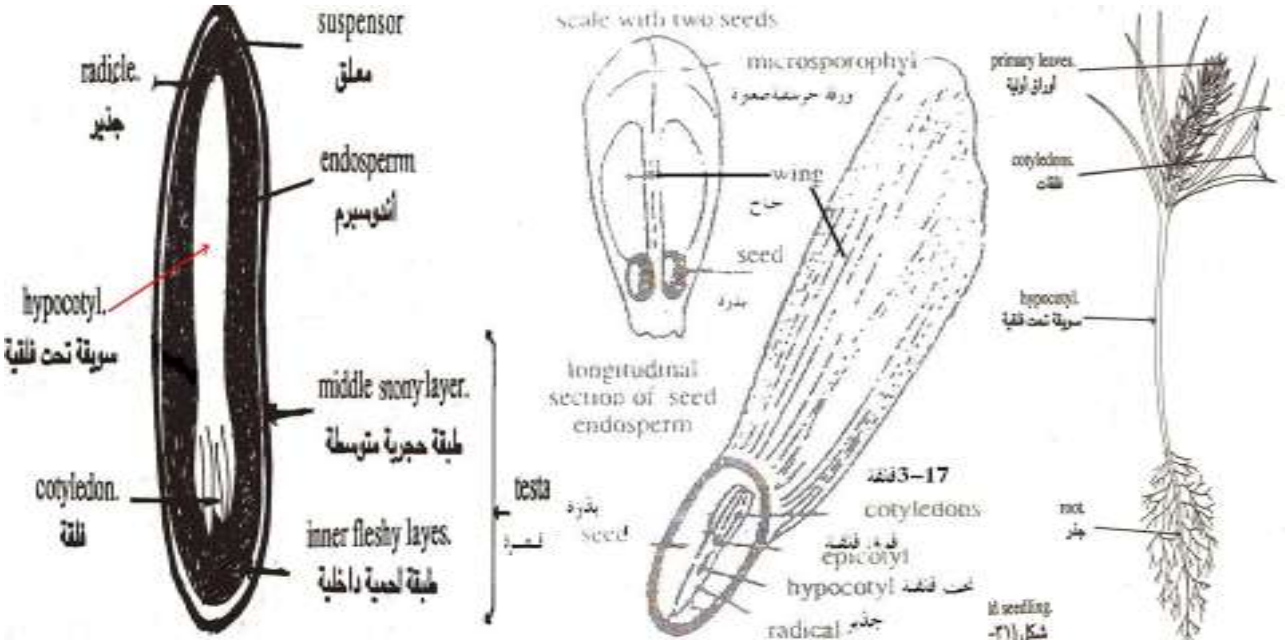
Pinus
L.S. in Male Cone of *Pinus*

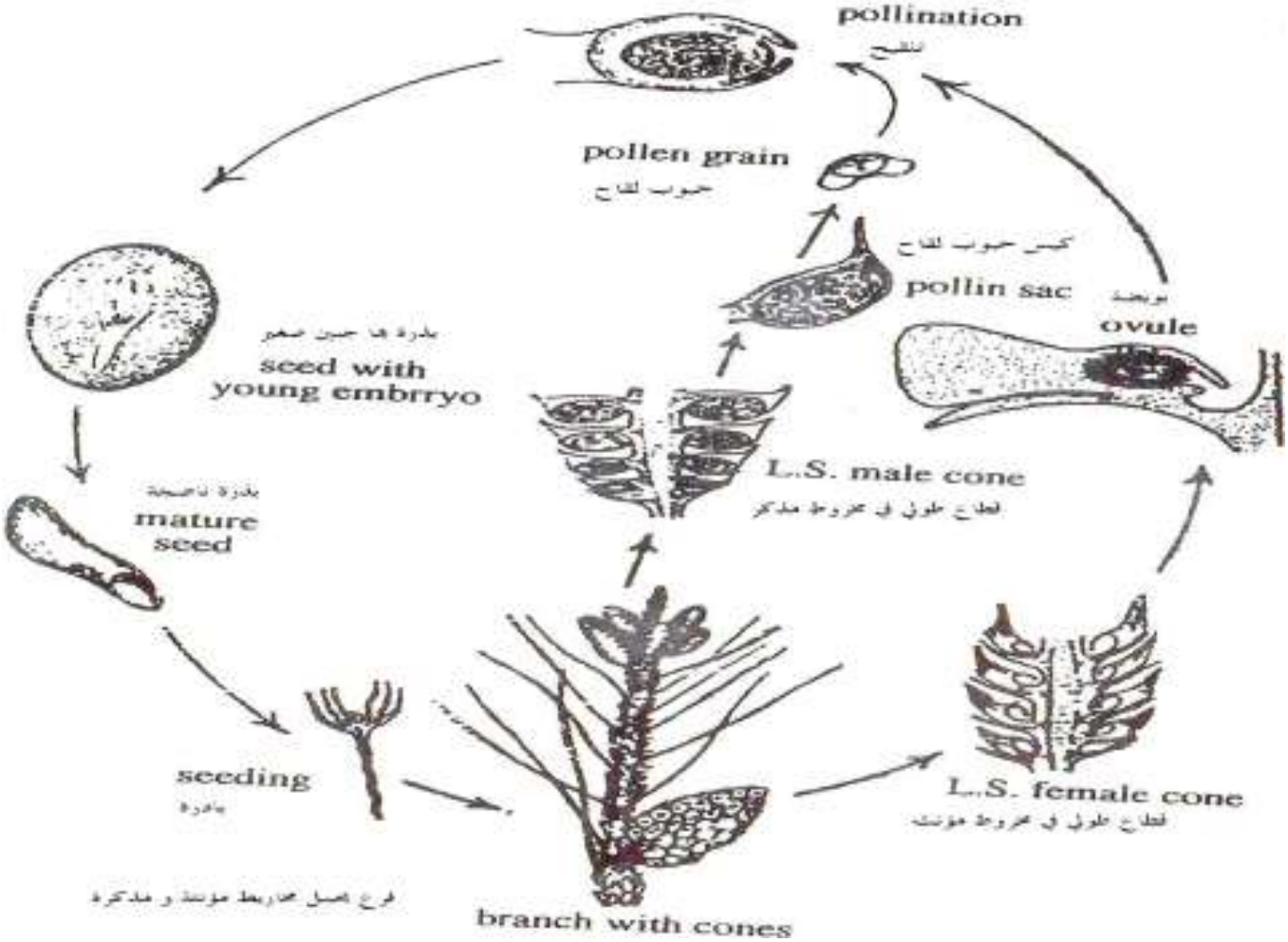




Pinus
L.S. in Male Cone

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***".

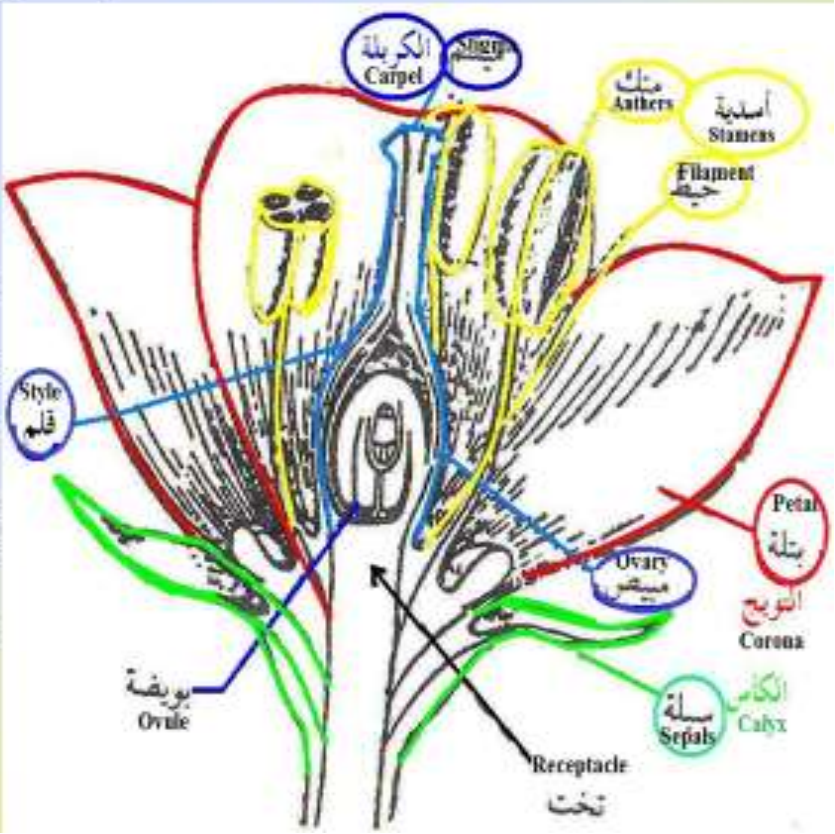

suspensor
معلق
radicle.
جذير
endosperm
اندوسبيرم
hypocotyl.
سويقة تحت فلقية
middle stony layer.
طبقة حجرية متوسطة
cotyledon.
فلقة
inner fleshy layes.
طبقة لحمية داخلية
testa
قشرة
بذرة
seed
scale with two seeds
microsporophyl
ورقة حرشفية محورة
wing
جناح
seed
بذرة
longitudinal section of seed endosperm
3–17فلقة
cotyledons
قرة فلقية
epicotyl
hypocotyl تحت فلقية
radical جذير
primary leaves
أوراق أولية
cotyledons.
فلقات
hypocotyl.
سويقة تحت فلقية
rot.
جذير
شكل (٢١)
ii seedling.


pollination
تلقيح
pollen grain
حبوب لقاح
كيس حبوب لقاح
pollin sac
بويضة
ovule
بذرة فيها جنين صغير
seed with young embrryo
L.S. male cone
قطاع طولي في مخروط مذكر
بذرة ناضجة
mature seed
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**

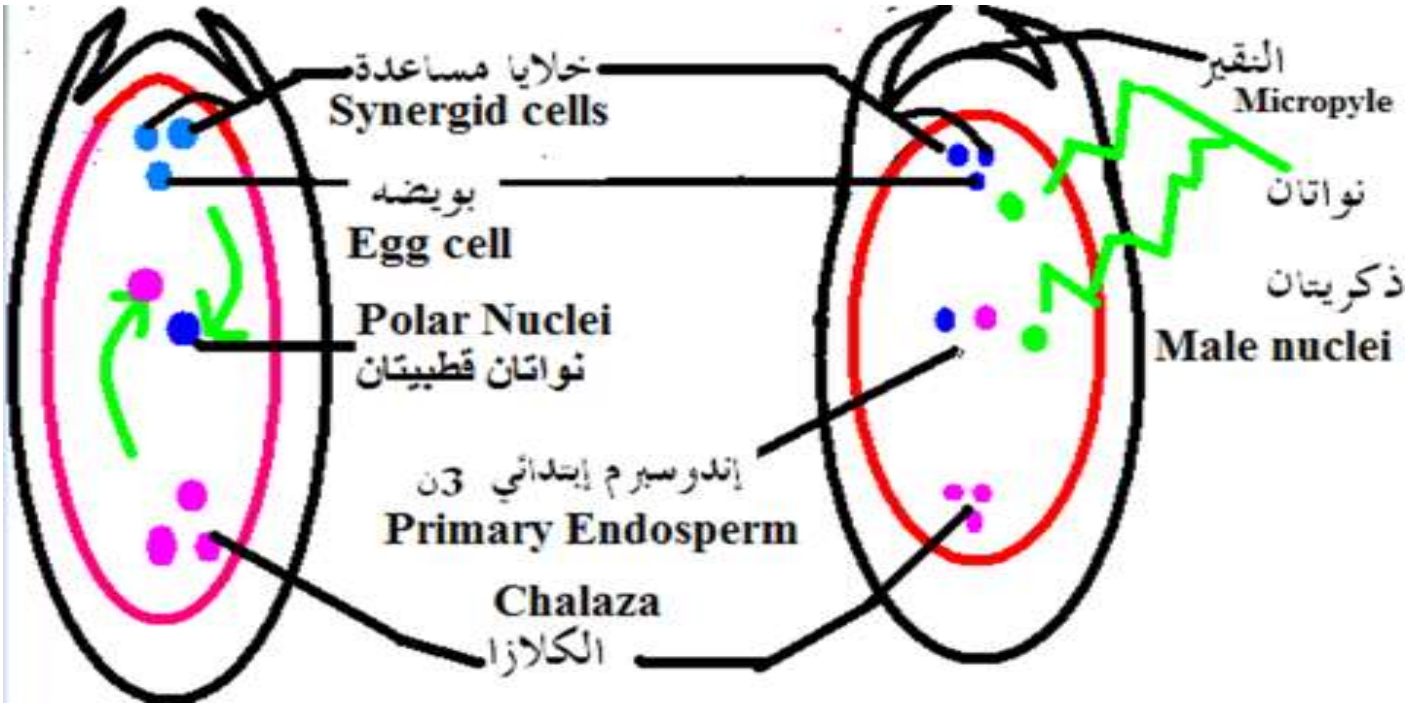
- **Fertilization:** The conjugation between the male nucleus and the female nucleus (egg) inside the embryo sac.

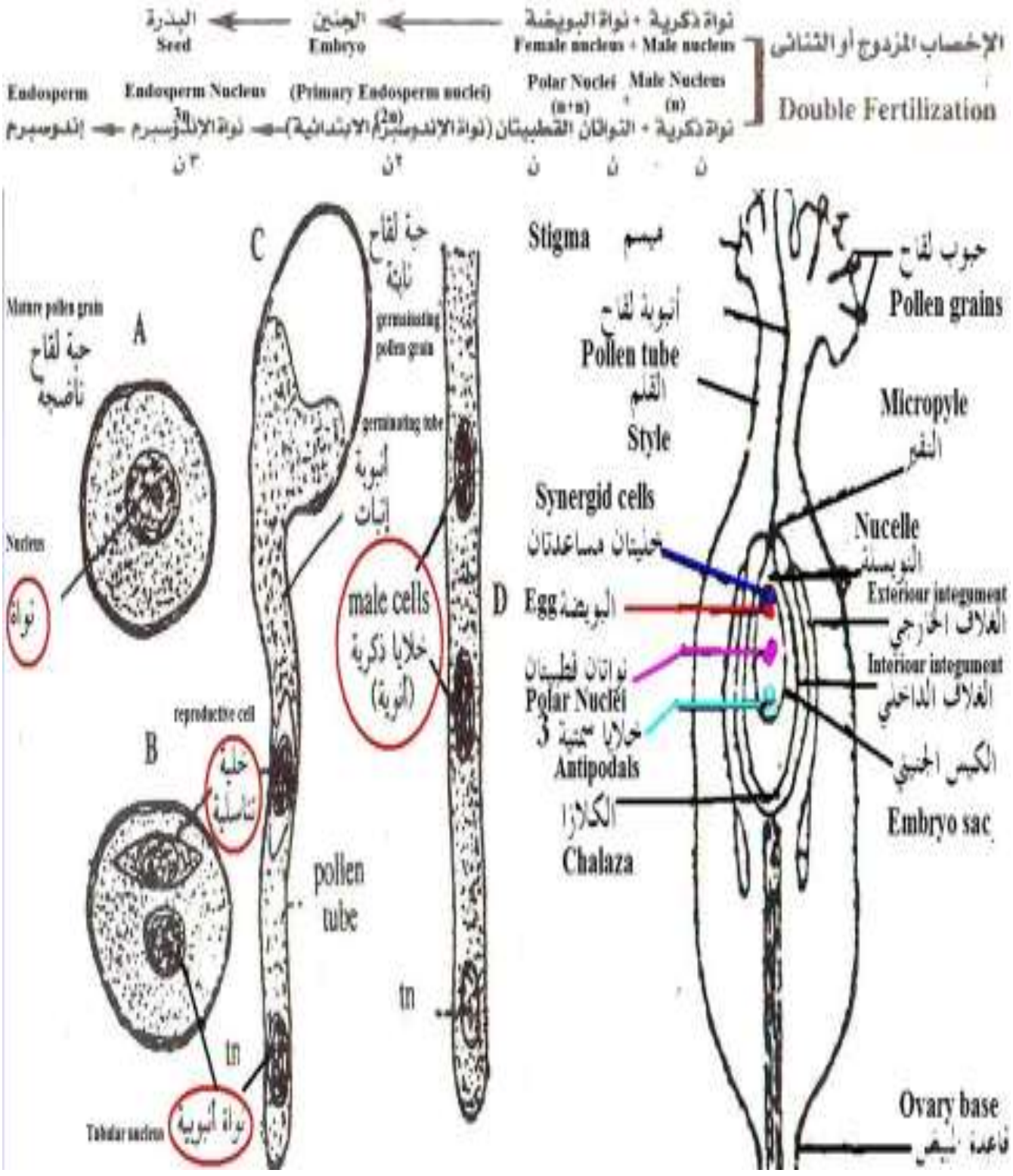
Double Fertilization in Plants

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

Part 2: Plant Anatomy

Prepared by: Dr. Azza Misk

1. Biological sciences are known since Paleothetic times. Biology started by illustrations of different plant and animal species where human survival mainly relied on the gathering knowledge of them.
2. **Morphology**; came first which describes the **external** structure of plants. Then with the invention of the light microscope, **Anatomy** came next with the extensive studies of the plant **internal** structure.
3. The electron microscopy was a revolutionary step for the start of many sciences such as **Microbiology** and **Genetics** where other branches were derived from as **Genetic Engineering**, **Molecular Biology** and **Biotechnology** .
4. **Molecular Biology** is concerned with the study of:

   1. Genetic structure 2. Micro-cellular structure

   3. Cellular differentiation.

- 5. Molecular analysis; comparing between different types of proteins, enzymes, hormones as well as amino acids' sequences in both DNA and RNA. Biology or life sciences are concerned with the study of a group of characters that characterizes only the living organism such as:

  1. Growth 2. Motility 3.Metabolism

  4. Reproduction 5.Adaptation

- **Anatomy** deals with the study of internal structure, function and evolution of the living being.
- **Cytology** deals with the structure and function of different cells.
- **<u>Scientific Information Resources</u>**:

  1. Where do we obtain them from?
  2. How to verify their credibility ?

Scientific Information Resources

It starts by observation and description

Information are gathered through experiments

Deduction of general relationships and discussions to come up with a hypothesis

If proven, the hypothesis becomes a theory and when generalized, it becomes a law. The verification of the studies done is the main core of science.

A new discovery can change previous laws, which is known as Scientific Criticism where it mainly relies on critical curiosity.

In conclusion, facts are only investigated through accuracy and honesty.

Research works are discussed through conferences and periodical meetings.

Researchers publish their research work as a research paper in specialized journals.

Scientific Nomenclature: is a formal system of naming species of living beings, structures, functions, even chemical components where Latin or Greek forms are used.

Measuring Units:

1. **Length Units:** micrometre (10^{-3} mm), nanometer (10^{-6} mm), Angstrom (10^{-9} mm).
2. **Weighing Units:** mg (10^{-3} g), micro gram (ηg) (10^{-6} g), Nanogram (10^{-9}g), Pico gram or Dalton (10^{-12} g).

Dalton: it is equivalent to the molecular weight of hydrogen atom. (the molecular weight of water molecule is 18 Daltons, while the molecular weight of hemoglobin is 64500 Daltons).

Cellular structures and vital functions

Any living being is called "Organism"

Organism: an organized system

With a specific identifiable shape

Each organ within this system has a specific function *i.e.* growth, reproduction, sensitivity, metabolism, etc…

So, it is easy to identify plants and animals as living organisms as well as rocks and stones as nonliving. On the other hand, it is not an easy task to define Viruses as living beings. Why?

The living material is called the Cytosol (portion of the cytoplasm) is a translucent semifluid substance of the cell, colorless to slightly yellowish viscous liquid resembles egg white.

The Cytosol is examined by the light or electron microscopy or by using diffractive analysis of X-ray.

Characters of living cell

1. Cellular organization: each organism has a specific form, shape and size by which it is identified. As each one consists of different parts that ends up with the cell.

   Body Systems Organs Tissues Cells

   The Cell: is the body building unit both in structure and function.

2. **Metabolism**: is essentially a collection of chemical reactions occurring within the body cell, where food is transformed into substances similar to that of the body. It consists of two processes:

   1. **Anabolism**: A process where energy is consumed for building up complex substances such as proteins, lipids or carbohydrates from simple ones

   2. **Catabolism**: A process where energy is released such as respiration or breaking up reserve food materials to simple substances to obtain energy during growth, mobility, reproduction, etc…

3. **Locomotion**: the ability of an organism to change place. This character differ from one organism to another. In plants, mobility is slightly noticed compared to animals, however plants mobility can be observed in blossoming of flowers and buds, opening and closure of stomata, streaming of the cytoplasm (cyclosis).

4. Response to Stimuli (Sensitivity): a reaction to an internal or external force i.e. phototropism or Geotropism.

5. Growth: Increase in size or weight till reaching a certain size. Growth is either limited (animals) or unlimited (plants).

6. Reproduction: it is the ability of the living organism to produce new individuals (offspring) when it reaches a certain age (maturation). As viruses have this character they were considered living beings, inspite of their inability to perform other characters such as growth, respiration, etc…

7. Respiration: a vital process which characterizes living organisms only.

$$C_6H_{12}O_6 + 6\ O_2 \qquad 6\ CO_2 + 12H_2O + Energy$$

8. Adaptation: the ability of the living organism to change slightly over time to be able to continue to exist in a particular environment. Adaptation can be quick or momentarily according to the response of enzymes, inhibitors or activators or it can be very slow in case of mutation or natural selection.

9. <u>Excretion</u>: a process by which metabolic wastes are eliminated from a living organism. It could be two contractile vacuoles as in *Chlamydomonas* or a complicated excretory system as in higher organisms.

- **<u>There are some common characters between living and non living which are</u>**:

1. **Increase in size**: like in crystals
2. **Movement**:

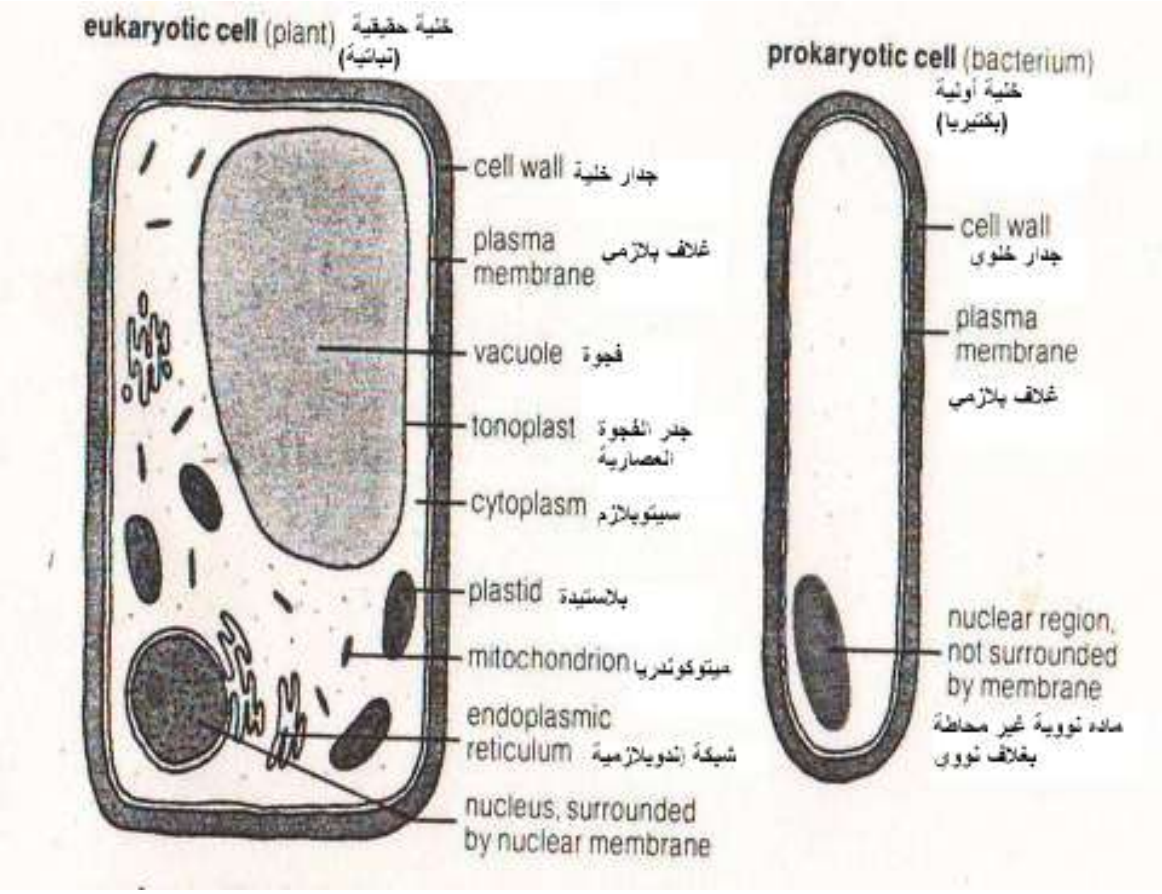
- a piece of metallic Sodium can move over water surface due to a chemical reaction.
- A drop of oil can move over water surface and form something like pseudopodia (false feet) in *Amoeba.*

Cellular Structures and Functions

- **The Cell**: is the body building unit both in structure and function.
- **Protoplasm**: It is called on the cell constituents.
- **Cellular Theory**: Plant and animal bodies consist of cells. New cells are only produced through the division of former existing cells (Schwan & Shleiden).
- Each cell consists of a nucleus surrounded by a nuclear membrane, with some exceptions as the Red Blood Cells (RBCs), losing its nuclei during maturation) or skeletal muscles (multinucleated).
-
- **<u>Organisms are either</u>**:

1. Cellular: either unicellular or multicellular
2. Acellular: Bodies whose cells never divide *i.e. Viruses*.

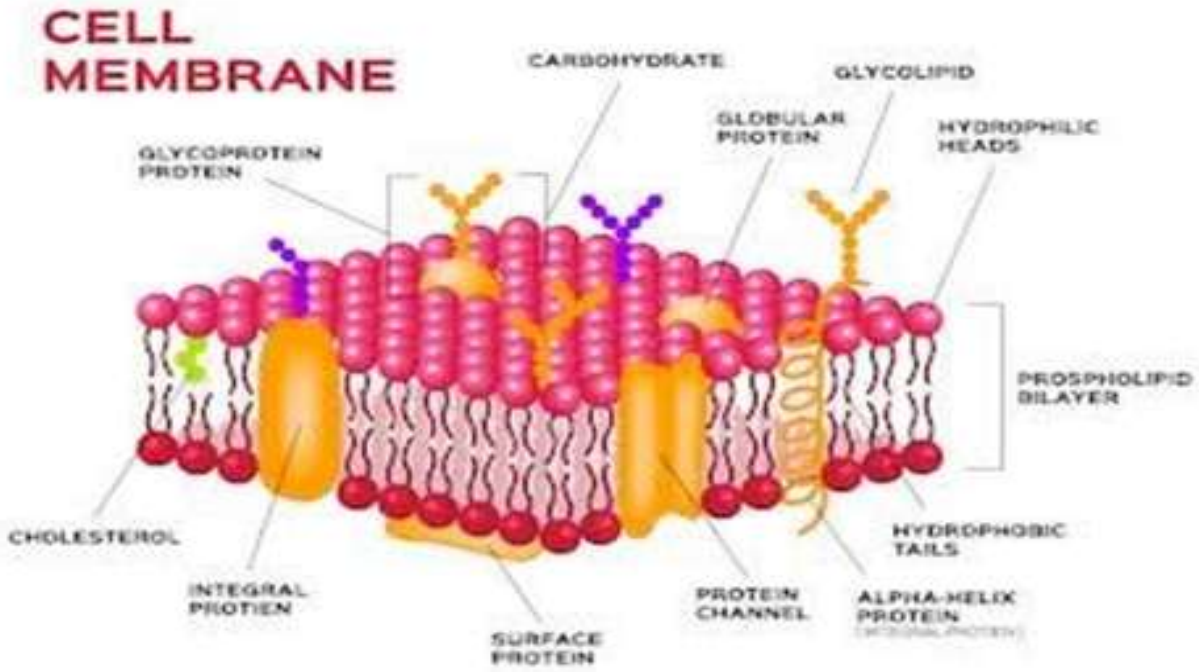
- Harrison-an American scientist-was able to cultivate *Salamander* cells in artificial media outside the body. Since then many plant and animal tissues were cultivated *in vitro* (in lab) by the help of Tissue Culture techniques.

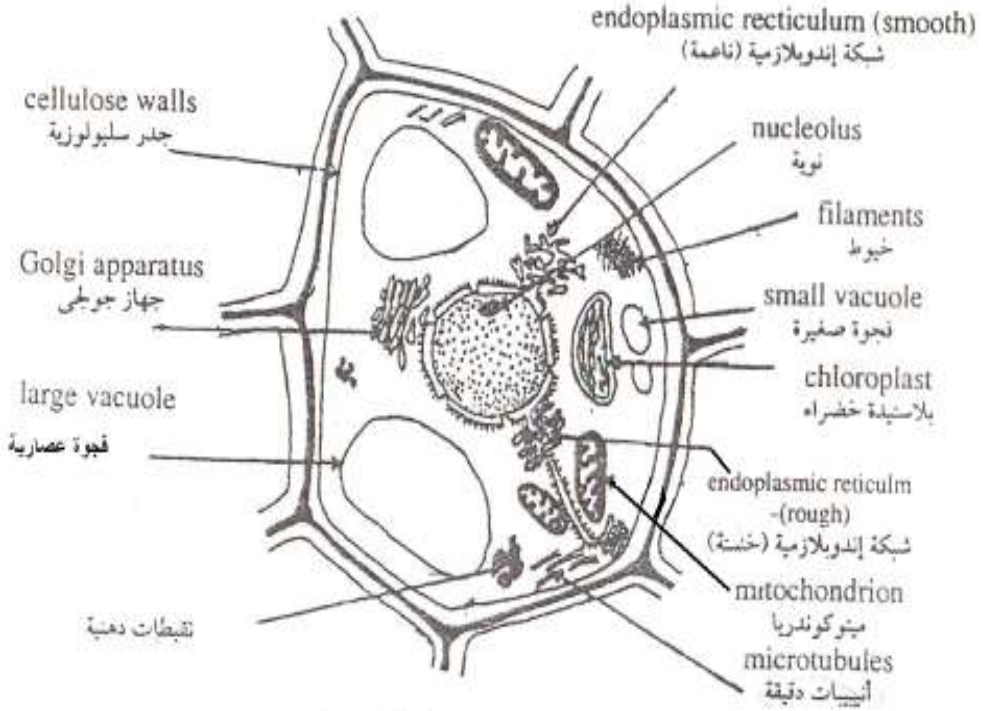


Exchanges of materials between cell and Environment

- **Plasma Membrane**: A membrane that regulates the possibility of substances or nutrients to pass in or out of the cell. They are living membranes that are selectively permeable. (they can allow the passage of substance even against concentration gradient).
- **Factors controlling the passage of a particle through cell membrane:**

1. Particle Size. 2. Solubility in lipids.
3. Number of water molecules adhered to the particle.
4. Electric charge carried on the particle.
5. Thickness of the *Endoplasmic reticulum* folds.





(شكل ٢): التركيب الدقيق لخلية نباتية

(Fig. 2) ultramicroscopic structure of plant cel

Endoplasmic Reticulum

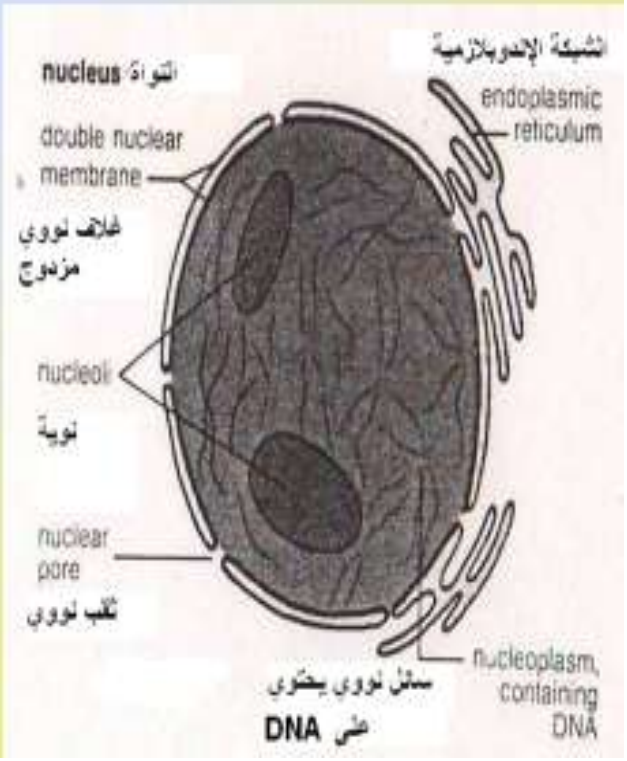
- ***Shape*:** Fine tubes and vesicles of two types:

1. Smooth
2. Rough: due to the presence of *Ribosomes*.

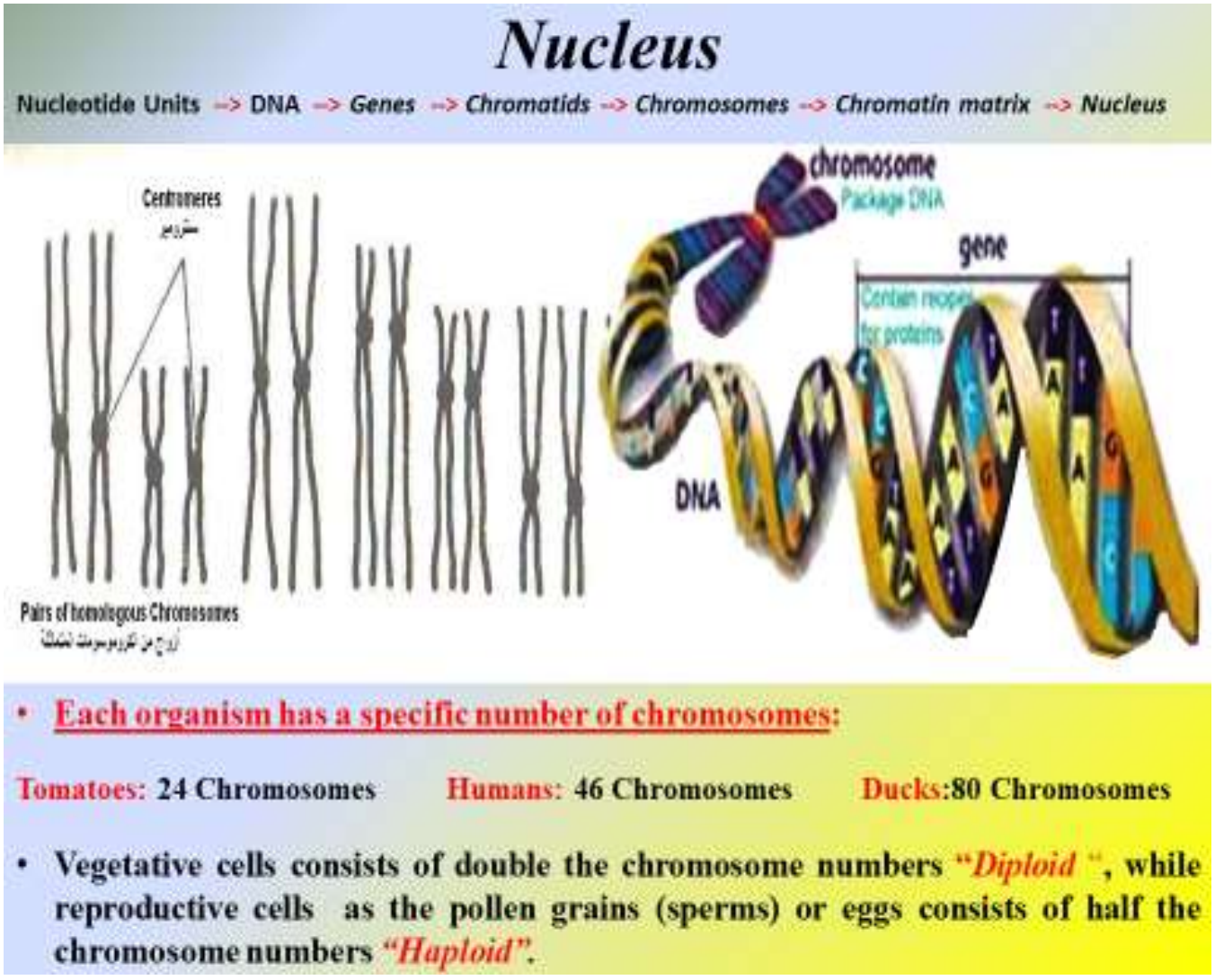
- ***Function*:** Passing and storing substances and nutrients inside the cell (specially the proteins)
- ***Ribosomes*:** Small protoplasmic bodies that maybe found free or attached to the rough *Endoplasmic reticulum*, *plastids*, *nuclei* and *mitochondria.*
- ***Function***: They attach to mRNA to synthesis protein in the cell.

Nucleus

- **A cell could be:**
  1. Uni-nucleated 2.Multinucleated
- **Also it could be:**
  1. Central: (*Meristematic* young cells).
  2. Lateral: (Permanent aged cells).
- ***Function*:** Controlling vital cellular functions.
- If the nucleus is separated from its cell, the cell dies.
- Due to the excess nuclear acids, they appear more viscous than the cytoplasm.
- ***Structure***: it contains DNA and different types of RNA as:
  1.mRNA (messenger)
  2. tRNA (transferring)
  3.rRNA (ribosomal)

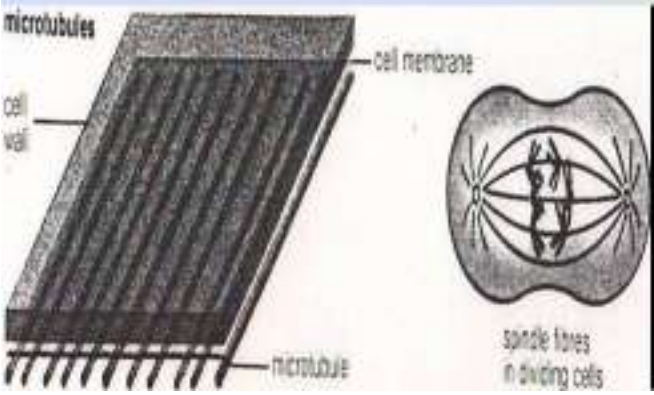


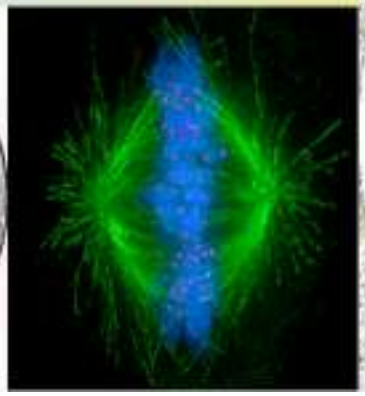
- It consists of a gelatinous substance rich in protein, fats and nucleic acids known as Nuclear Sap.
- It is enveloped by a nuclear membrane which is a bilayer membrane carries *Ribosomes* on its surface.
- One or more *Nuclei* is found in the nuclear sap.
- ***Nuclei***: A spherical body devoid of a membrane, more viscous than the nuclear sap as it is very rich with RNA and proteins with little DNA.
- ***Function***: Center of formation of RNA, proteins and *Ribosomes.*
- It is composed of a chromatin matrix from units called *Chromosomes.* Each *Chromosome* consists of two *Chromatids* connected by a *Centromere.*
- Each *Chromatid* consists of proteins and nucleic acids.
- Each *Chromatid* consists of *genes* that compose DNA.

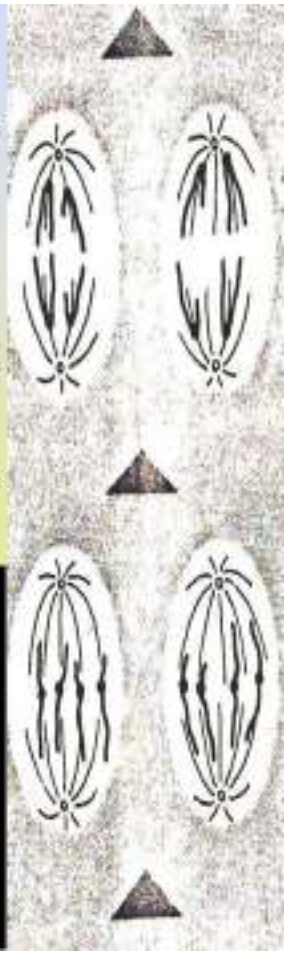


Centrioles

- Two small dark colored cylindrical bodies found near the nucleus.
- Found in animal cells and primitive plant cells.
- It plays a basic role in cell division.
- Form what is known as Spindle Fibers (Chromosomal & Continuous).
- **Spindle Fibers**: Microtubules radiating filaments, lies between the Chromosomes and on the cell poles.

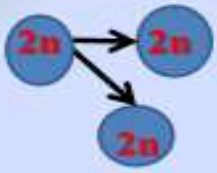




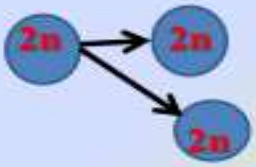


Cell Division

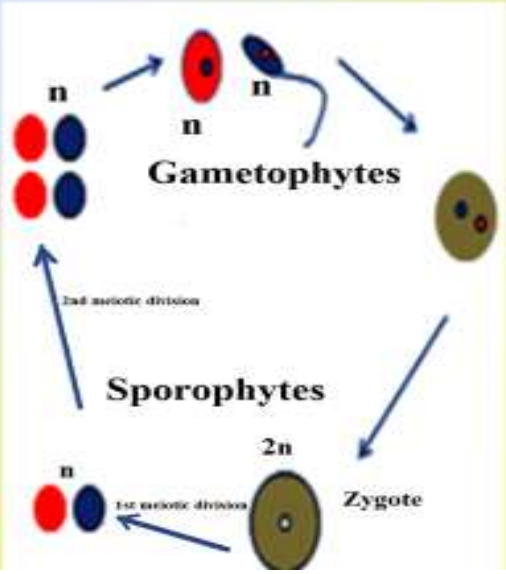
1. *Amitosis* (fission)

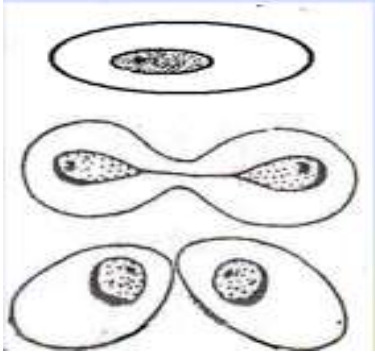


2.*Mitosis*



3.*Meiosis*

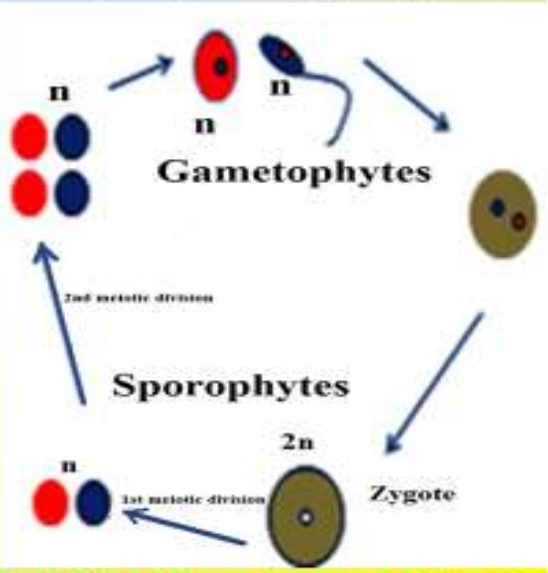




Cell Division
Meiotic Division

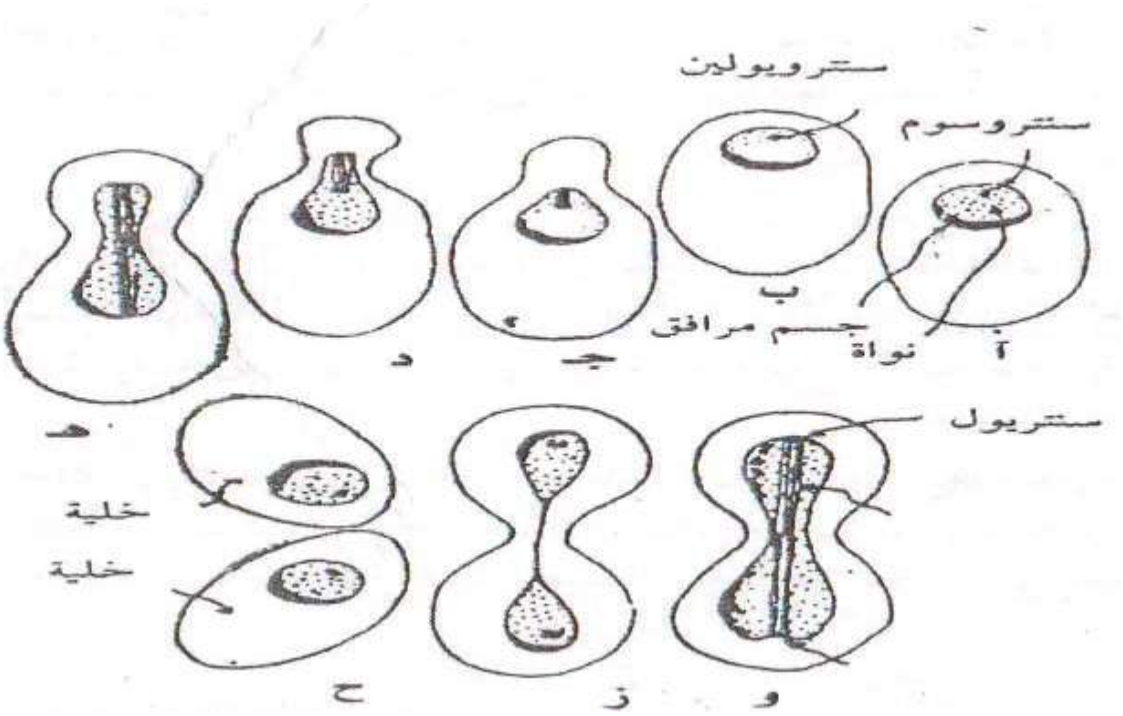
- Known as reduction division and happens in all higher plants (Sporophyte).
- Consists of two **consecutive divisions** where **four** gametes are produced:
- **In the first division:** Chromosomal number is reduced to half.
- **In the second division:** Chromosomal number remained the same, but the cells duplicate.
- In the final cell stage, a cellular lamella is formed that is then becomes the middle lamella on which cellulose deposits forming the primary wall.
- **Give Reason:**

Chromosomal numbers are reduced to half while cell numbers duplicate?



Cell division
1. *Amitosis* (Fission)

- It is also called Binary fission, it happens in lower organisms like *Bacteria* and some *Fungi*.



Cell division

2. *Mitosis*

- **It occurs in five stages:**

1. Interphase stage:

- DNA duplicates.
- Nucleus enlarges and cytoplasm becomes granular.

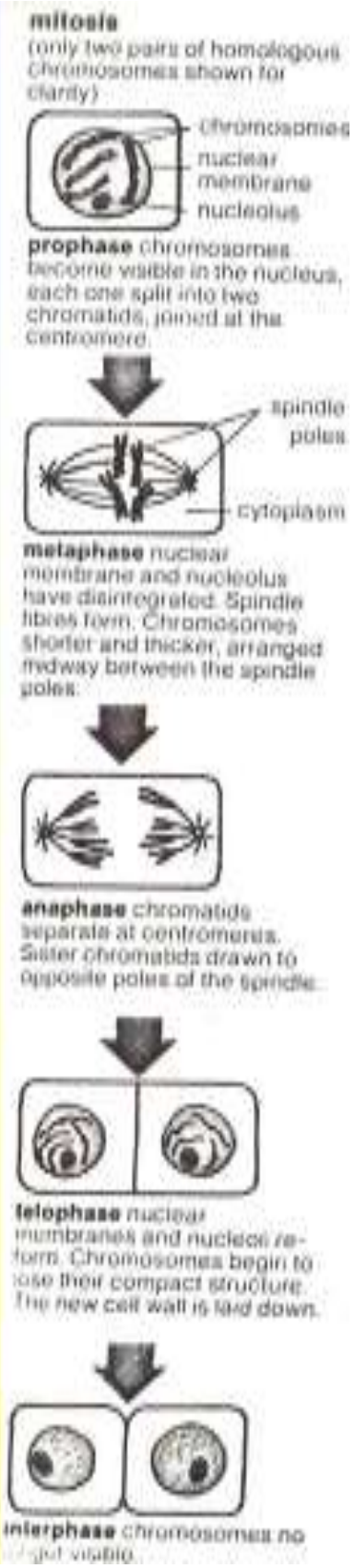
2. Prophase stage:

- Chromosomes get short, thicker and is coated by the matrix.
- Nucleus and nuclear membrane disappear.

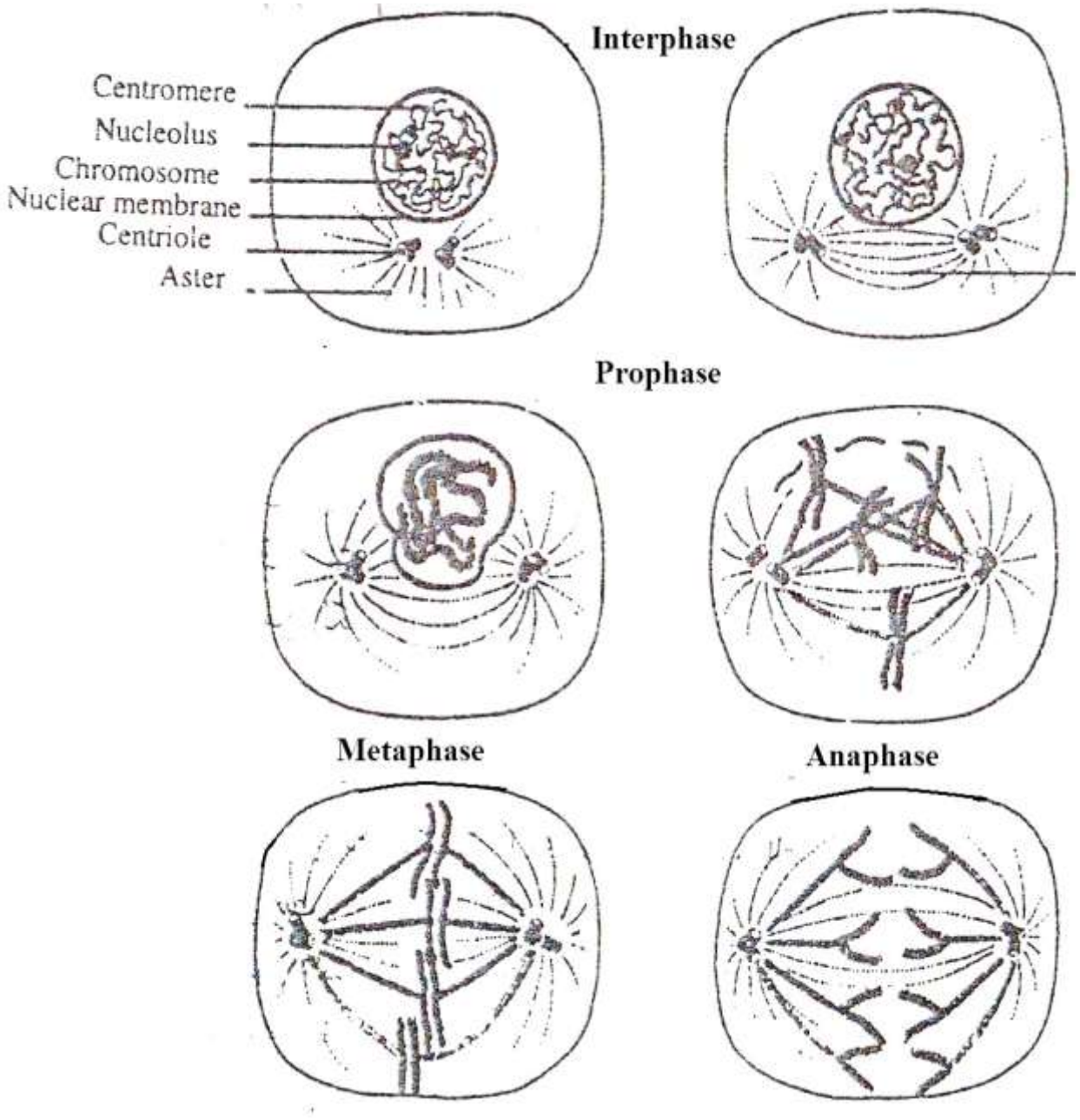
3. Metaphase stage:

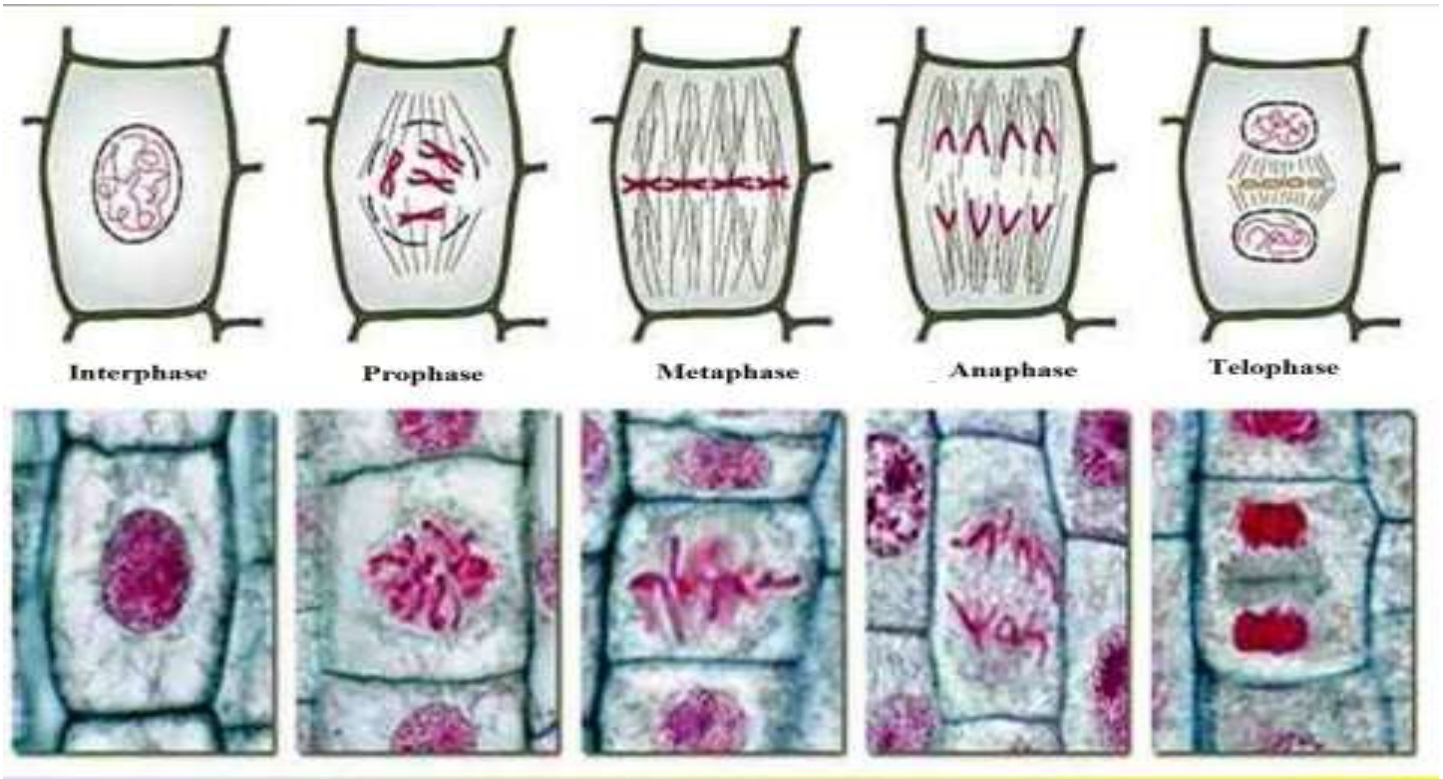
- Each centriole migrates to one pole of the cell.
- Spindle fibers form, those attached to the centromere are called "Chromosomal fibers" while the others are called "Continuous fibers".
- Chromosomes are arranged in midway.

4.Anaphase stage: Chromosomes at the centromeres, sister chromatids drawn to opposite poles of the spindle.



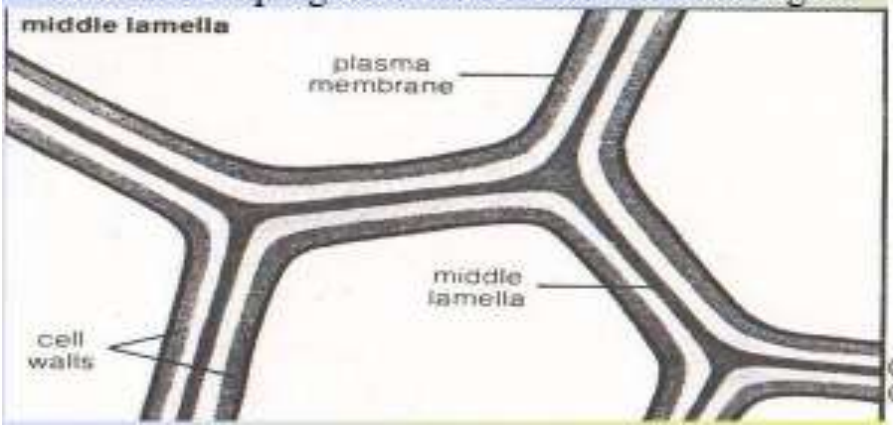
5. Telophase stage: the steps are opposite to that of prophase, where:
   - The matrix disappears, the chromosomes become thinner and longer.
   - Nuclear membrane and nucleoli reform.
   - Vesicles are formed in the cell midway by Golgi apparatus forming the cell lamella which with two plasma membranes form the middle lamella on which cellulose is deposited to form the primary cell wall.

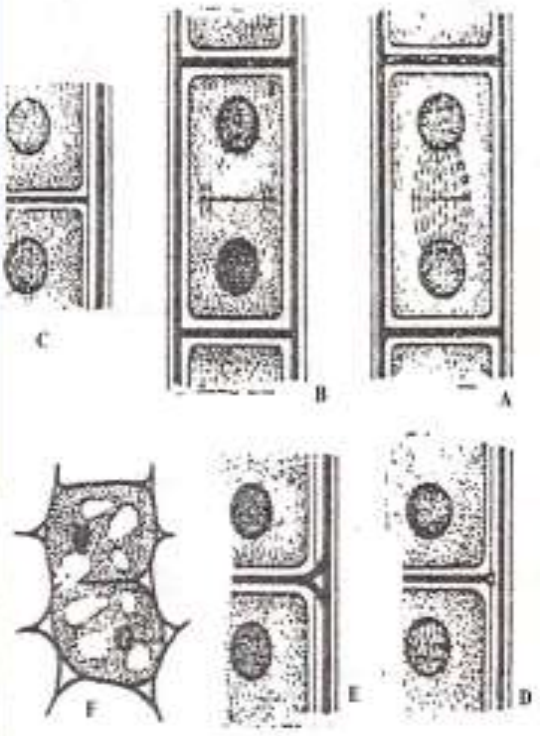




Cell Wall

1. **Cellular Lamella** is formed in between the two cells resulting from division.
2. Ca and Mg pectates are deposited to form the **Middle lamella**.
3. **Primary cell wall** is formed when cellulose is deposited.
4. **Secondary cell wall** is then formed of three layers, the middle is thick and the other two surrounding it are thin where they all are of cellulose impregnated with Suberin and Lignin





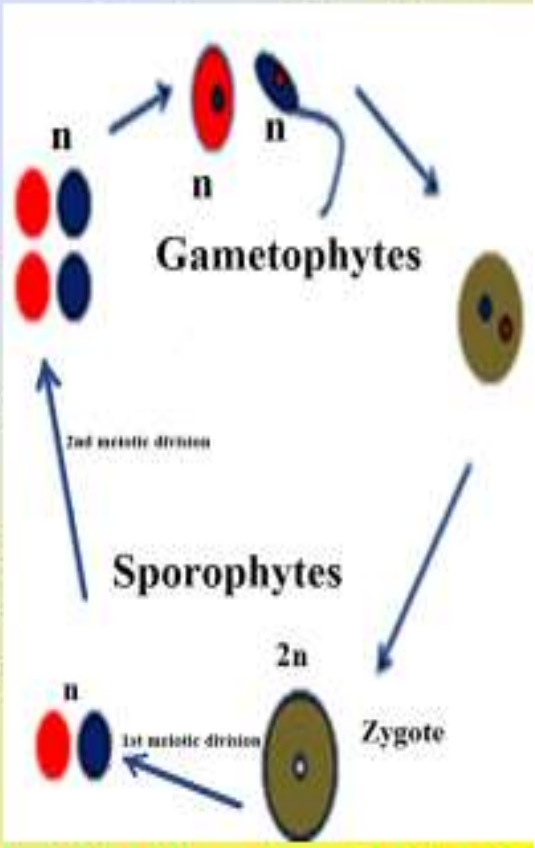
(شكل ٧) : خطوات تكوين الجدار الخلوي

(Fig. 7) steps of cell wall formation

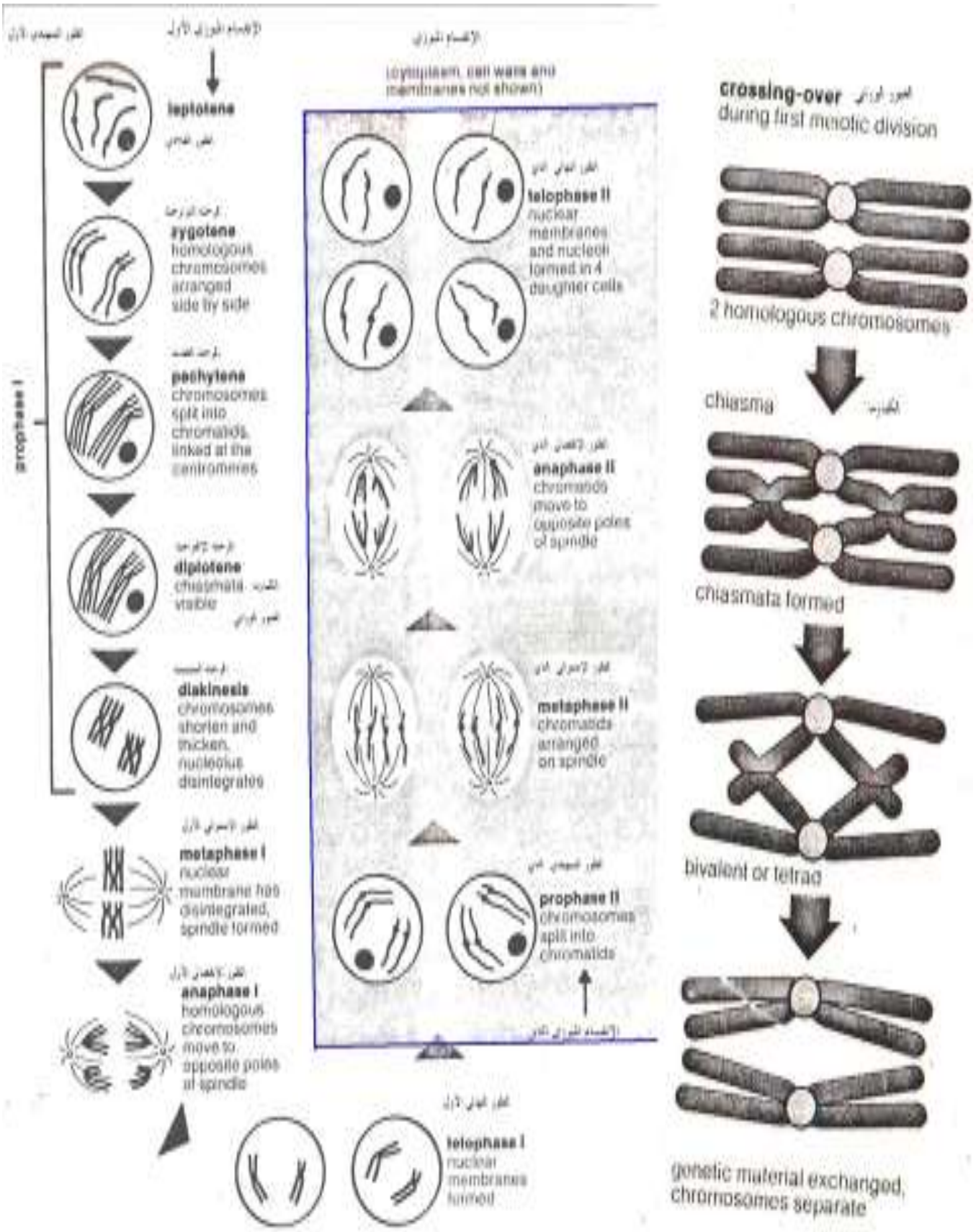
(A),(B) Cellular Lamella Formation (C) Middle Lamella Formation
(D),(E) Intercellular Spaces (F) Formation of Divided Cells

Cell Division
Meiotic Division

- Known as reduction division and happens in all higher plants (Sporophyte).
- Consists of two **consecutive divisions** where **four** gametes are produced:
- **In the first division:**
  Chromosomal number is reduced to half.
- **In the second division:**
  Chromosomal number remained the same, but the cells duplicate.
- In the final cell stage, a cellular lamella is formed that is then becomes the middle lamella on which cellulose deposits forming the primary wall.
- **Give Reason:**

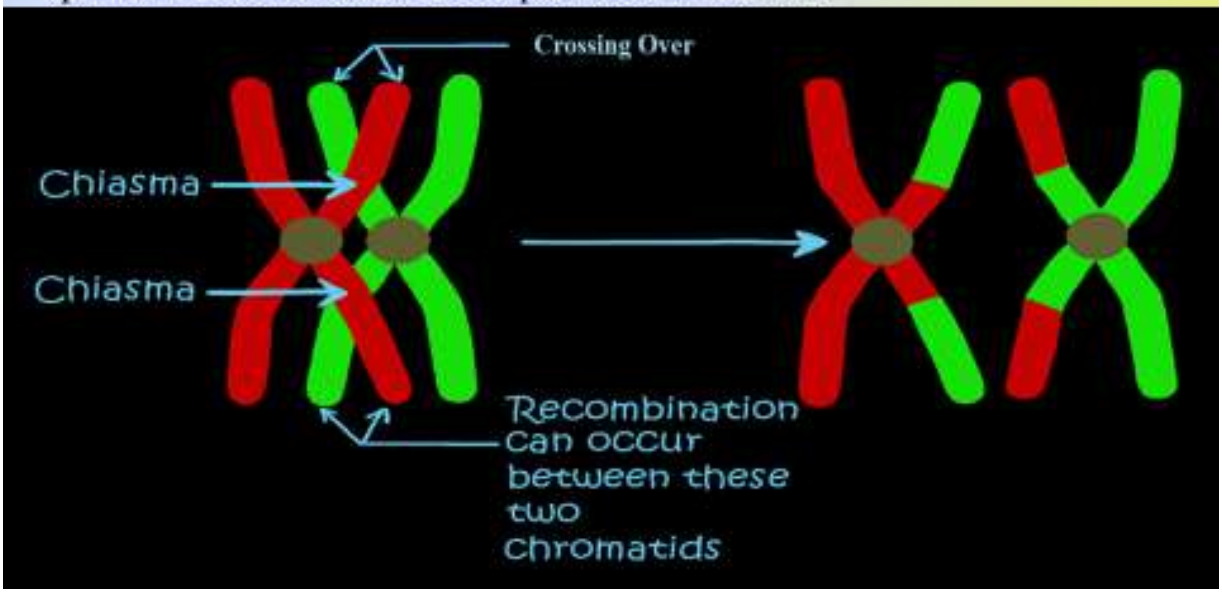


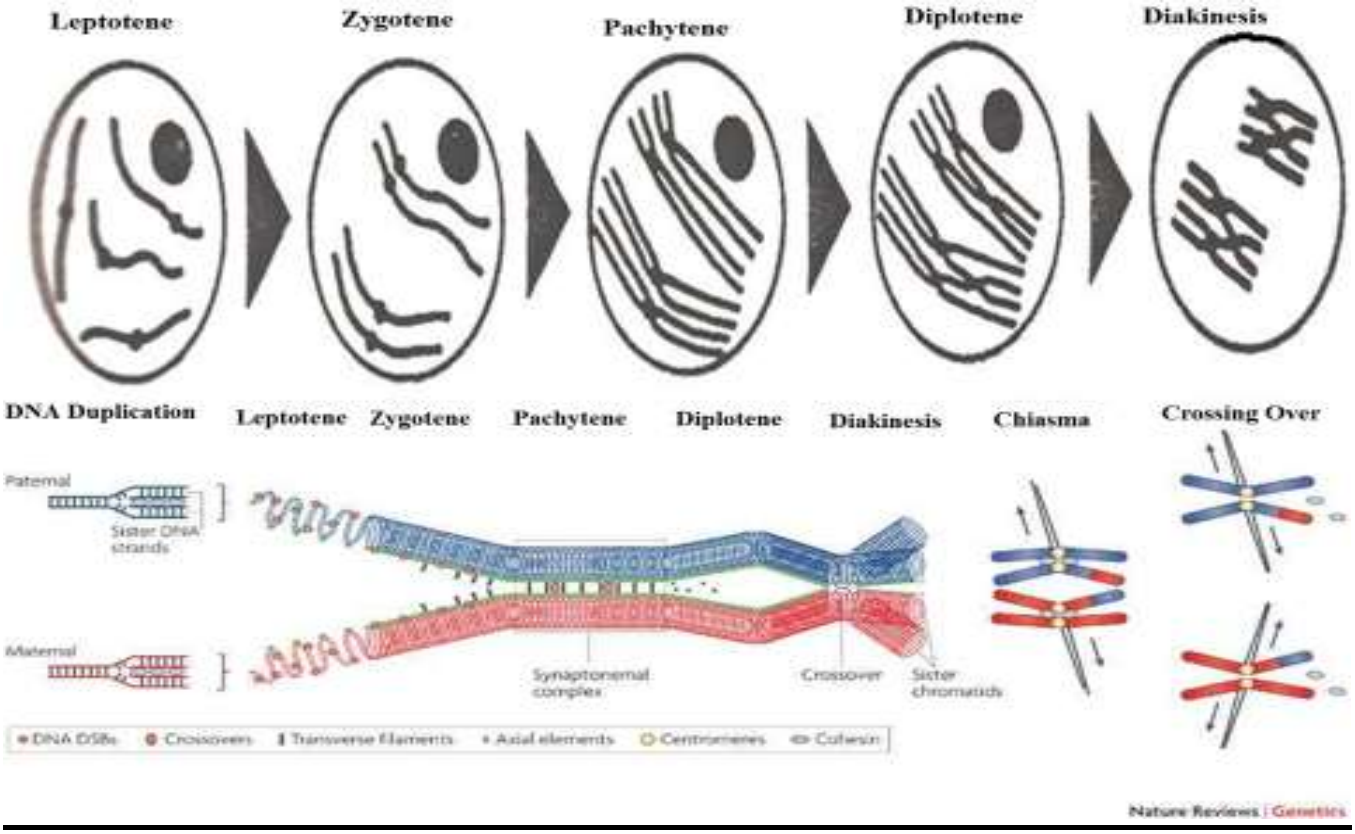
Chromosomal numbers are reduced to half while cell numbers duplicate?


(cytoplasm, cell walls and membranes not shown)
prophase I
leptotene
zygotene
homologous chromosomes arranged side by side
pachytene
chromosomes split into chromatids, linked at the centromeres
diplotene
chiasmata visible
diakinesis
chromosomes shorten and thicken, nucleolus disintegrates
metaphase I
nuclear membrane has disintegrated, spindle formed
anaphase I
homologous chromosomes move to opposite poles of spindle
telophase I
nuclear membranes formed
telophase II
nuclear membranes and nucleoli formed in 4 daughter cells
anaphase II
chromatids move to opposite poles of spindle
metaphase II
chromatids arranged on spindle
prophase II
chromosomes split into chromatids
crossing-over
during first meiotic division
2 homologous chromosomes
chiasma
chiasmata formed
bivalent or tetrad
genetic material exchanged, chromosomes separate

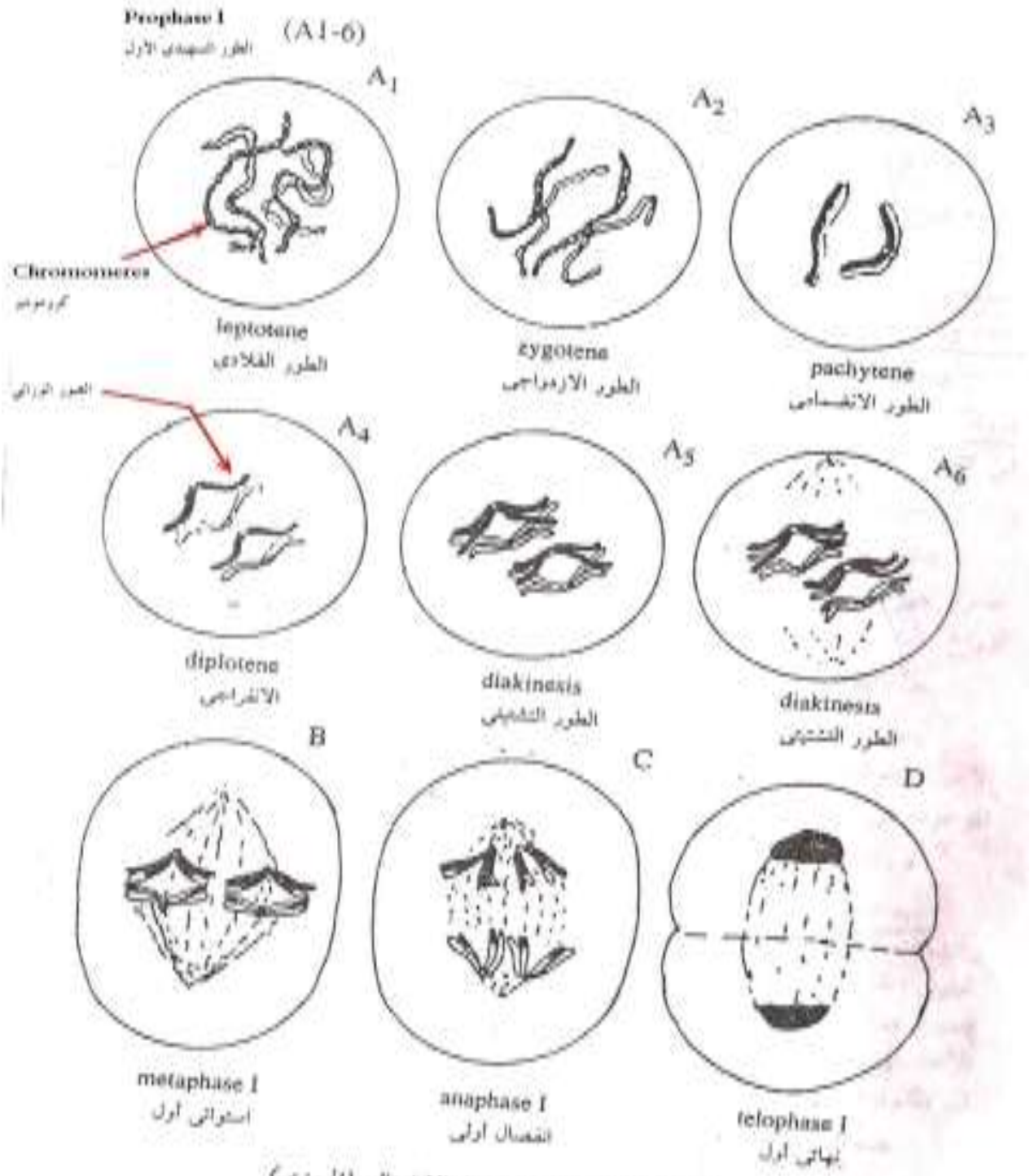
Meiotic Division

- **Chiasma:** The recombination of the internal chromatids of the two sister chromosomes during the diplotene phase in the 1st meiotic division.
- **Crossing Over:** The exchange of parental genetic material during the split of the chromatids at the points of chiasmata.



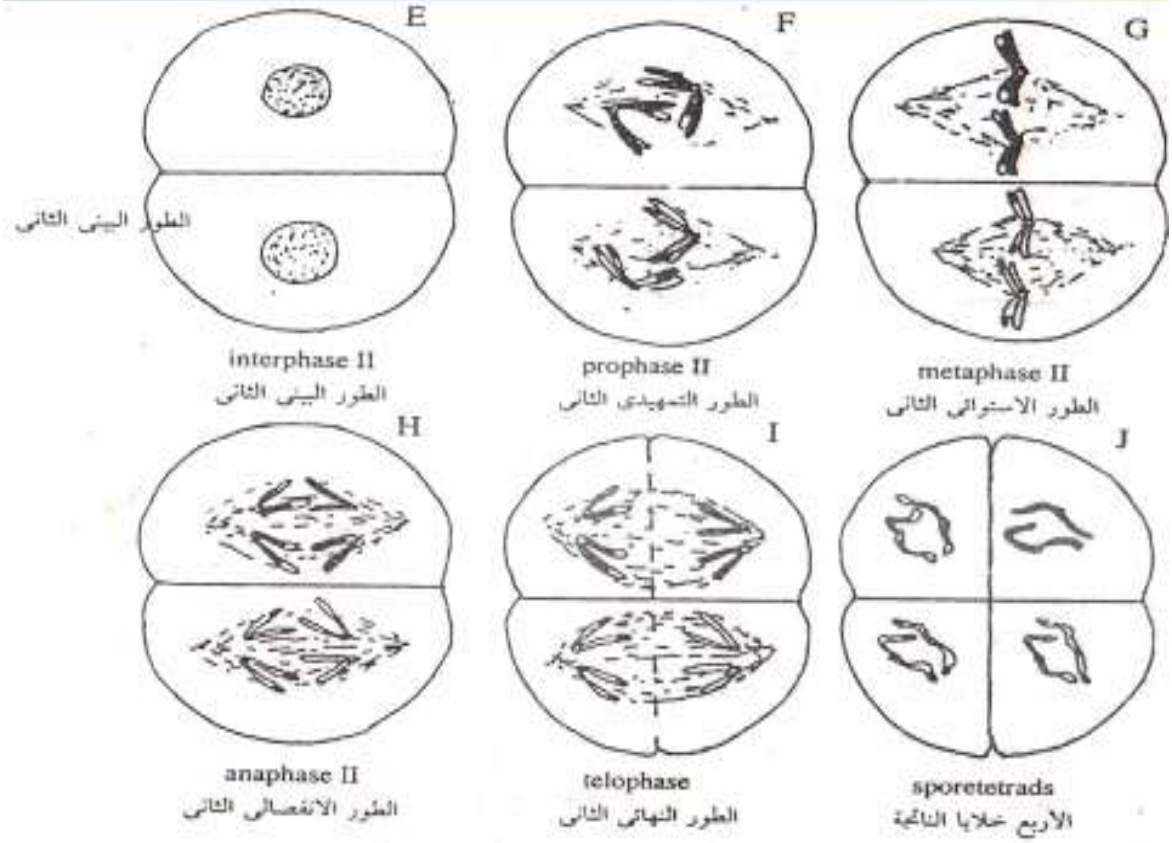


1st *Meiotic* Division



(شكل ٦): خطوات الانقسام الاختزالي (الميوزي)
(Fig. 6) stages of meiosis

2nd *Meiotic* Division



تابع (شكل ٦): خطوات الانقسام الاختزالى (الميوزى)
(Cont. Fig. 6) stages of meiosis

Cytoplasmic Organelles

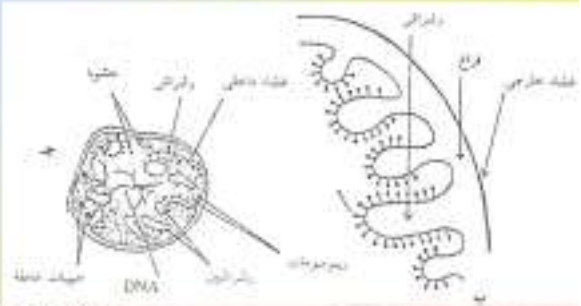
1. *Mitochondria*:

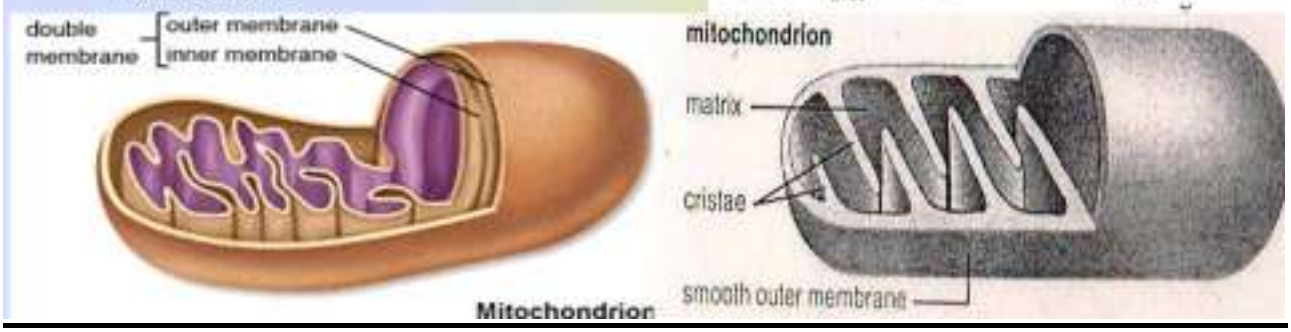
- **Shape:** Protoplasmic living bodies maybe circular, cylindrical or filamentous. It is formed of proteins (matrix). It has DNA and ribosomes.
- **Function:**

1. It possesses enzymes necessary for phosphorylation:

ATP ⟶ ADP ⟶ AMP

2. It contains Cytochrome enzymes necessary for Kreb's cycle during respiration reactions and energy formation.





2. Plastids:

Structure:

Protoplasmic living organelles that are able to grow and divide.

It is formed from small bodies called Proplastids.

It is not found in lower organisms like Bacteria and Fungi. The cell may possess one large plastid (as in Algae i.e. Chlamydomonas) or many plastids (as in higher plants).

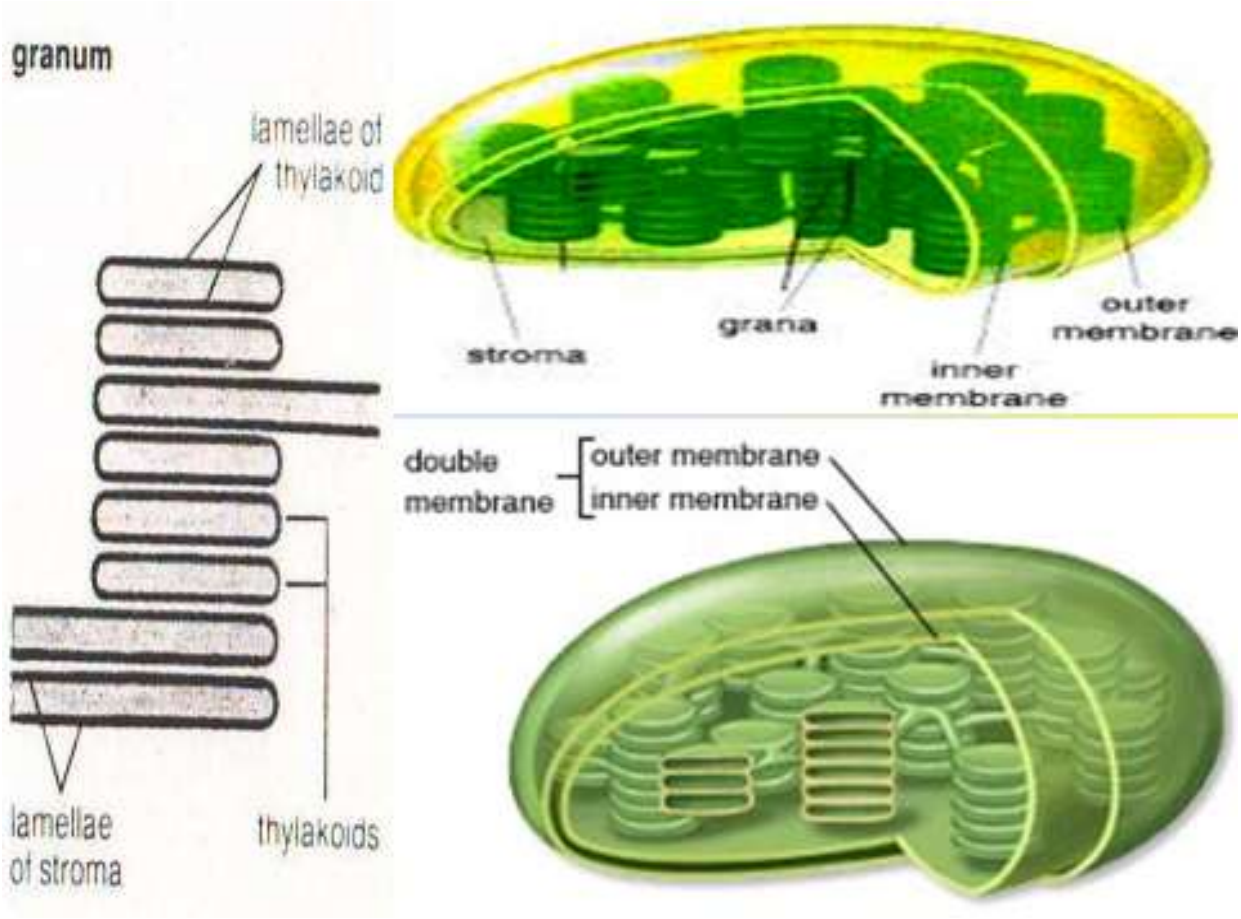
The plastids may be green, colored (pepper) or colorless (onion) and it can change from form to another when exposed to light.

It contains Chlorophyll A, B, Carotene and Xanthophyll.

Function:

It undergoes photosynthesis through transforming light energy into chemical energy.

Colorless plastids are centers of storing starch or any other substance.



chromoplasts in a root cell of *Daucus carota*

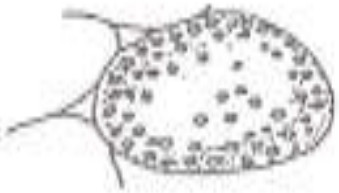
بلاستيدات ملونة في خلية لجذر نبات الجزر

leucoplasts in a young endosperm cell of *Zea mays.n*

بلاستيدات عديمة اللون في خلية صغيرة لاندوسبيرم نبات الذرة الشامية

chromoplasts in an epidermal cell from calyx of *Tropaeolum majus*

بلاستيدات ملونة في خلية بشرة الكأس لنبات أبو خنجر

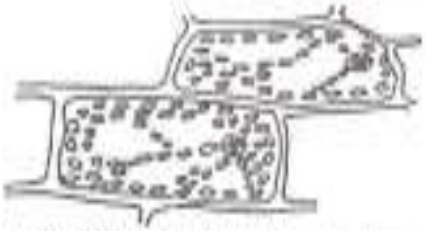


chromoplasts in a fruit cell of *Capsicum*

بلاستيدات ملونة في خلية ثمرة نبات الفلفل

Spirogyra showing spiral - shape chloroplast

طحلب اسبيروجيرا لمشاهدة البلاستيدات الخضراء الحلزونية الشكل



Elodea leaf showing disc shape chloroplast

ورقة نبات الالوديا لمشاهدة البلاستيدات الخضراء القرصية الشكل

Zygnema showing star-shap chloroplast

طحلب الزيجنما لمشاهدة البلاستيدة الخضراء النجمية الشكل

(شكل ٩) أنواع البلاستيدات

(Fig. 9) types of plastids

Cytoplasmic Organelles

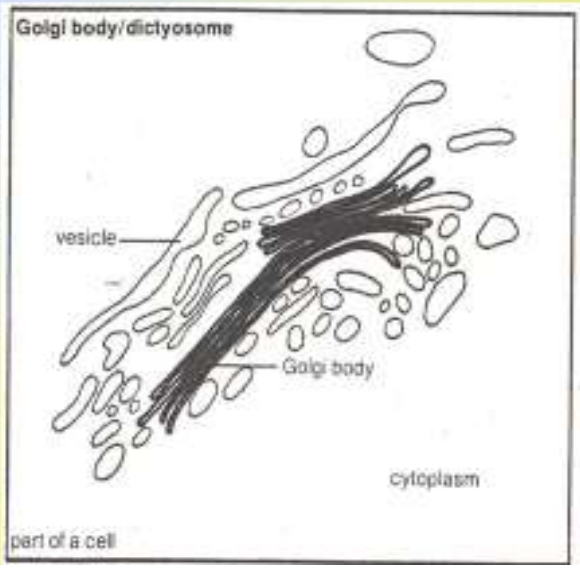
3. Golgi Apparatus: Found in all animal cells except sperms and RBCs.

- Shape:

1. It consists of group of bodies called ***Dictysomes***, which are hollow discs contains carbohydrates and proteins.
2. *Dictysome* wall is formed of a membrane made up of lipids and proteins.

- Function:

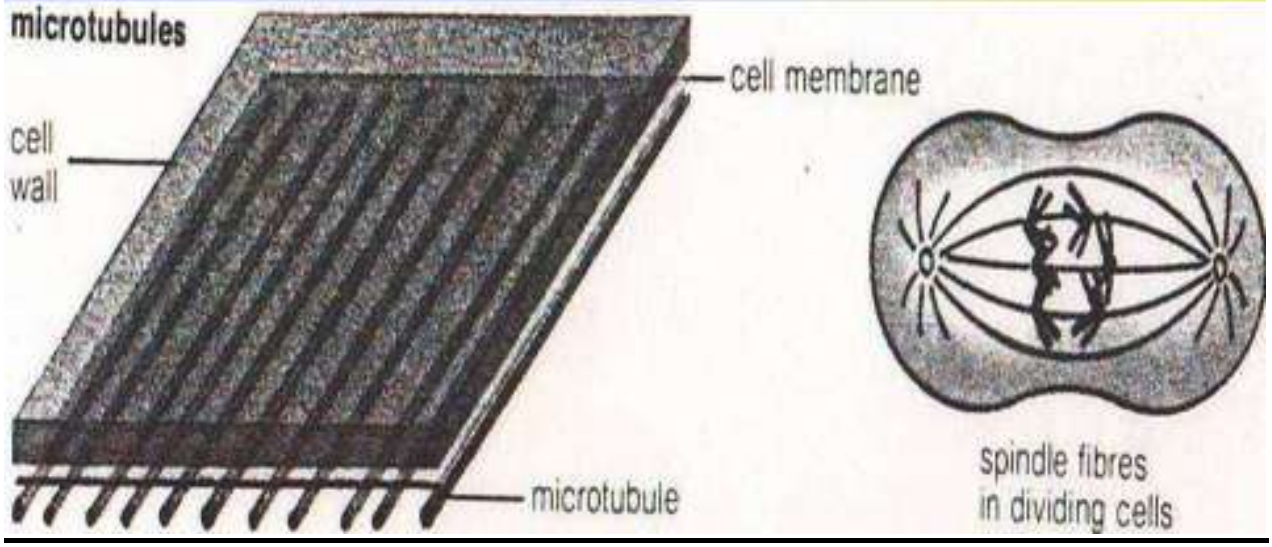
1. It secretes pectin substances necessary for the middle lamella formation.
2. It secretes mucilaginous substances to easy the penetration of root tips into the soil.
3. It secretes cellulose for cell wall formation.
4. Storage of proteins, carbohydrates and fats.
5. Transferring stored substances in and out of the cell



Cytoplasmic Organelles

4. *Microtubules*:

- **Shape**: Rod-like hollow proteinous membranes. It is formed of ß and ∝ tubulin (types of proteins).
- **Function**: 1. It controls cell shape
  2. It plays an important role in the movement inside the cell (chromosomes by spindle fibers) and the cytoplasm cyclosis.



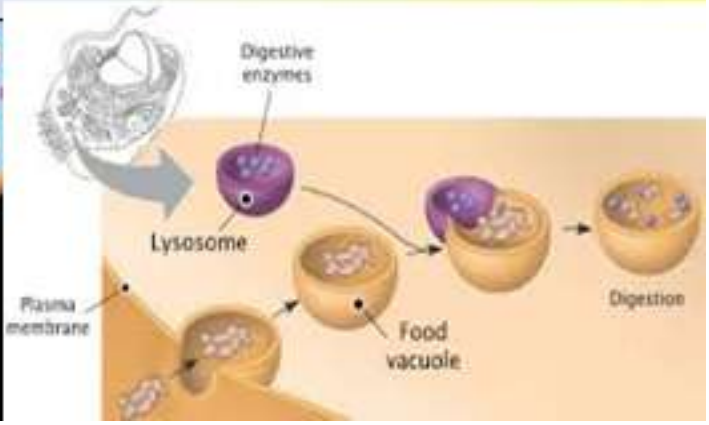
5. *Lysosome*:

- Shape:

1. It is found in most animal cells and if found in plant cells they are in small spherical bodies.
2. It appears as a vesicle surrounded by a membrane. It contains digestive active enzymes. When its walls ruptures it helps in destroying the cell.

- Function:

1. Secreting enzymes as lipases (digesting fats), proteases (digesting proteins) and nucleases (digesting nucleic acids and nuclear membranes).



Non-protoplasmic Components

Peroxisomes

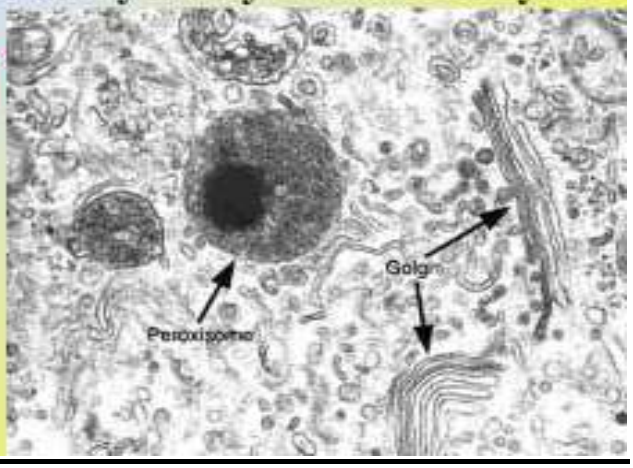
Structure:

- **They are vesicles the size of which reaches 1 mμ.**
- **They are filled with enzymes and proteins.**

Function:

- **They produce peroxides which are analyzed by Catalase enzymes during photosynthesis.**

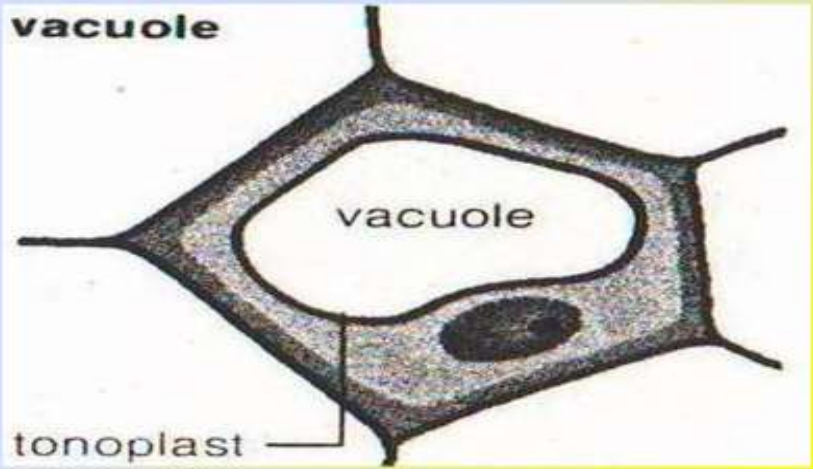
$$2\,H_2O_2 \xrightarrow{\text{Catalase}} 2\,H_2O + O_2\uparrow$$



Non-protoplasmic Components

Vacuole

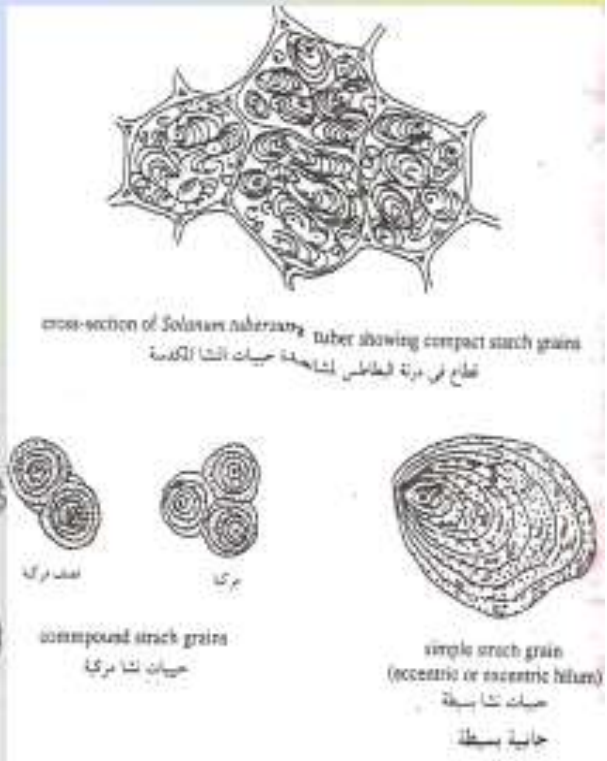
- It contains a colloidal solution, which consists of sugars, salts, proteins in addition to other metabolic wastes

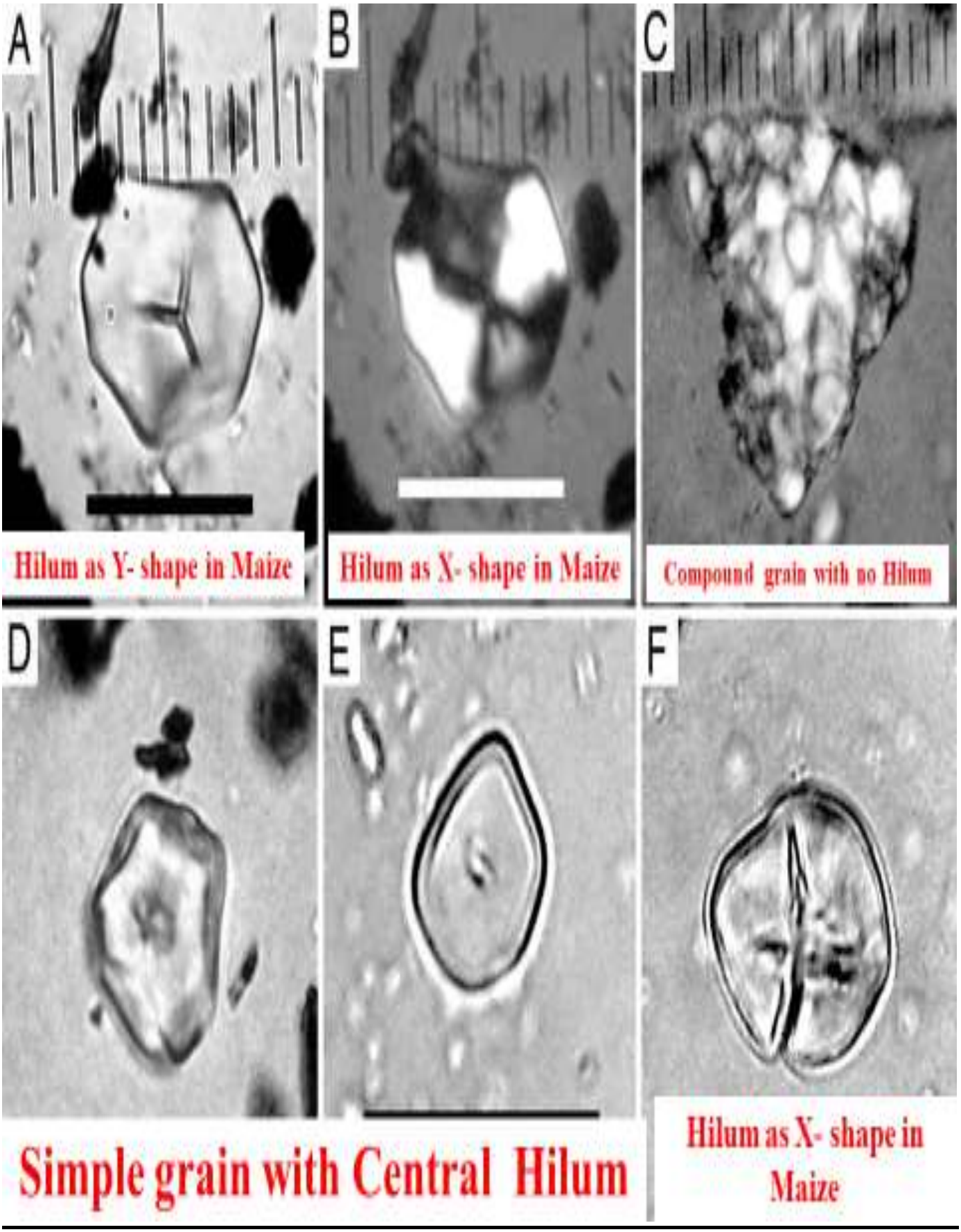


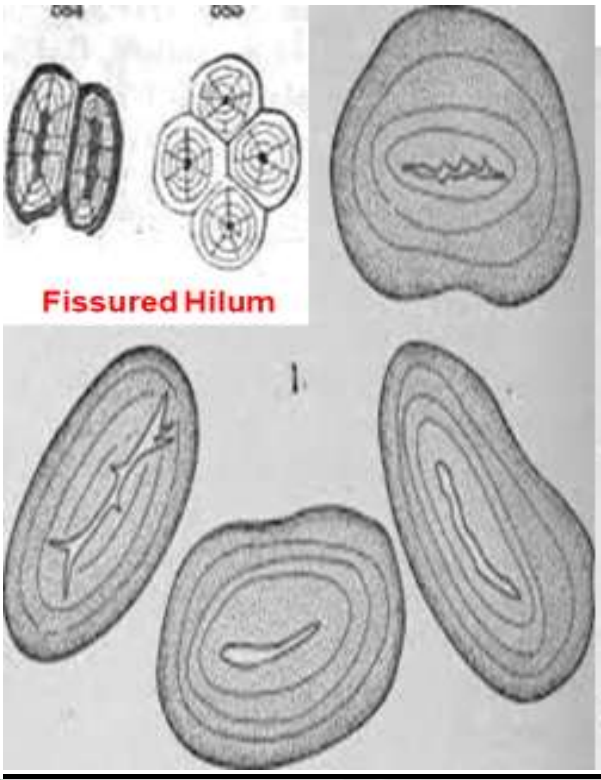
Non-Protoplasmic components

Starch grains

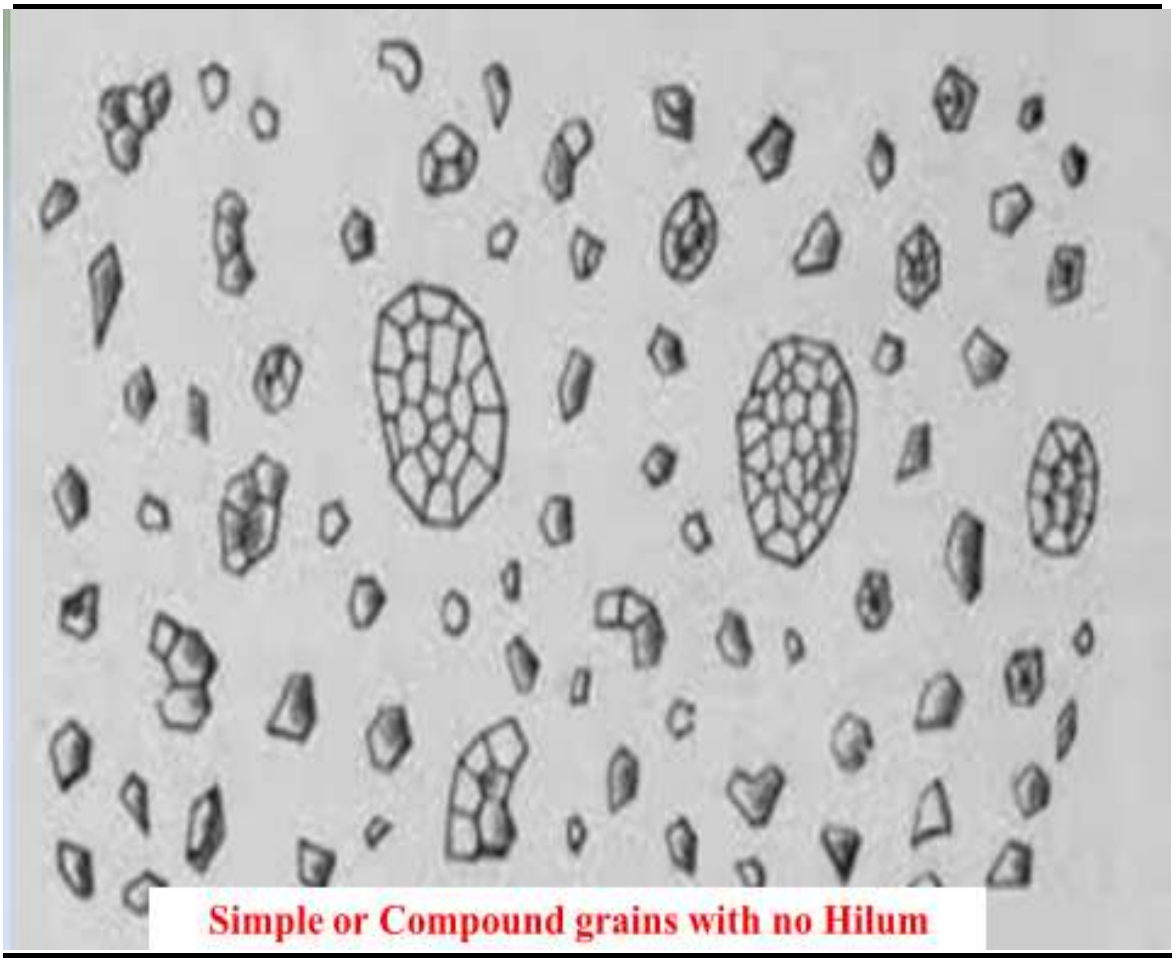
- Striations of starch formation around a central point called the "**Hilum**", where the starch grains are:
  - Either: **Simple** or **Compound**.
  - According to the position of the Hilum they are either **Central** or **Lateral**.
  - In some plants the Hilum appears as:
    1. X or Y- shaped: Maize.
    2. Fissure: Kidney beans or Peas.
    3. No hilum: Rice.




A
B
C
Hilum as Y- shape in Maize
Hilum as X- shape in Maize
Compound grain with no Hilum
D
E
F
Simple grain with Central Hilum
Hilum as X- shape in Maize

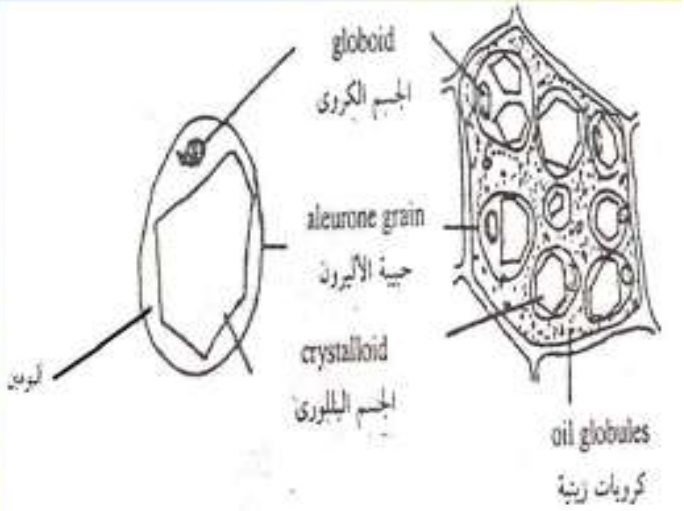

Fissured Hilum


X or Y-shaped Hilum


Simple or Compound grains with no Hilum

Non-Protoplasmic components

- **Proteins:**
- It consists of *Aleurone* grains which is composed of:
  - Globoid Body of proteins.
  - Crystalloid Body
- **Function:** it is responsible for seed germination by the production of enzymes.



(شكل ١٢): حبيبات الإليرون فى خلية الندوسبيرم نبات الخروع

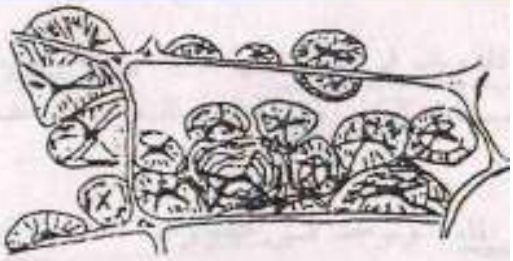
- **Fats and Oils:**

It is stored in fruits, seeds as well as rhizomes and tubers.

Non-Protoplasmic components

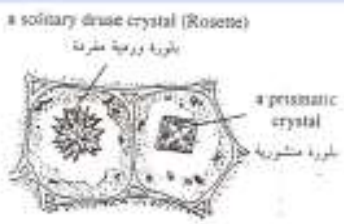
Crystals

- **Types:**
  1. **Proteinous**; in the form of small cubes.
  2. **Sugary**; like Inulin spherical crystals.
  3. **Salts**; Calcium crystals are one of the most widespread ones. It's divided into:
     - ✓**Ca-oxalate**:Solitary-Raphides-Druses.
     - ✓**Ca-carbonate**



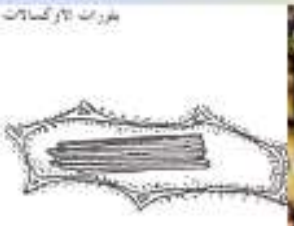
(شكل ١٣): بللورات الإنيولين فى خلايا درنة نبات الداليا

(Fig. 13) sphaerocrystals of inulin in cells of a Dahlia tuber



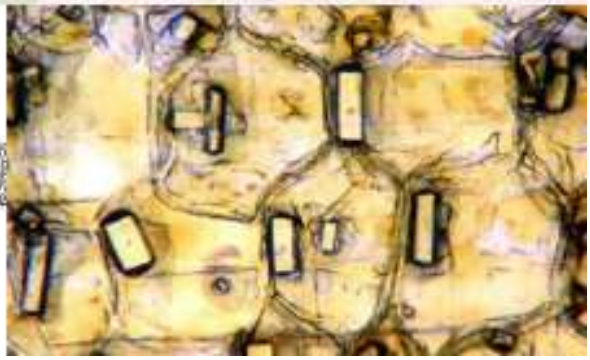
(شكل ١٤): خليتان من عنق نبات البيجونيا

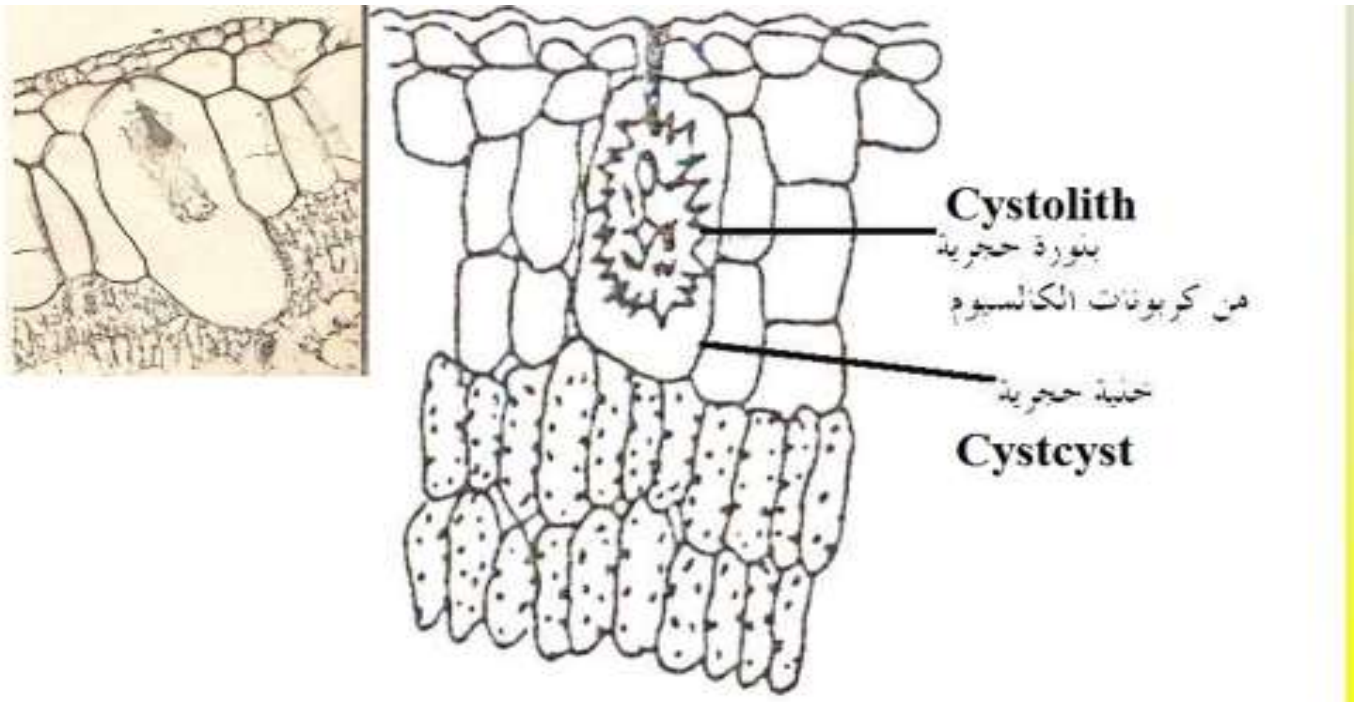
(Fig. 14) two parenchyma cells from the petiole of Begonia.



(شكل ١٤): حزمة من بللورات إبرية

(Fig. 14) a bundle of raphides.





T.S. in *Ficus elastica* leaf showing stone cell

(شكل ١٤): بلورة حجرية فى نصل ورقة نبات الفيكس المطاط

Non-Protoplasmic components

- **Tanins**: Phenolic compounds that is characterized by:

  Being colloidal in nature.

  It is found in dead tissues.

  It appears like thin or thick masses.

  It appears in red, yellow or brown colors.

  Function: 1. They protect the plants against drought.

  2. They are antioxidant in nature.

  3. They are antimicrobial agents.

- **Alkaloids**: Nitrogenous compounds, examples of which are:
- **Caffeine**:(In tea leaves or coffee beans) a nervous system stimulant
- **Opium**: the dried latex of Opium plants. Used as analgesic.

- **Quinine**: Isolated from the bark of Cinchona tree . Used to treat Malaria, but can cause deafness, irregular heart beat and sweating.
- **Pigments**: They are divided into two groups of pigments:
  1. Insoluble in water: They dissolve in alcohol. Examples of which are those pigments found in plastids as Chlorophyll and Carotene.
  2. Soluble in water: It includes Flavones and Anthocyanins

Flavones $\xrightarrow{(O)}$ Anthocyanins

<u>Anthocyanin changes its color according to the pH</u>:

a. It is Red in Acidic, and
b. Blue in Alkaline

Comparison between Plant and Animal Cells

Point of Comparisons	Plant Cell	Animal Cell
Centrioles	Do not exist	Exist
Plastids	Exist	Do not exist
Cellulosic Cell Wall	Exist	Do not exist
Plasma Membrane	They Both have plasma membranes	
Size	They range from 1µm to less than 1cm	

Methods Of Studying Cells

The Possibility Of Cell Cultivation In Laboratory:

1. It can be cultivated on nutrient media of:

    - Blood Plasma - Embryonic tissues -Salts &vitamins

2. The nutrient media is either liquid or solid (by adding agar)

3. The media is then sterilized to be used later.

Cell Microscopic Examination:

Chemical fixation of the tissue to stabilize the specimen's mobile macromolecular structure.

The tissue is sectioned into thin slices using a microtome.

A slice is then placed in a glass slide and covered by a thin cover; to be examined later under the microscope.

Parts of the cell can be stained (i.e. nucleus or mitochondria).

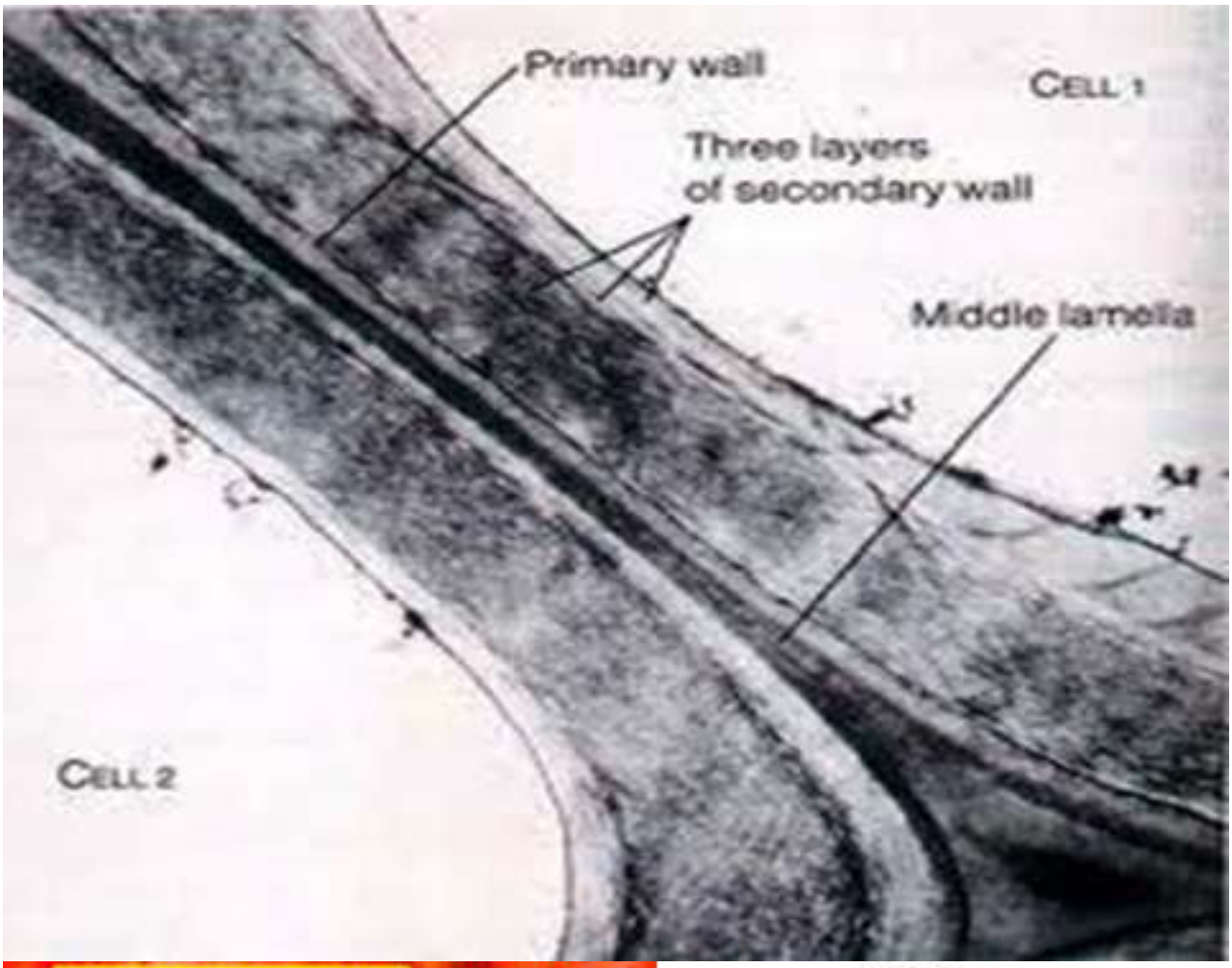
Using the electron microscope, the tissue is fixed by Osmic acid and embedded in acrylic plastic or resin to be sectioned by an ultra-microtome with glass or diamond.

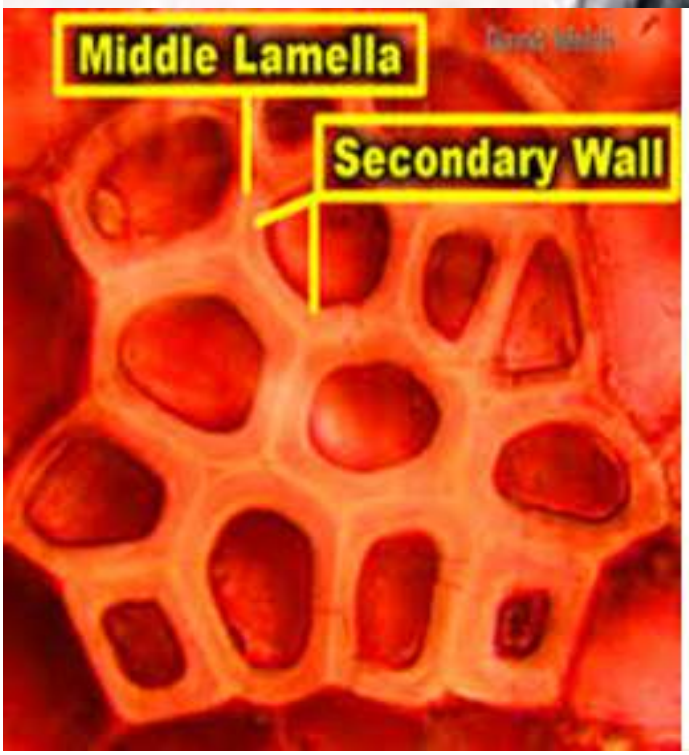
Electron Microscopy revealed the following:

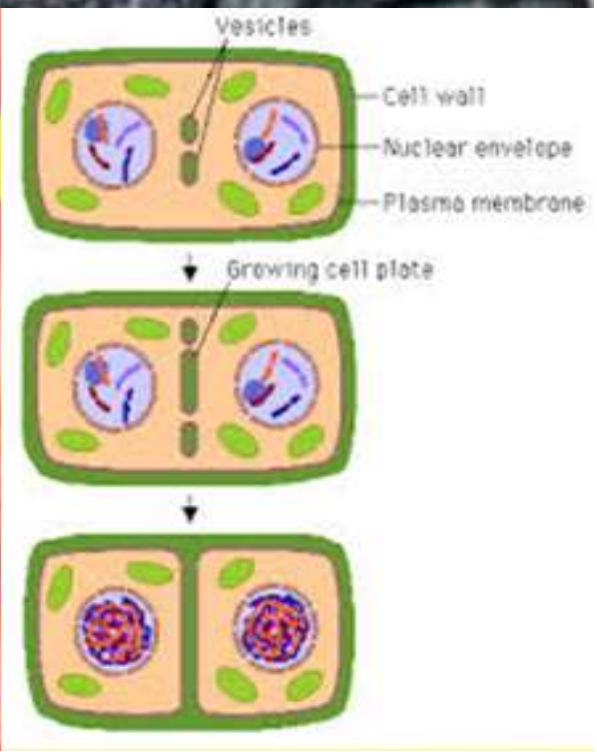
A skeletal network of cellulose in the form of bundles -with spaces in between- Cell wall: they are first collected as **microfibrils** then are gathered to form **macrofibrils** in the secondary cell walls. In these spaces different materials are deposited according to the type of wall as well as cell type and age.

Examples of which are:

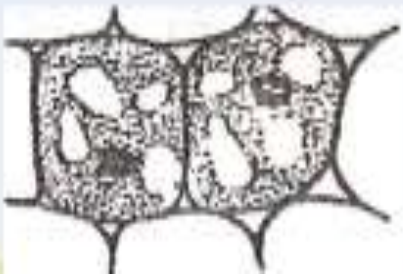
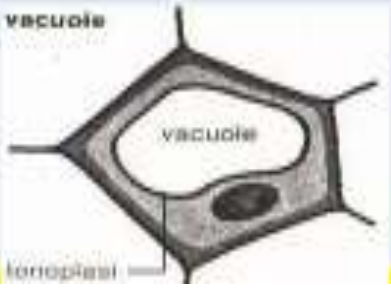
1. Primary cell walls are filled with Ca- and Mg- pectates.
2. Xylem Vessels are filled with lignin.
3. Epidermal Cell wall is filled with Cutin (impermeable to water)
4. Phellem is filled with Suberin (impermeable to water).
5. While Root Cell Wall -in secondary cell wall- is filled with water, like those in cotton plant.


Primary wall
CELL 1
Three layers
of secondary wall
Middle lamella
CELL 2


Middle Lamella
Secondary Wall

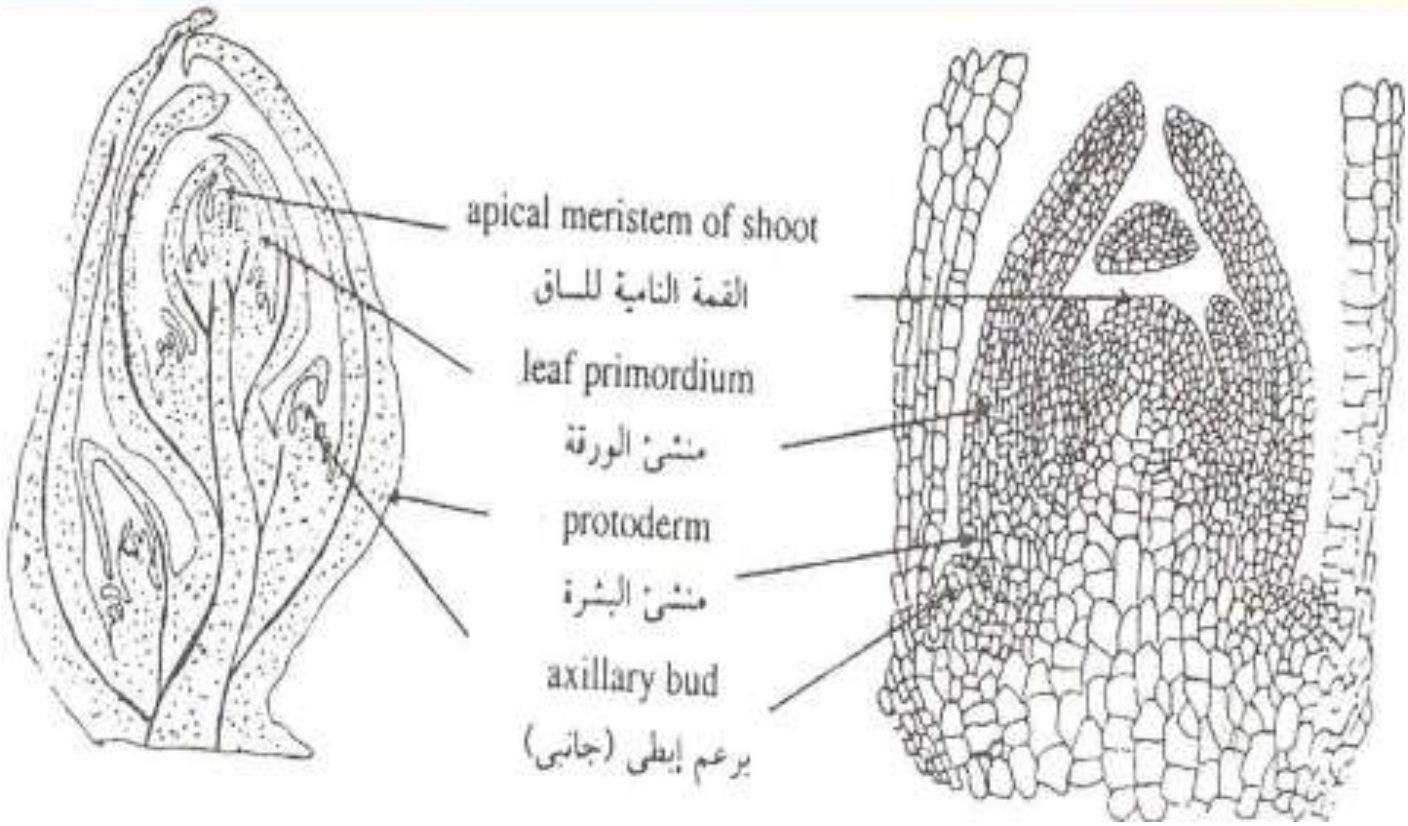

Vesicles
Cell wall
Nuclear envelope
Plasma membrane
Growing cell plate

Comparison Between *Meristematic* and Permanent Tissues

Points of Comparison	*Meristematic* Tissue	Permanent Tissue
Size	Small	large
Cell Wall	Thin	Thick
Vacuole	Does not exist and if found are small and scattered	Large
Intercellular Spaces	Exist	Does not exist
Cell Division	Divisible	Lost its ability to divide
Nucleus	Small & lateral	Large & Central
Nature	Subdivided into primary and secondary	-------
Shape		

1. Primary *Meristematic* Tissue

1. It includes the whole "**Embryo**": the root and stem Apices, leaf primordia as well as bases of the internodes.



The term "meristem" was coined in 1858 by Karl Wilhelm von Nägeli. The term is adapted from the Greek word "merizein," meaning "to divide," a reference to the function of the cells in the meristematic tissue. Characteristics of Meristematic Plant Tissue

The Cells Within the Meristem Have Some Unique Characteristics:

Cells within the meristematic tissues are self-renewing, so that each time they divide, one cell remains identical to the parent while the other can specialize and become part of another plant structure. The meristematic tissue is therefore self-sustaining.

While other plant tissues can be made of both living and dead cells, the meristematic cells are all living and contain a large ratio of dense liquid.

When a plant is injured, it is the undifferentiated meristematic cells that are responsible for healing the wounds through the process of becoming specialized.

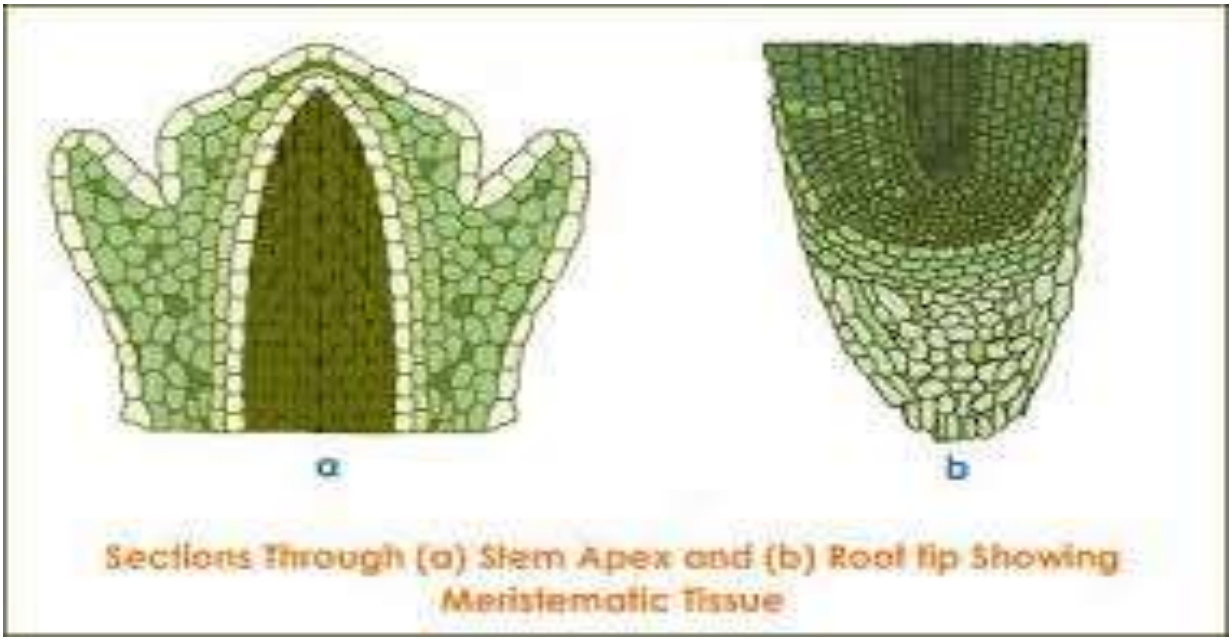
Types of Meristematic Tissue

There are three types of meristematic tissues, categorized according to where they appear in the plant: "apical" (at the tips), "intercalary" (at the middle), and "lateral" (at the sides).

The apical meristematic tissues: are also known as "**Primary Meristematic Tissues**," because these are what form the main body of the plant, allowing for vertical growth of stems, shoots, and roots. The primary meristem is what sends a plant's shoots reaching for the sky and the roots burrowing into the soil.

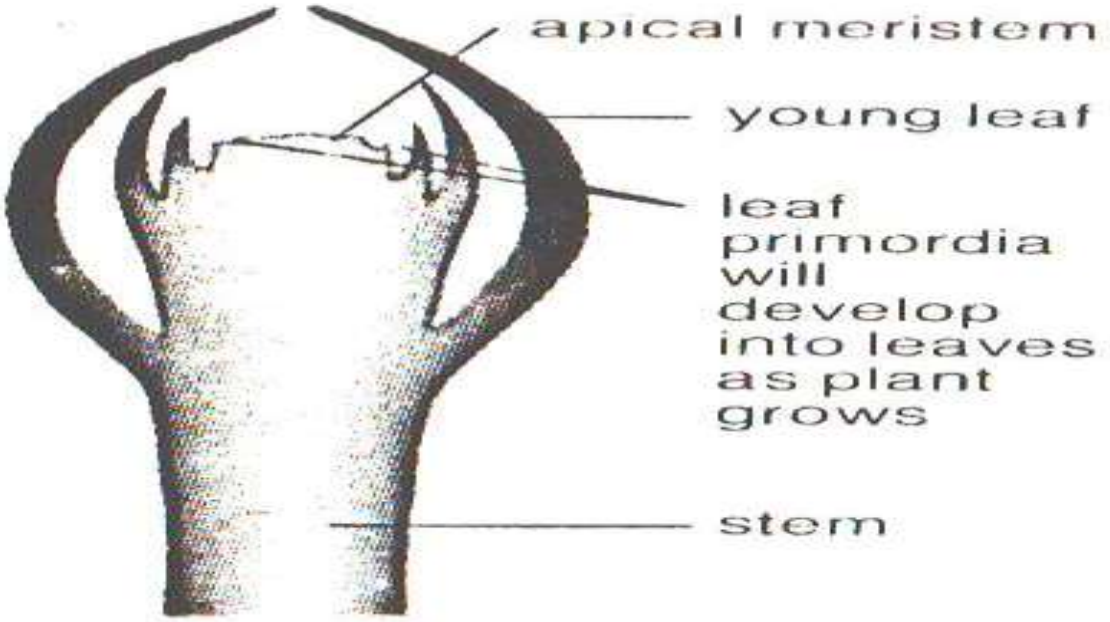
Lateral meristems are known as "**Secondary Meristematic Tissues**" because they are what is responsible for an increase in girth. The secondary meristematic tissue is what increases the diameter of tree trunks and branches, as well as the tissue that forms bark.

Intercalary meristems occur only in plants that are monocots, a group that includes the grasses and bamboos. Intercalary tissues located at the nodes of these plants allow the stems to regrow. It is intercalary tissue that causes grass leaves to grow back so quickly after being mowed or grazed.

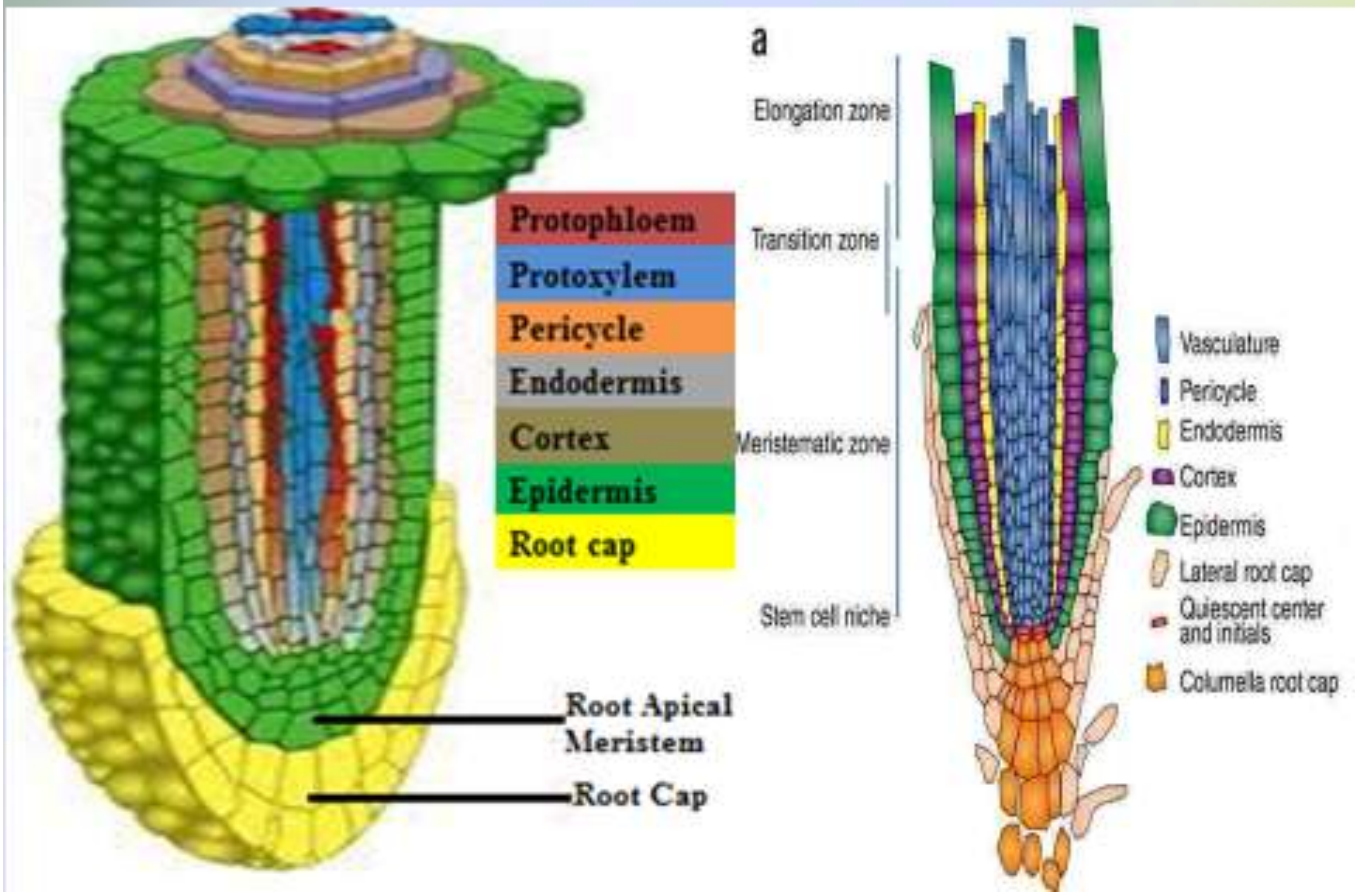


Sections Through (a) Stem Apex and (b) Root tip Showing Meristematic Tissue

primordium
L.S. through dicotyledon shoot tip



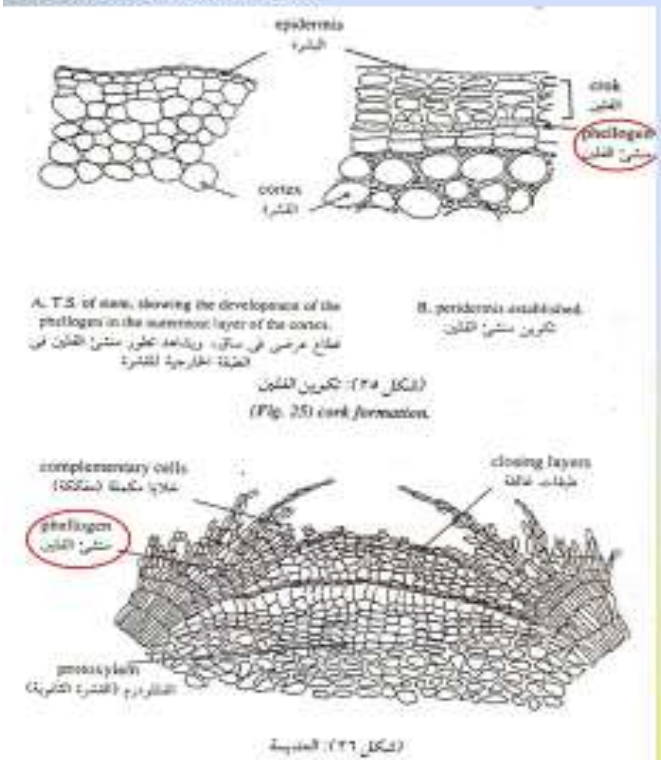
1. Primary *Meristematic* Tissue: Root Apex



2. Secondary *Meristematic* Tissues

It is formed from primary meristems that lost its ability to divide for sometime and gained it back. **Examples:**

1. Cork Cambium

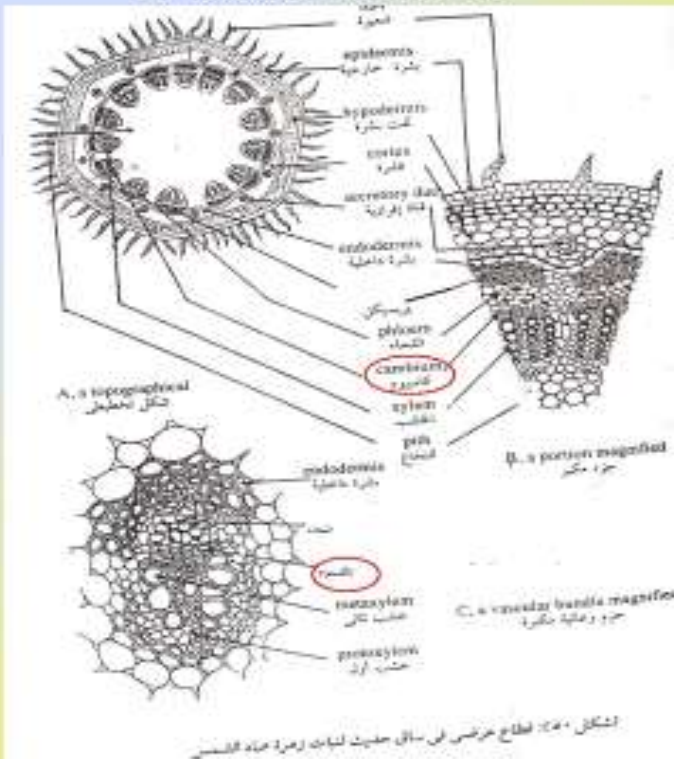


A. T.S. of stem, showing the development of the phellogen in the outermost layer of the cortex. B. periderm established.

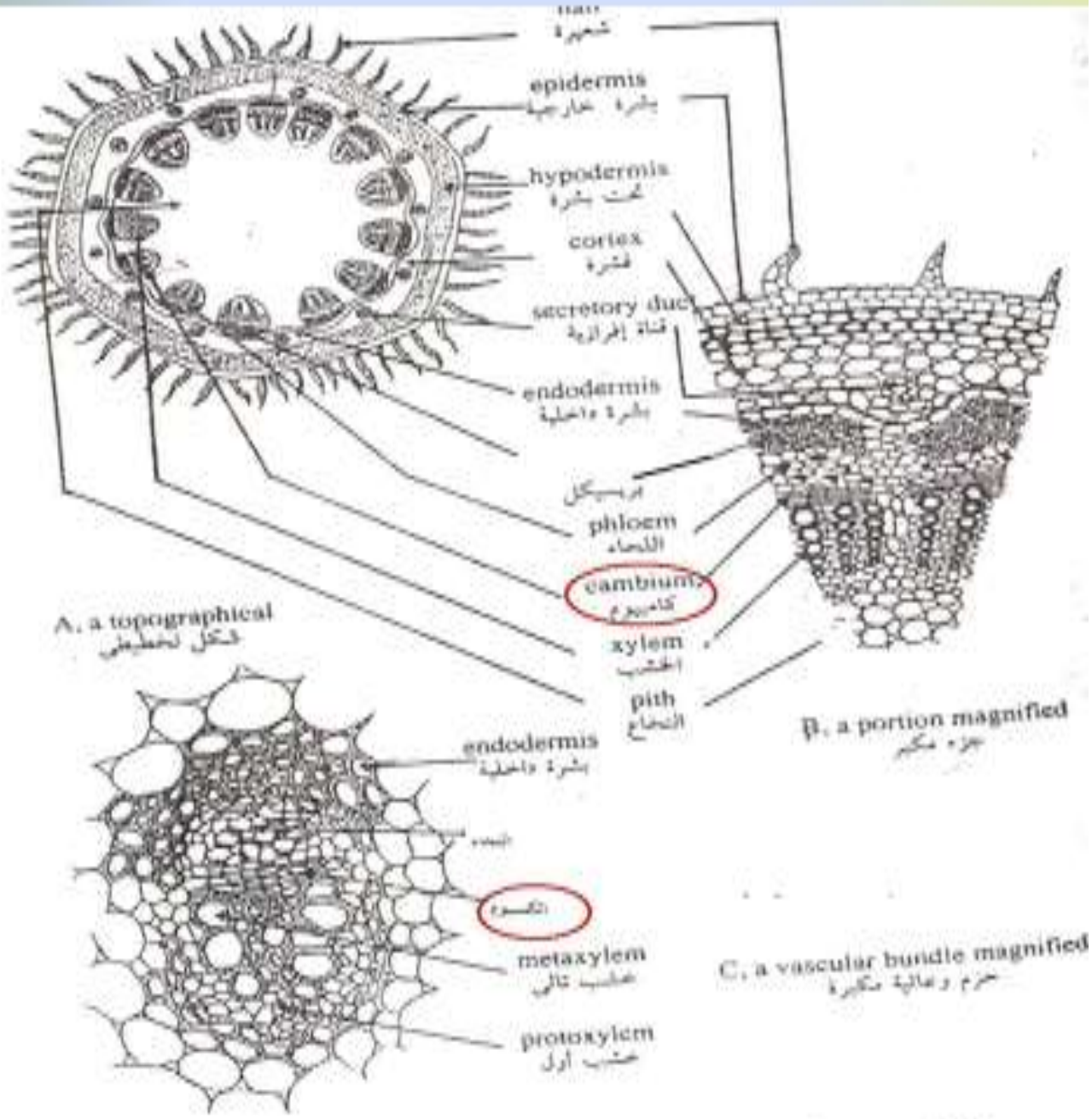
(شكل ٢٥): تكوين الفلين

(Fig. 25) cork formation.

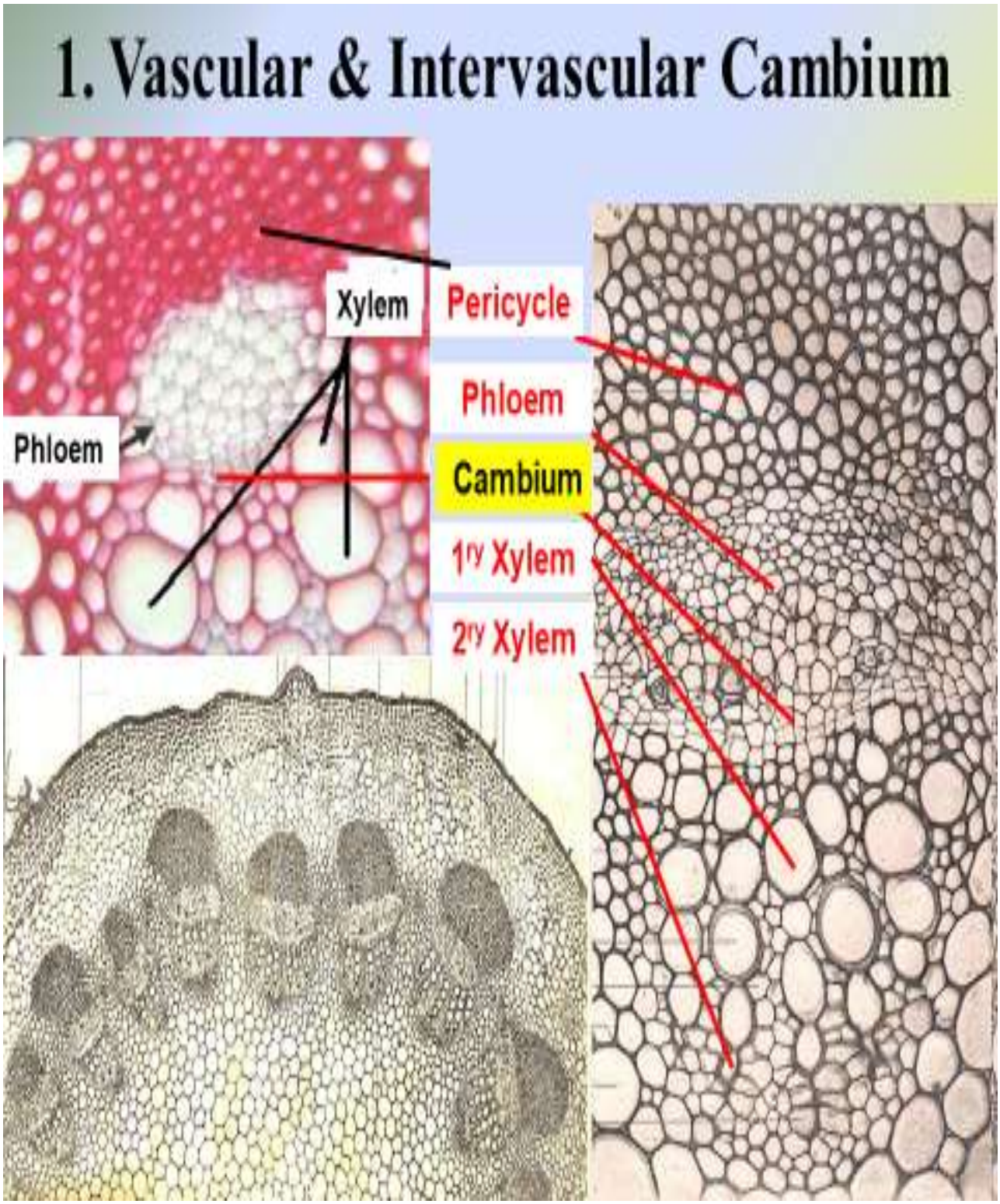
2. Vascular Cambium



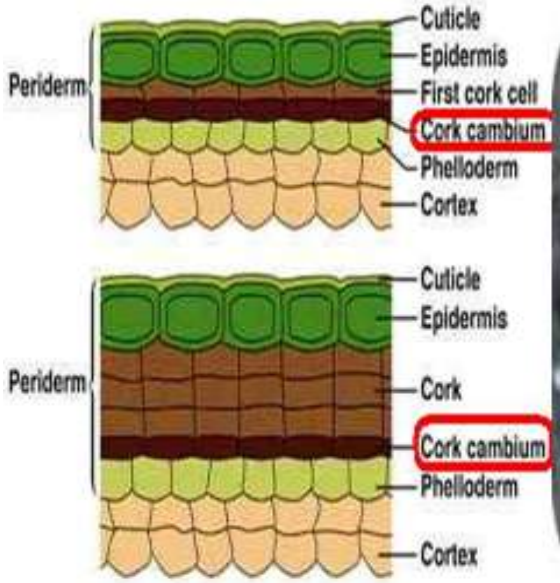
1. Vascular & Intervascular Cambium



(شكل ٥٠): قطاع عرضي في ساق حديث لنبات زهرة عباد الشمس


1. Vascular & Intervascular Cambium
Xylem
Pericycle
Phloem
Phloem
Cambium
1ry Xylem
2ry Xylem

2. Cork Cambium



Tissue Systems

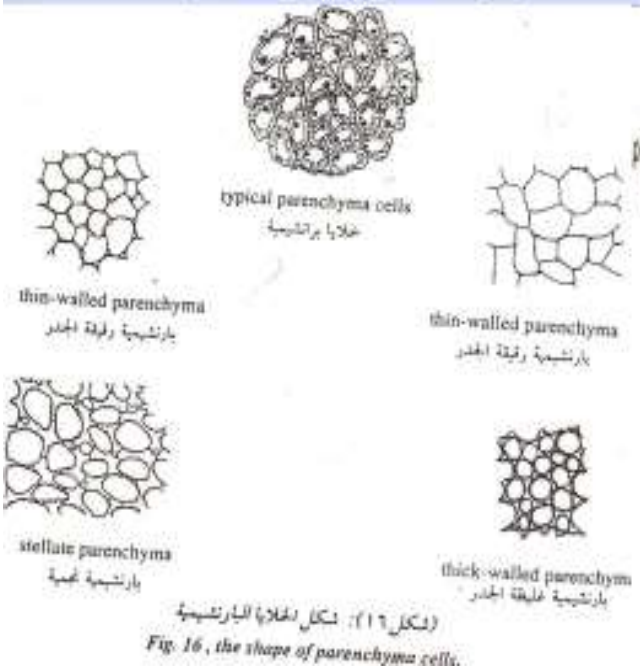
It is divided into three groups:

1. Ground Tissue **2. Epidermal Tissue** **3. Vascular Tissue**

1. Ground Tissue: *Parenchyma, Collenchyma, Sclerenchyma* and Secretory tissues.

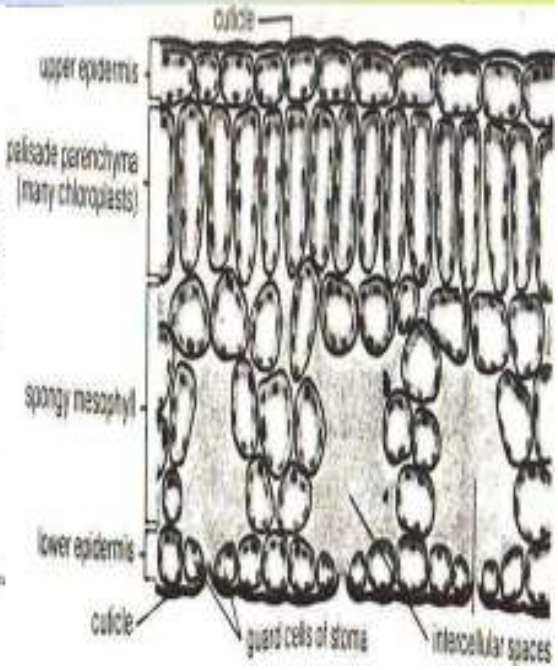
A) *Parenchyma*: Thin cellulosic cell wall, types of which are:

- *Chlorenchyma*: contains Chlorophyll -*Aerenchyma*: contain intercellular spaces



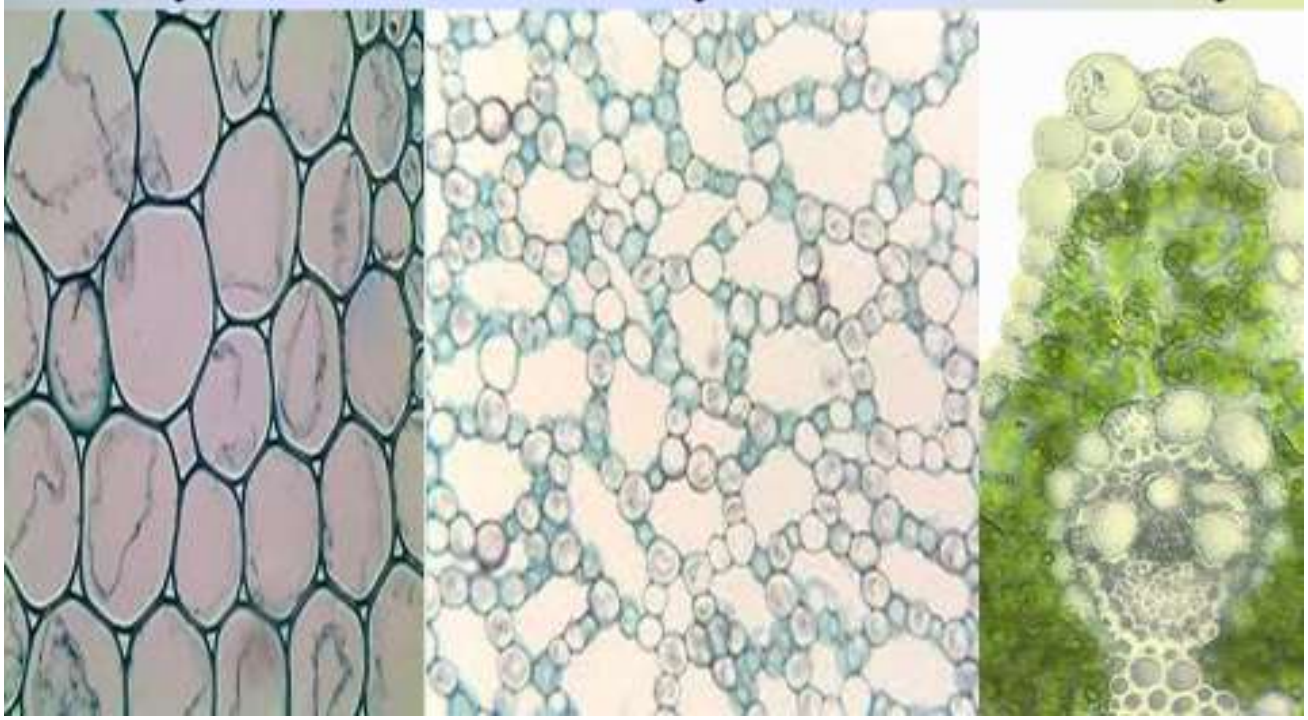
(شكل ١٦): شكل لخلايا البارنشيمية

Fig. 16, the shape of parenchyma cells.



A. *Parenchyma*

Parenchyma ***Aerenchyma*** ***Chlorenchyma***

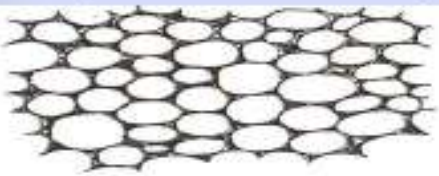


Tissue System: 1. Ground Tissue

B. Collenchyma: According to the quantity and position of cellulosic thickening, *Collenchyma* are of various types:

1. Angular 2. Lamellar 3. Lacunar 4. Annular

- It provides the tissue (stems and leaves) with elasticity and strength.



angular collenchyma
كولنشيمة ركنية

lamellar collenchyma
كولنشيمة صفيحية

annular collenchyma
كولنشيمة حلقية

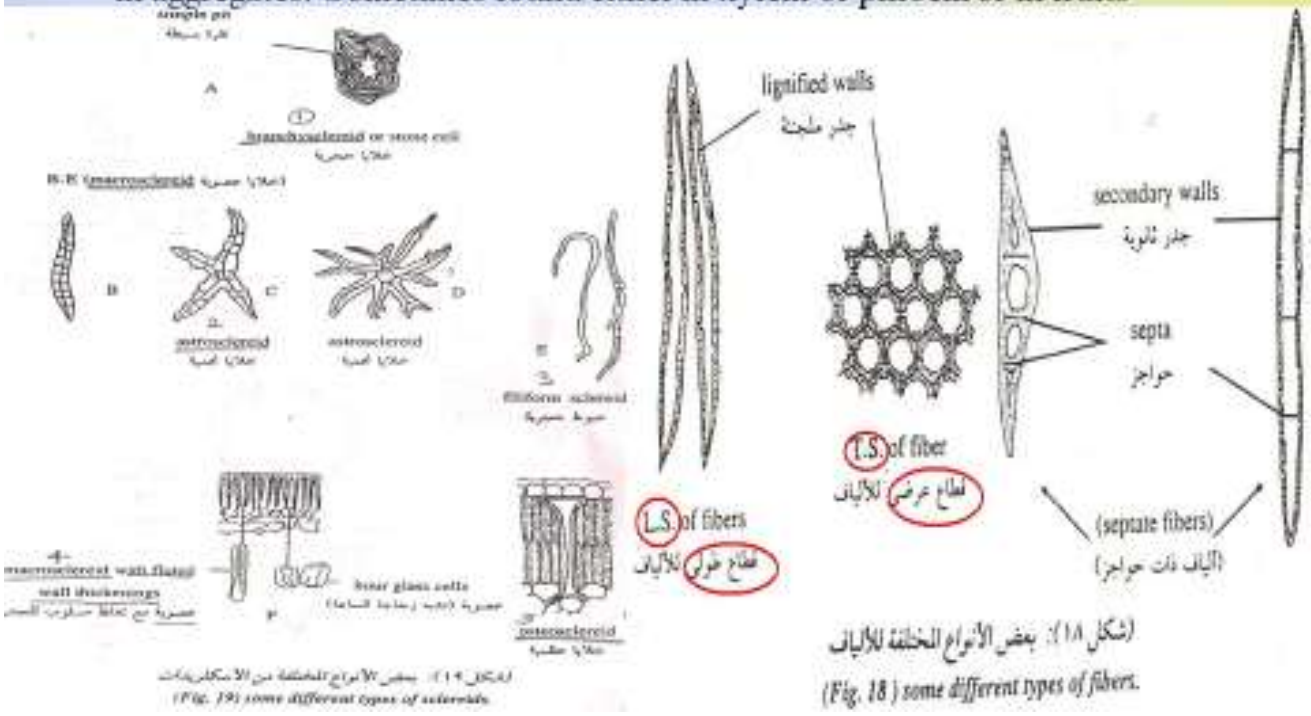
lacunar collenchyma
كولنشيمة فجوية

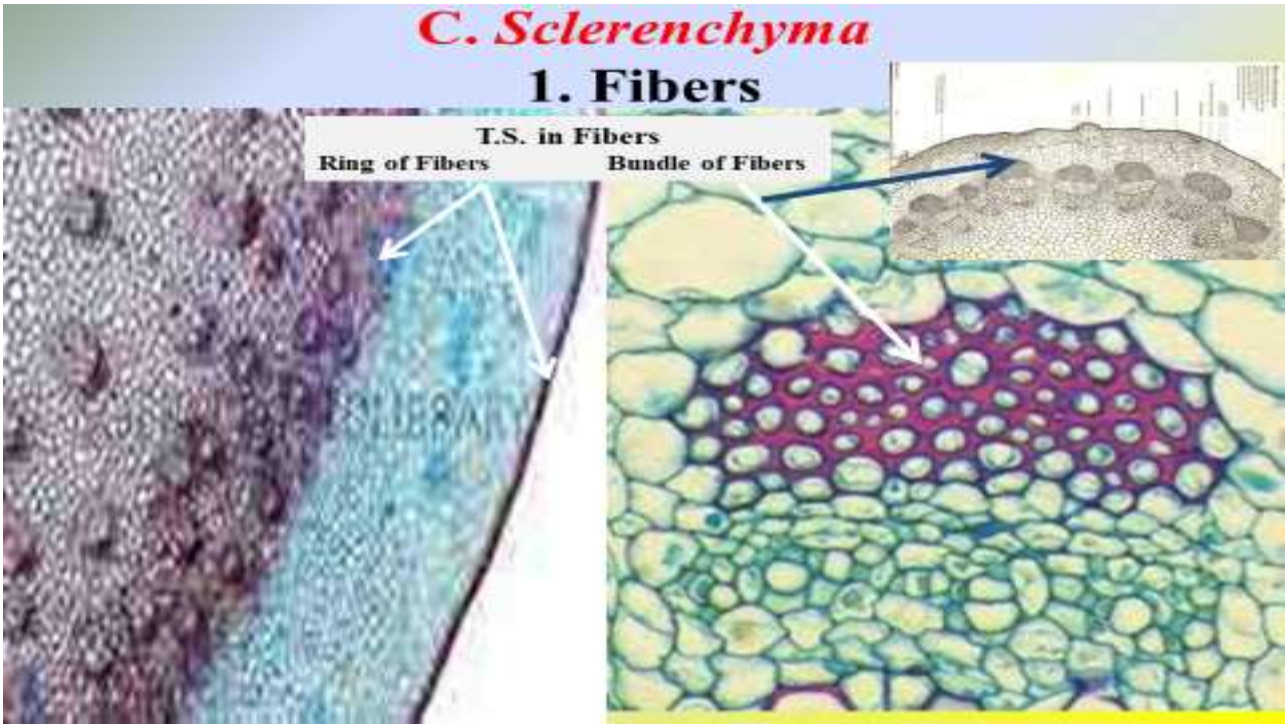
(شكل ١٧): الأنواع المختلفة من النسيج الكلنشيمي
(Fig. 17) different types of collenchyma.

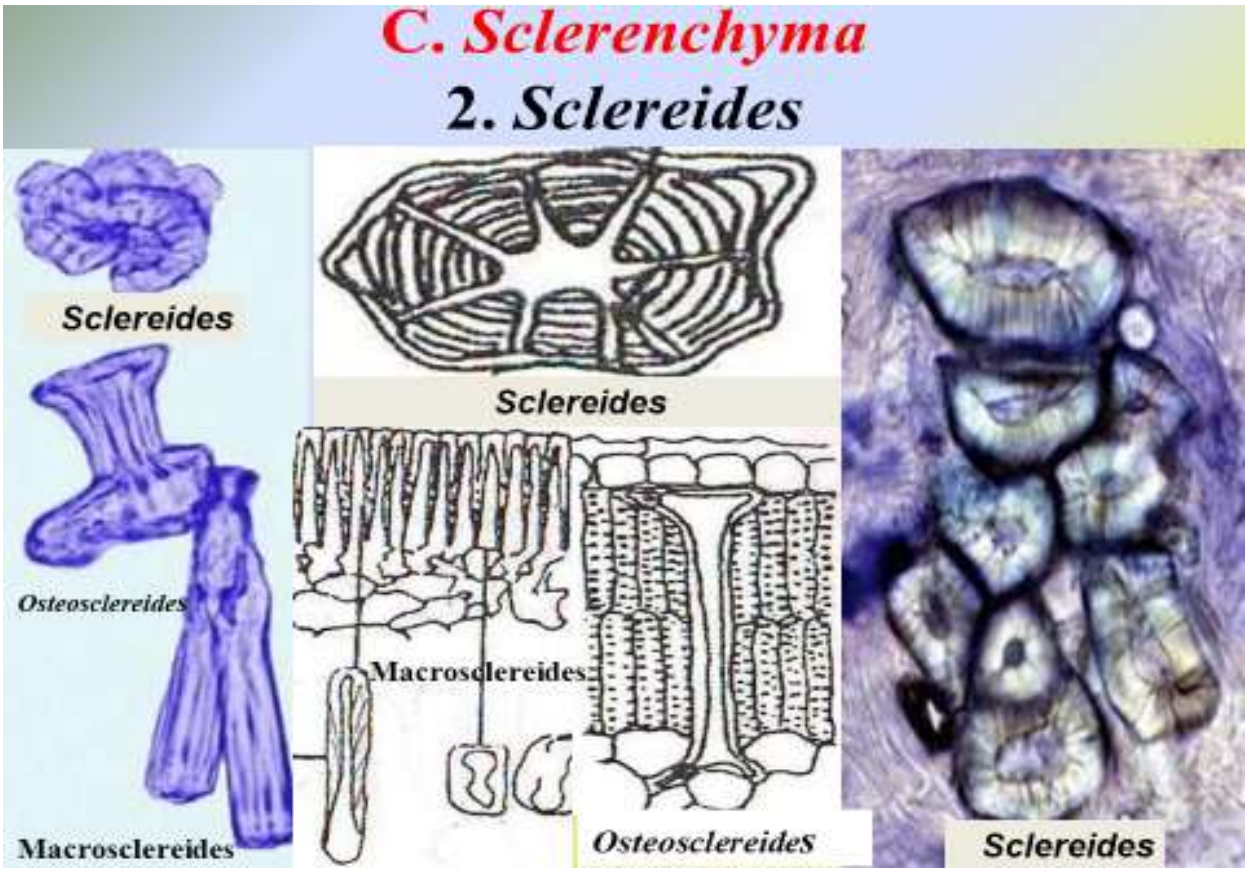
Tissue System: 1. Ground Tissue

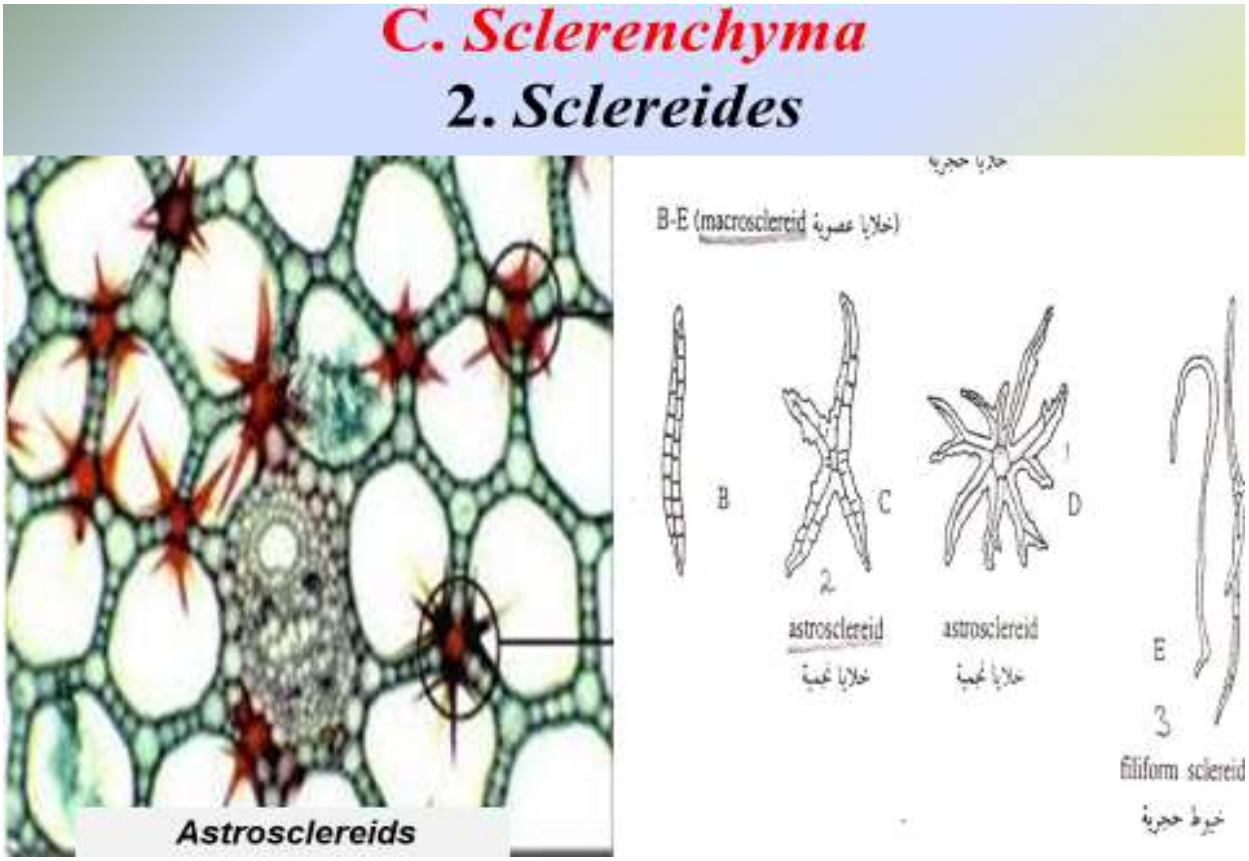
***C. Sclerenchyma* fibers:** They provide strength to the plant body. They are mostly dead tissues, thickened with lignin. They are of two types:

1. **Fibers:** Their walls are lignified in an **early** stage in the form of: Ring or Bundle
2. **Sclereides:** Their walls are lignified in a **later** stage. They are found in solitary or in aggregates. Sometimes found either in xylem or phloem or in fruits





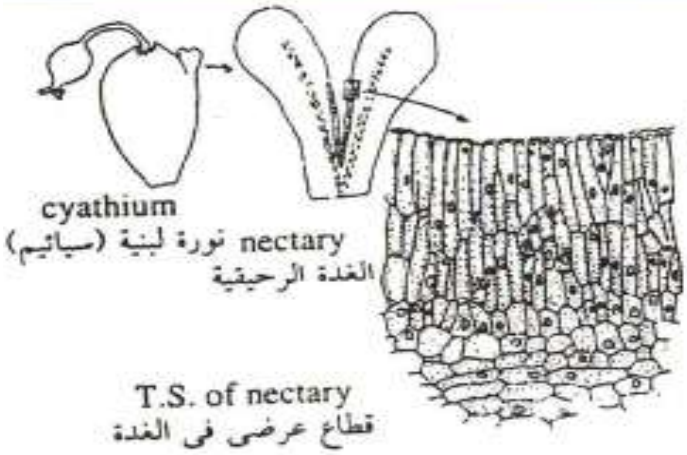

C. Sclerenchyma
2. Sclereides
Sclereides
Sclereides
Osteosclereides
Macrosclereides
Macrosclereides
Osteosclereides
Sclereides


C. Sclerenchyma
2. Sclereides
Astrosclereids
B-E (macrosclereid خلايا عصوية)
B
C
D
E
2
astrosclereid
خلايا نجمية
astrosclereid
خلايا نجمية
3
filiform sclereid
خيوط حجرية

Tissue System: 1. Ground Tissue

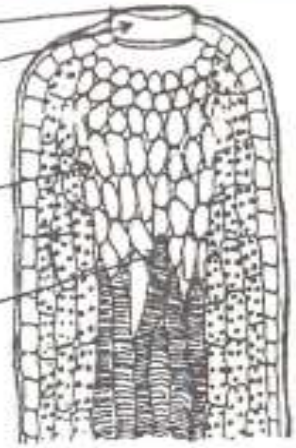
4. Secretory Tissues: They are of two types: 1. External 2. Internal

1. External Secretory Tissues: Examples of which are; **nectar glands** (flowers), **Hydathodes** on leaf margins, (**Guttation**) and **glandular hairs** (Tentacles in insectivorous plants).



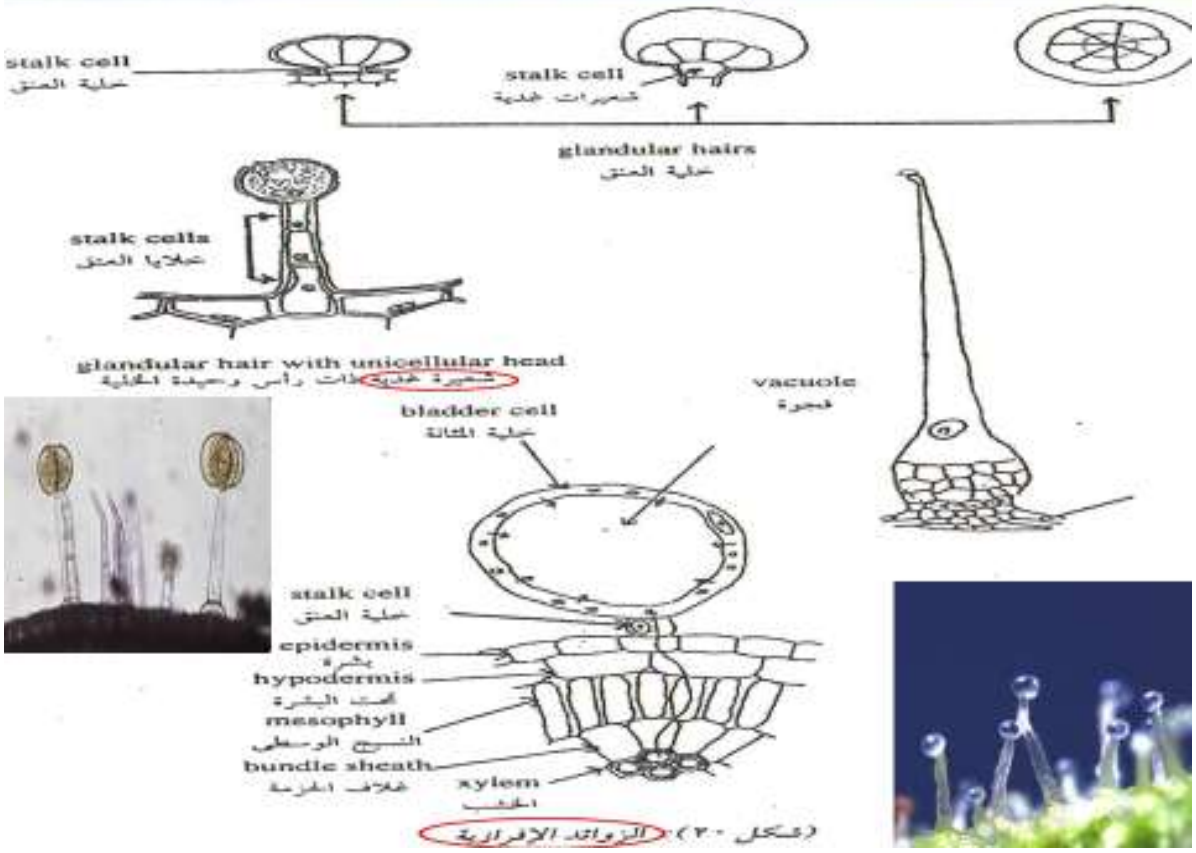
تابع (شكل ٢٠ب): غدة زهرية

(Fig. 20 b) floral nectary.



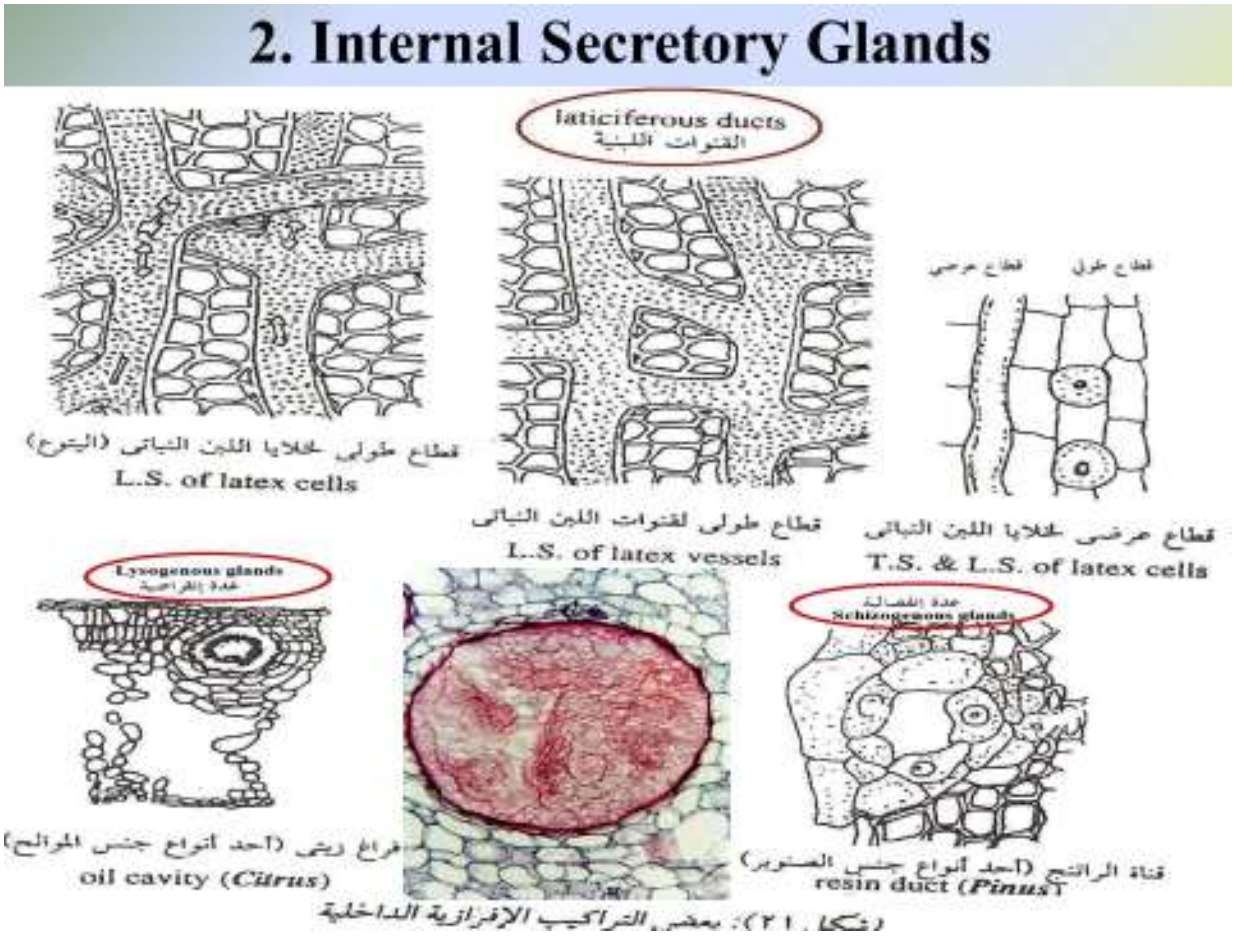
تابع (شكل ٢٠ أ) : الثغر المائى

1. External Secretory Glands



2. **<u>Internal Secretory Glands:</u>** Vacuoles inside the tissues; they are of three types according to their origin:

- **Lysogenous glands:** They are originated by the disintegration and dissolution (autolysis) of the glandular cells. *i.e.* Citrus fruits
- **Schizogenous glands:** They are commonly produced by the separation of cells of vascular tissues or ground tissues, resulting in an intercellular space lined with secretory epithelial cells, <u>thus the vacuoles appear more regular than the Lysogenic glands</u> *i.e. resin ducts*
- **Laticiferous glands:** They refer to individual cells or groups of connected cells containing a liquid called **Latex**. When formed of several cells, they can produce complex tube-like structures. They are classified into two types:
    1. **Articulated:** Longitudinal chains of connected cells**.**
    2. **Non-articulated**: A long tube like single cells

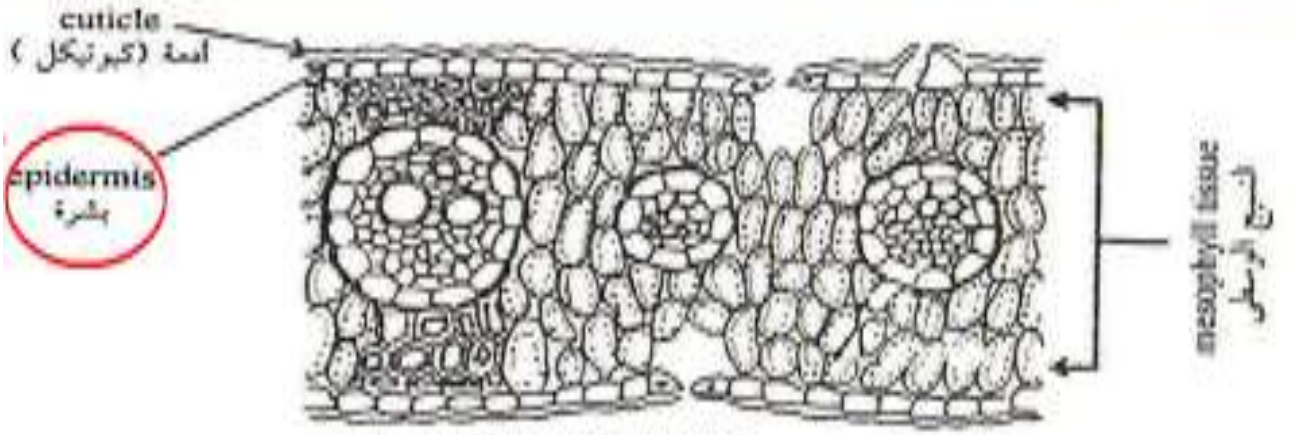


Tissue System: 2. Epidermal Tissue

- One or more layers surround plant body to protect it against external factors.

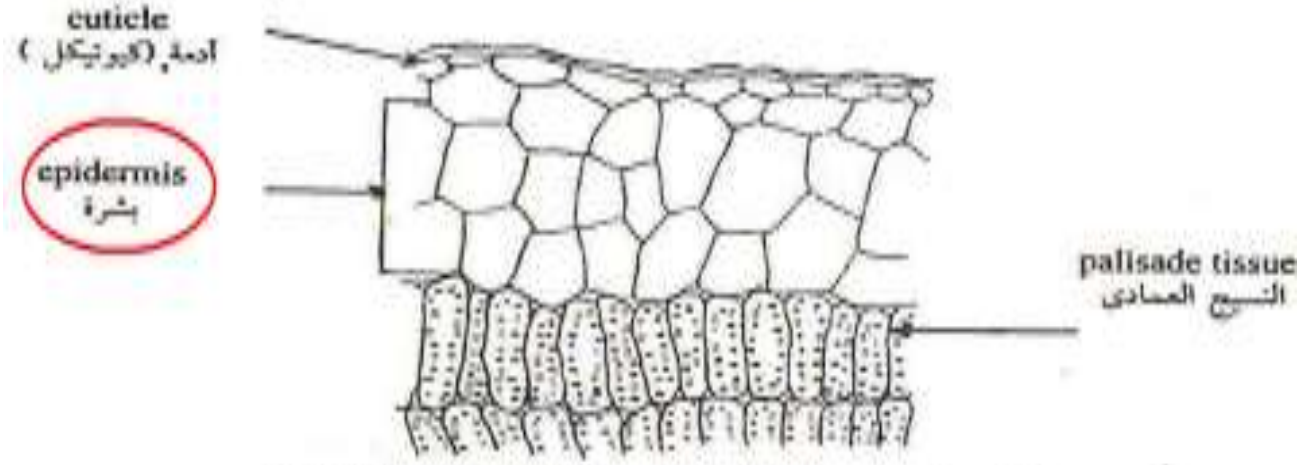
1. Epidermis: 1ry permanent tissue of **uni** or multilayered cells covered by cuticle.

2. Periderm: 2ry tissue found in **older** roots and stems replacing the epidermis when it is torn away.



قطاع عرضي في ورقة نبات الذرة ليبان البشرة البسيطة

T.S. of ***Zea mays*** leaf, showing uniseriate



قطاع عرضي في ورقة نبات الفيكس المطاط ليبان البشرة المتضاعفة

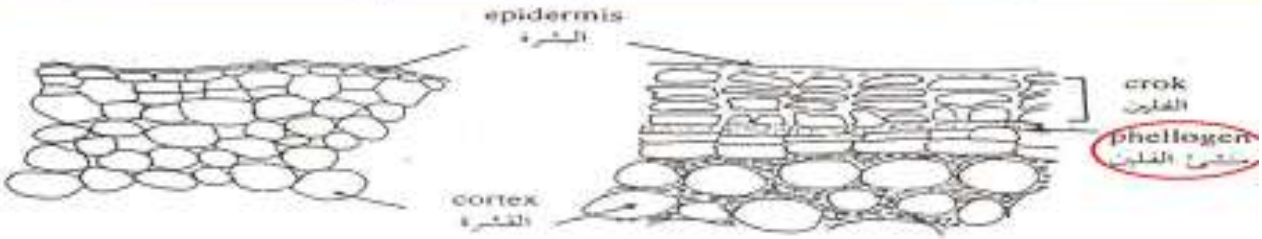
T.S. of ***Ficus elastica***
leaf showing multiseriate epidermis

(شكل ٢٢): البشرة البسيطة والمتضاعفة

Tissue System: 2. Epidermal Tissue

B. *Periderm*

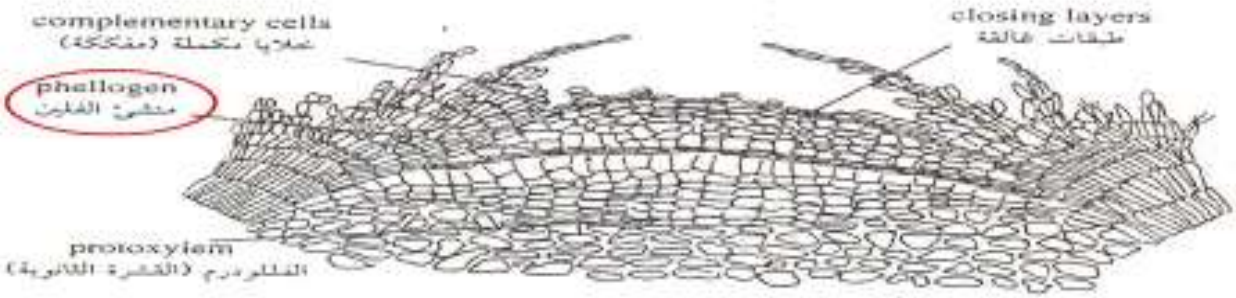
- **Lenticels:** Intercellular spaces within periderm for aeration, similar to stomata.



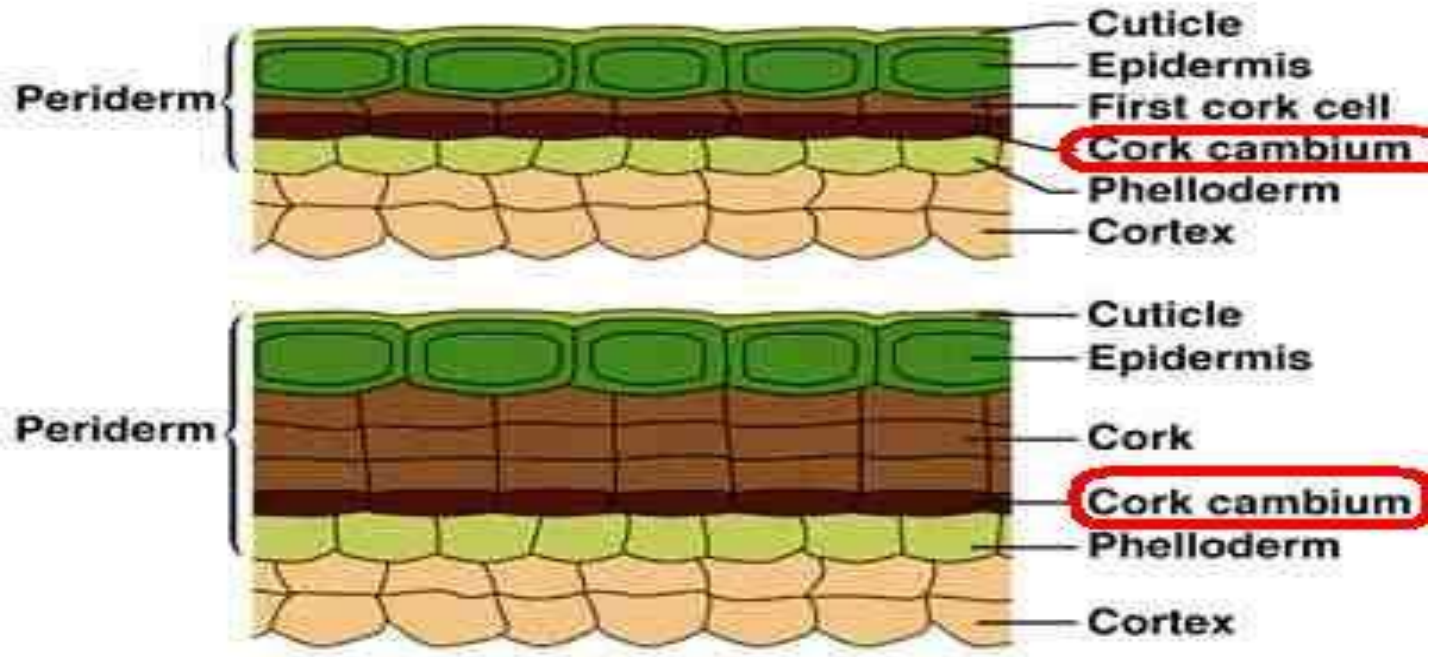
A. T.S. of stem, showing the development of the phellogen in the outermost layer of the cortex.
قطاع عرضي في ساق، ويشاهد تطور منشئ الفلين في الطبقة الخارجية للقشرة

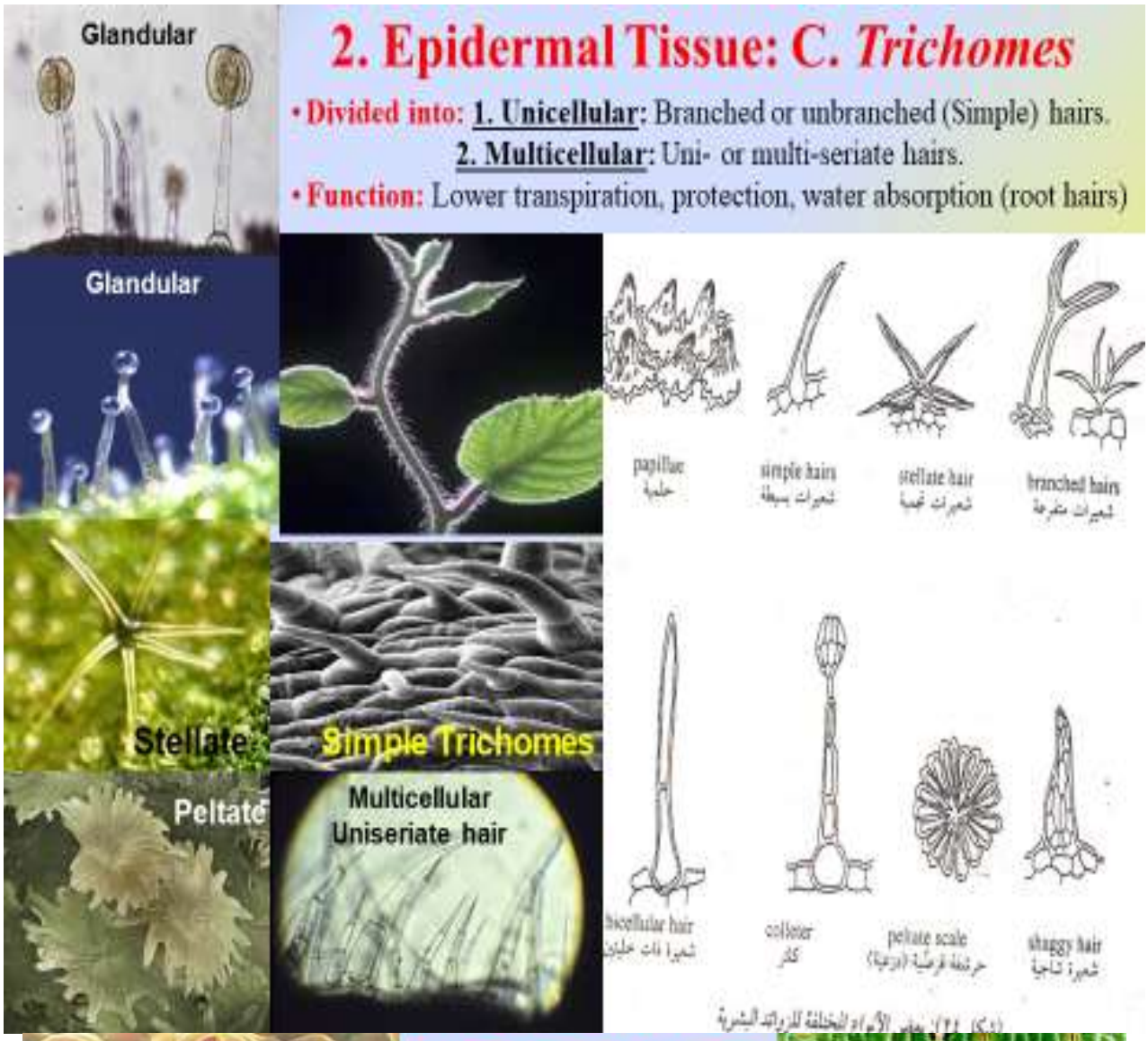
B. peridermis established.
تكوين منشئ الفلين

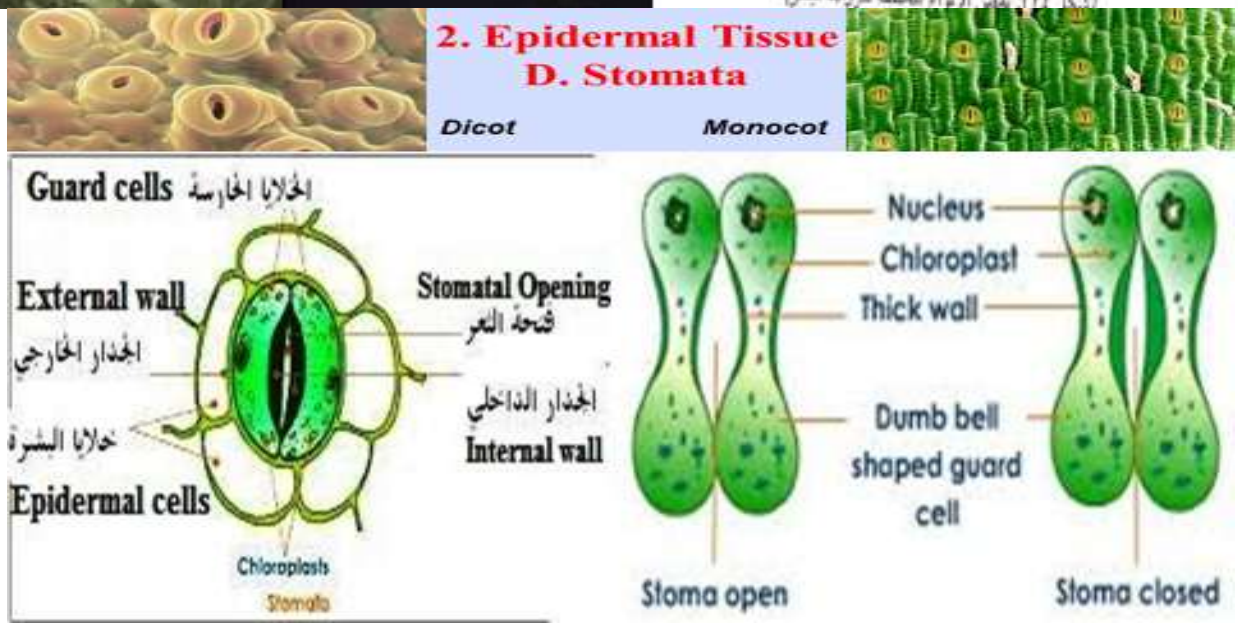
(شكل ٢٥): تكوين الفلين
(Fig. 25) cork formation.



(شكل ٢٦): العديسة

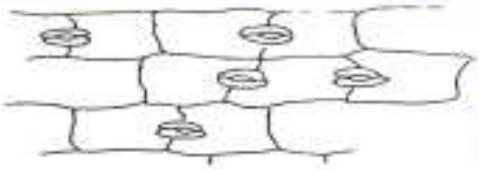



Glandular
2. Epidermal Tissue: C. Trichomes
• Divided into: 1. Unicellular: Branched or unbranched (Simple) hairs.
2. Multicellular: Uni- or multi-seriate hairs.
• Function: Lower transpiration, protection, water absorption (root hairs)
Glandular
papillae
حلمية
simple hairs
شعيرات بسيطة
stellate hair
شعيرات نجمية
branched hairs
شعيرات متفرعة
Stellate
Simple Trichomes
Peltate
Multicellular
Uniseriate hair
bicellular hair
شعيرا ذات خليتين
collétor
كاثر
peltate scale
حرشفة قرصية (درقية)
shaggy hair
شعيرة تاجية

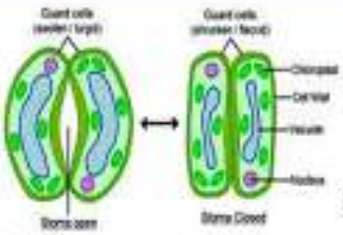

2. Epidermal Tissue
D. Stomata
Dicot
Monocot
Guard cells الخلايا الحارسة
External wall
الجدار الخارجي
Stomatal Opening
فتحة الثغر
الجدار الداخلي
Internal wall
خلايا البشرة
Epidermal cells
Chloroplasts
Stomata
Nucleus
Chloroplast
Thick wall
Dumb bell shaped guard cell
Stoma open
Stoma closed

Tissue System: 2. Epidermal Tissue
D. Stomata

- **Function:** 1.Gaseous exchange (photosynthesis& respiration).
  2. Getting rid of excess water by transpiration.
- **Opening & Closure of Stomata:** By changing cellular osmotic pressure.

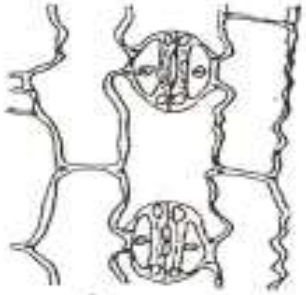


diacytic type (caryophyllaceous)
الطراز القنفلي

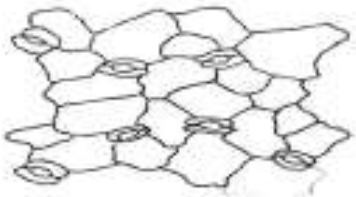


paracytic type (rubiaceous)
الطراز البني

anisocytic type (cruciferous)
الطراز الصليبي

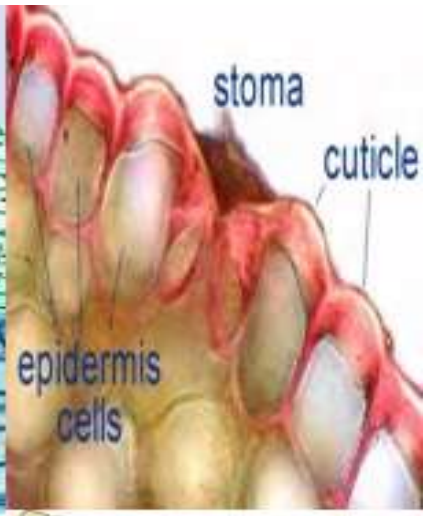


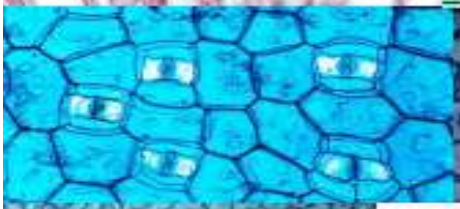
monocotyledous type
طراز الفلقة الواحدة

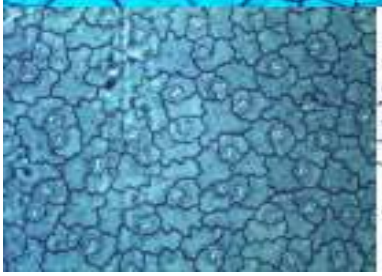


anomocytic type
(ranunculaceous)
الطراز الشقيقي

2. Epidermal Tissue
D. Stomata (*Dicots*)

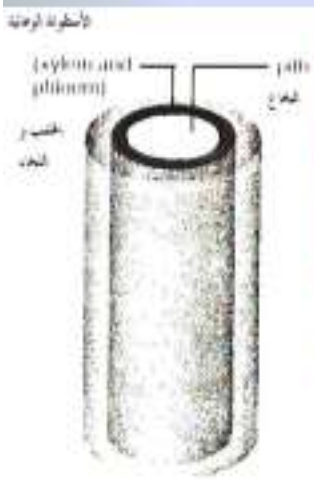


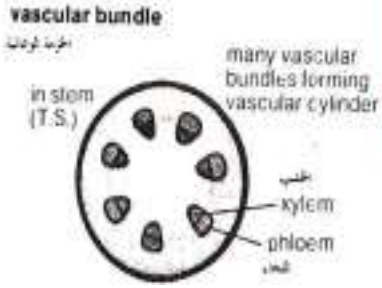


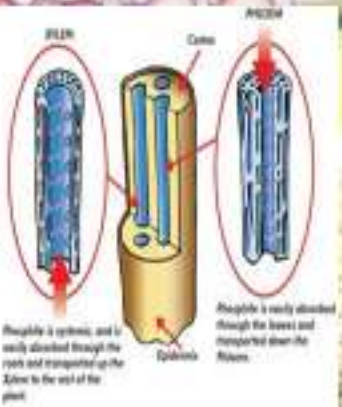


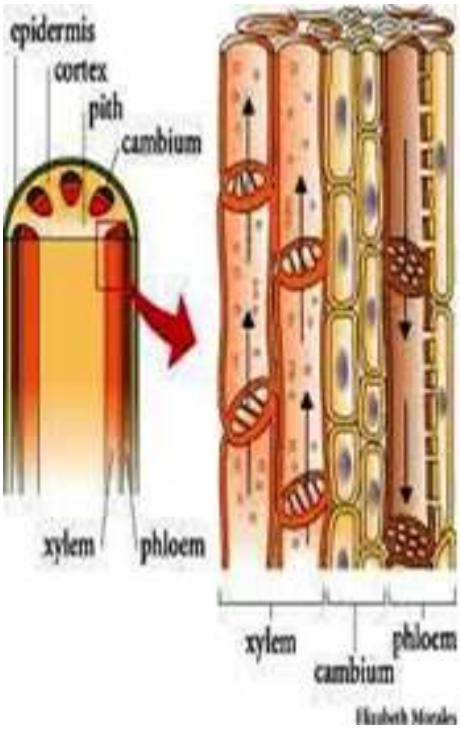
Tissue System: 3. Vascular Tissue

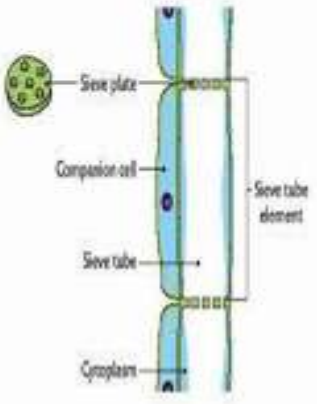
- **Vascular Tissue:** Conducting nutrients, water and minerals. Xylem & Phloem sap
- **Consists of:** 1. Xylem 2. Phloem

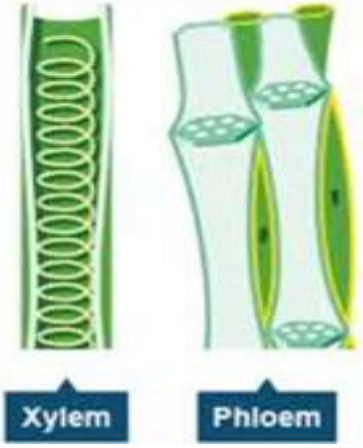












1. Xylem

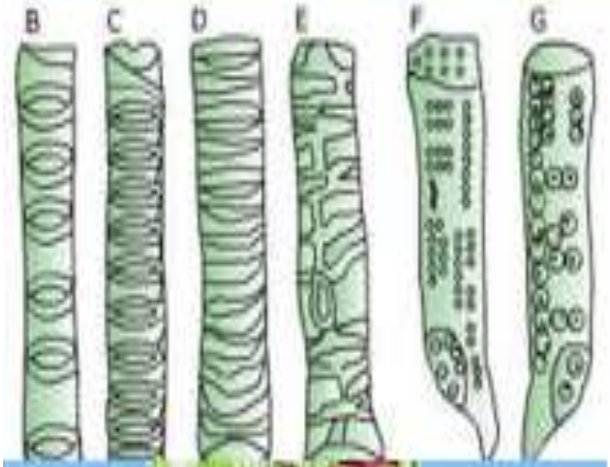
- **Consists of:** 1. Vessels 2. Tracheids 3. Fibers 4. Xylem parenchyma

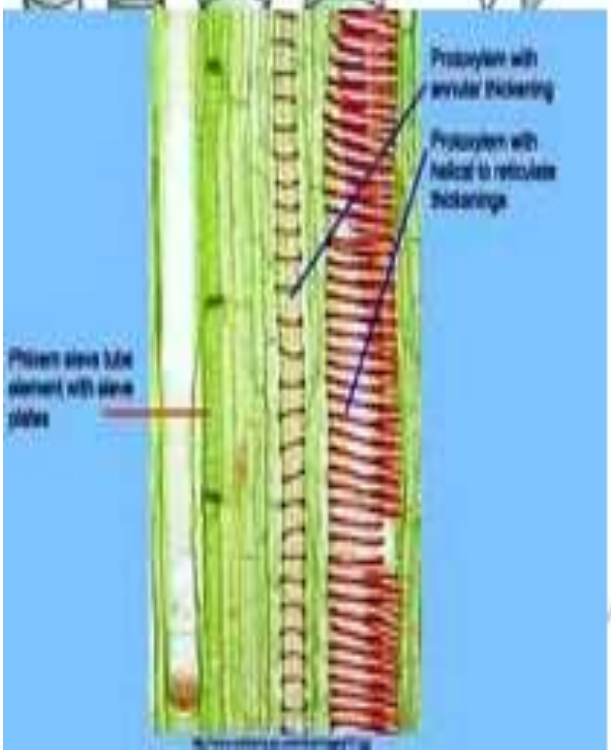
1. Vessels: Lignified walls: **1ry** (annular, spiral) **or** **2ry** (pitted, scalariform, reticulate).

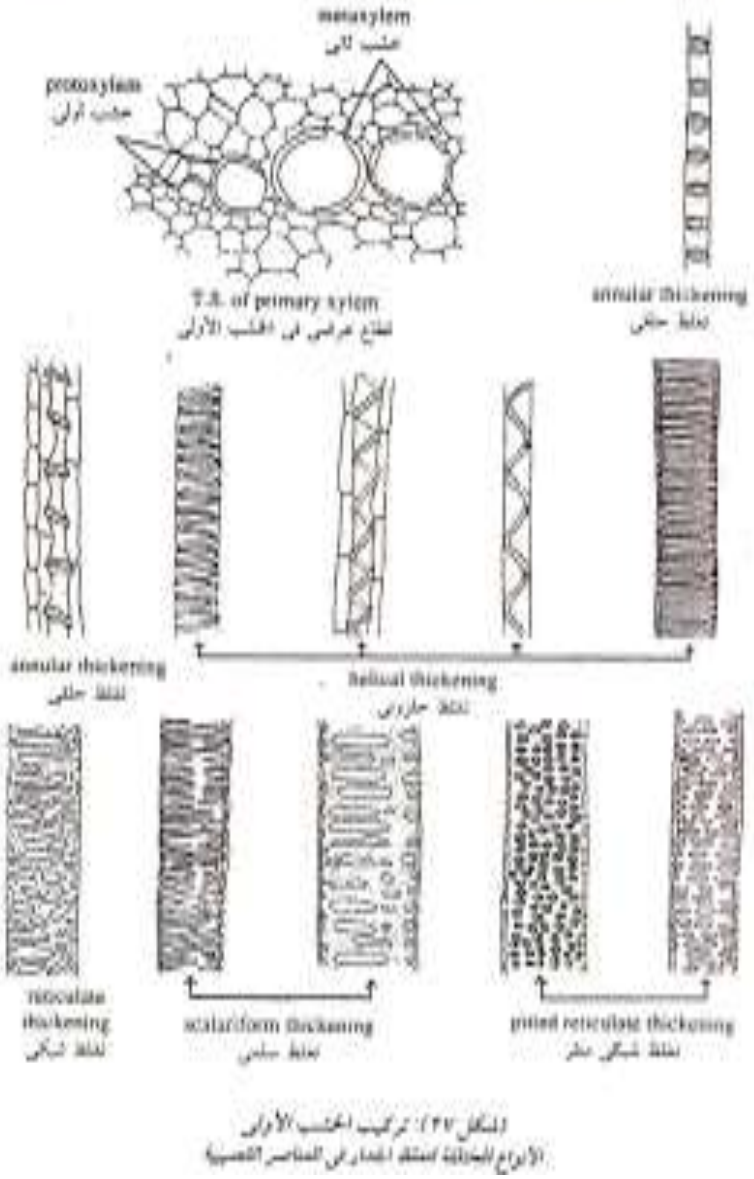
2. Tracheids: A dead lignified cell **3. Xylem parenchyma:** found with 1ry&2ry xylem

4. Fibers: **Lignified pointed pitted** cells, resemble sclerenchyma, found in old xylem.

Xylem vessels with tracheids have **lesser** fiber elements as fibers do the same function

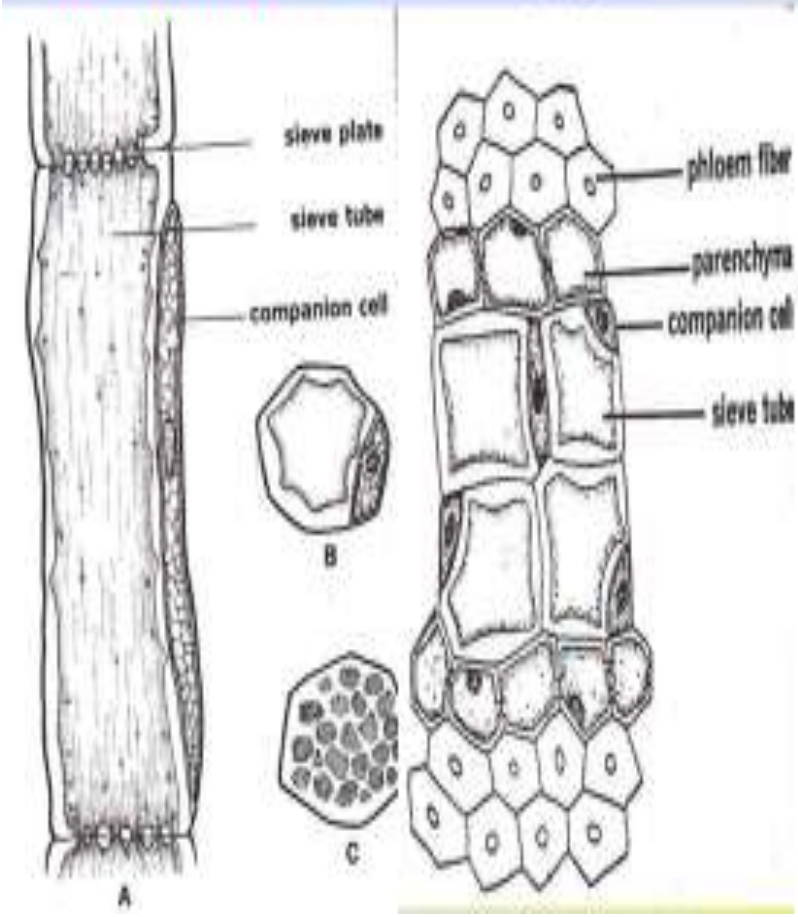


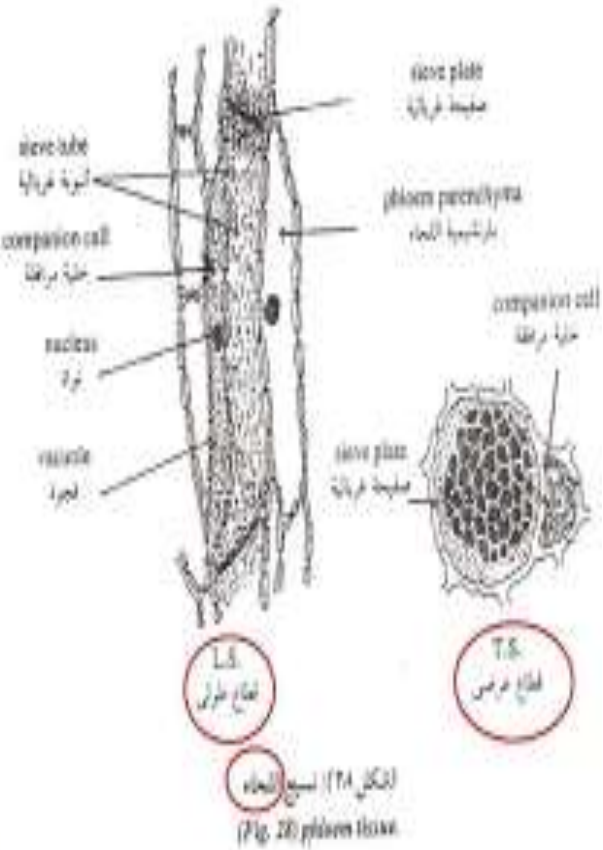




2. Phloem

- **Function:** Conducting nutrients from leaves to the rest of the plant body.
- **Consists of:**
  1. **Sieve tube:** Rectangular cellulosic thin walled perforated cells. Lost their nucleus during growth.
  2. **Companion cell:** the cell divides into two unequal cells, the larger becomes the sieve tube and the smaller is the companion cell.
  3. **Phloem parenchyma:** Store starch formed by photosynthesis.
  4. **Phloem fibers:** found in aging cells to strengthen the tissue

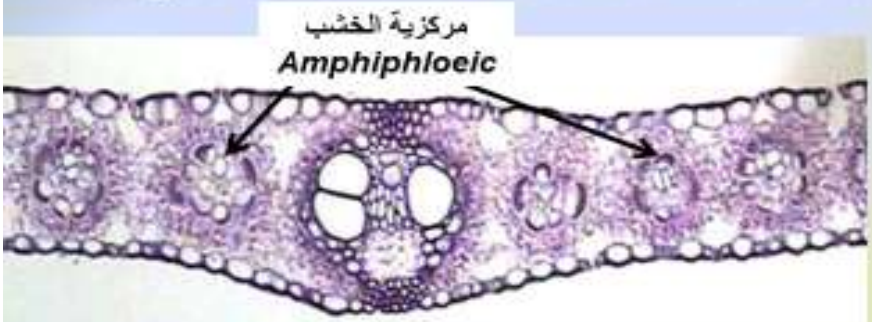




Vascular Tissues

- **It divides into:** **1.** Concentric **2.** Radial **3.** Collateral

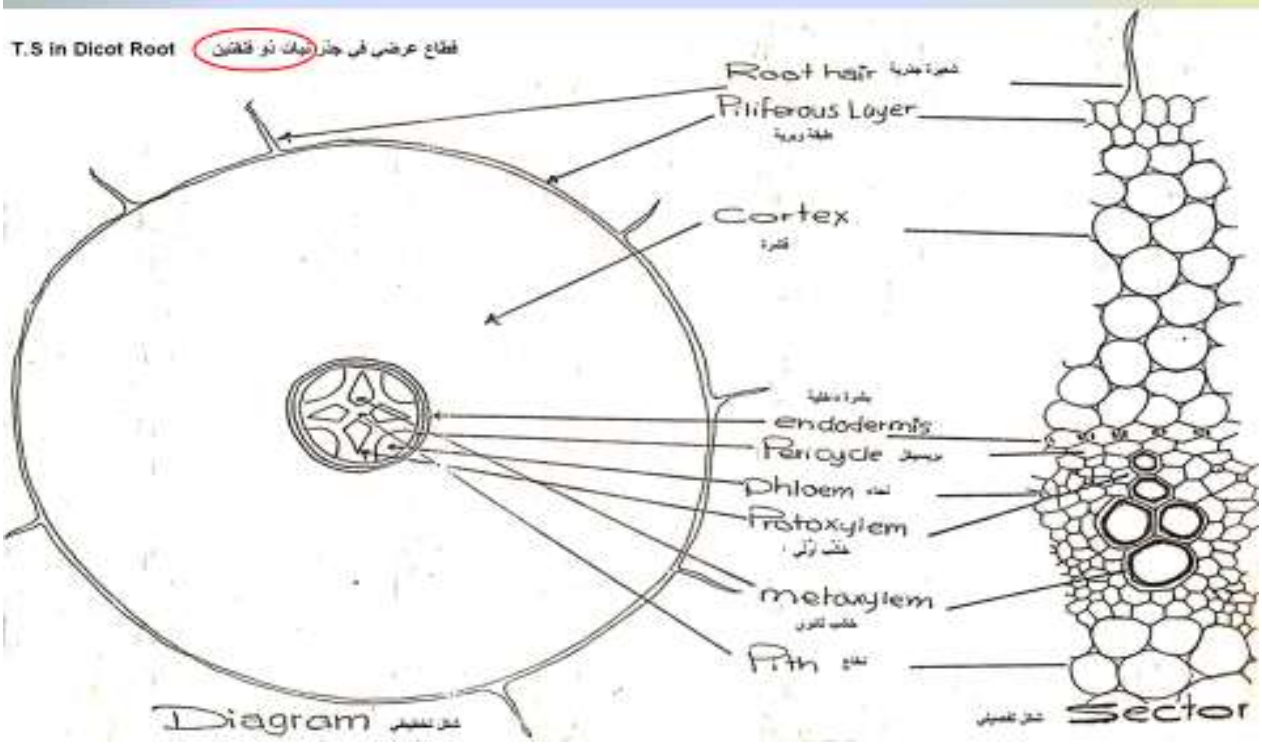
1. Concentric Vascular Bundle: Either the xylem or the phloem occupies the center of the bundle while the other one surrounds it.



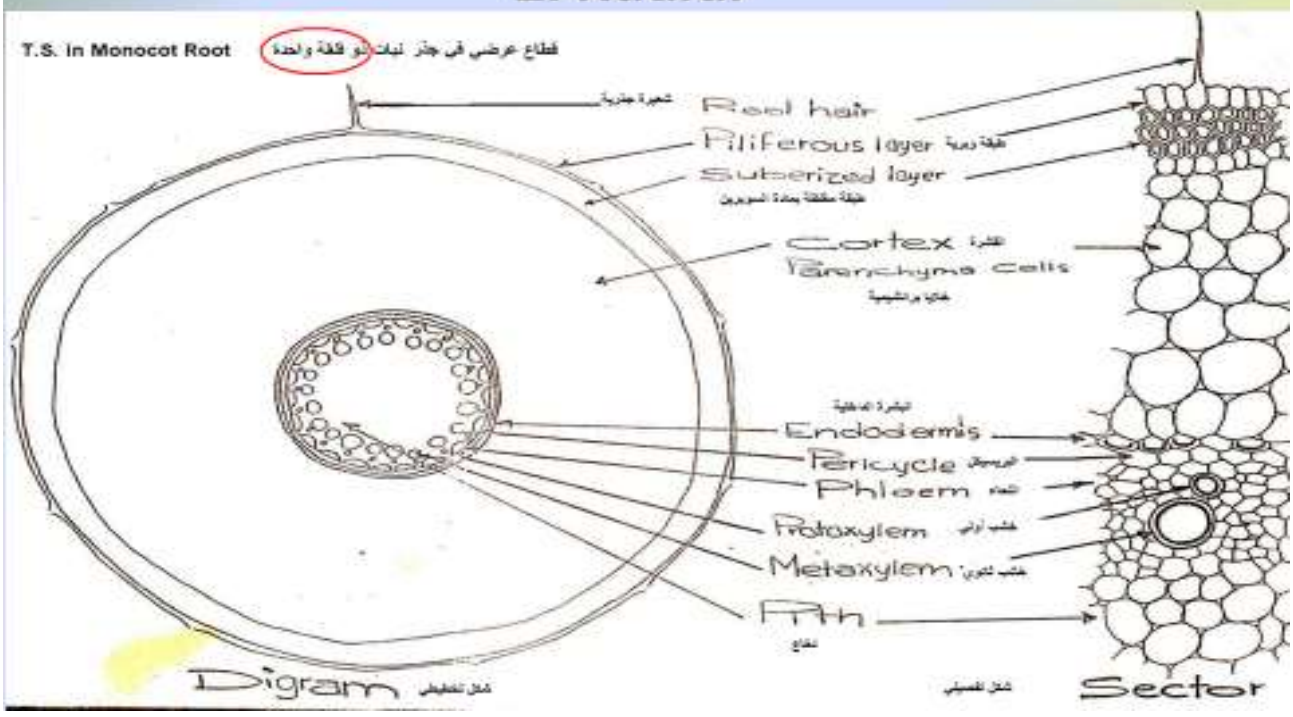
2. Radial V.B. : Both the xylem and the phloem are arranged on different radii, the vascular bundle is surrounded by a one layered cells called "**Pericycle**" *i.e.* roots.

3. Collateral V.B. : Both the xylem and the phloem are arranged on the same radius (*i.e.* stems). There is another type called "**Bicollateral Vascular Bundle**" where inner and outer phloem are present.

Vascular Tissues
2. *Radial*



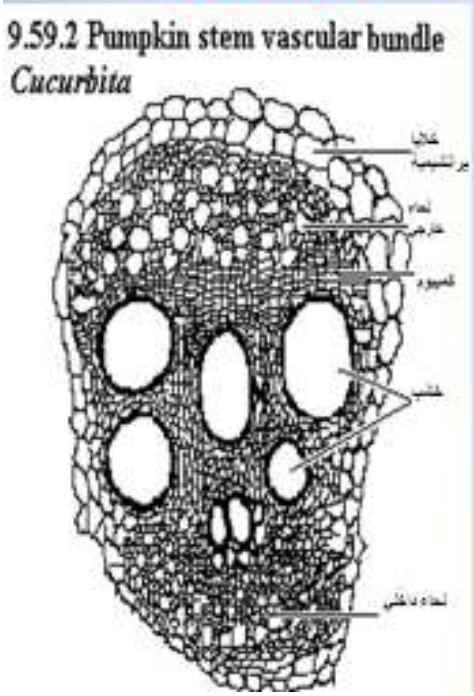
Vascular Tissues
2. *Radial*

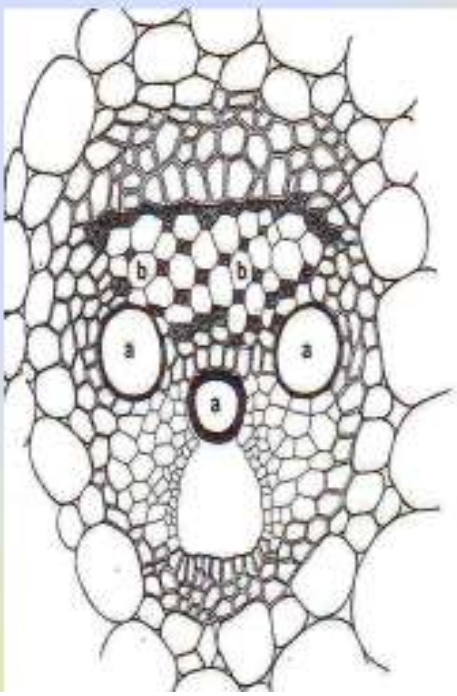


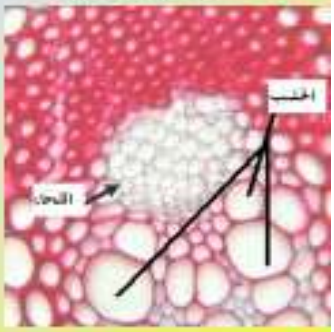
Vascular Bundles
3. Collateral and Bicollateral

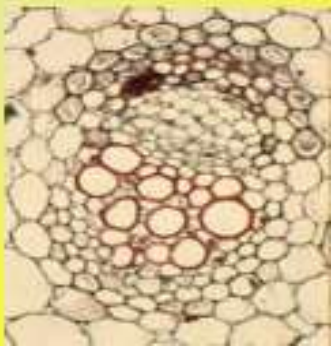
Collateral

Bicollateral | **Monocot .2** | **Dicot .1**





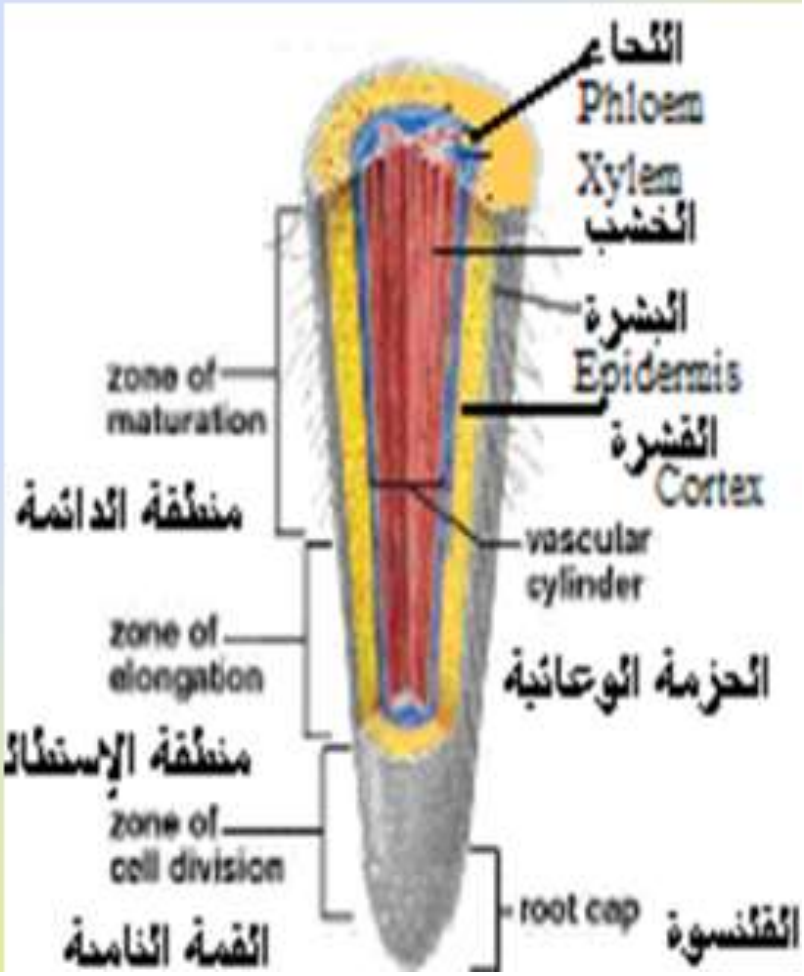




Anatomical structure of young roots

L.S. in root apex, showing from outside to inside the following:

1. Root cap (*Calyptra).*
2. Zone of cell division (Meristematic tissue).
3. *Epidermis* (Piliferous layer)
4. *Cortex*
5. Vascular cylinder: Xylem & phloem
6. Pith



Different Regions of Dicot Root:

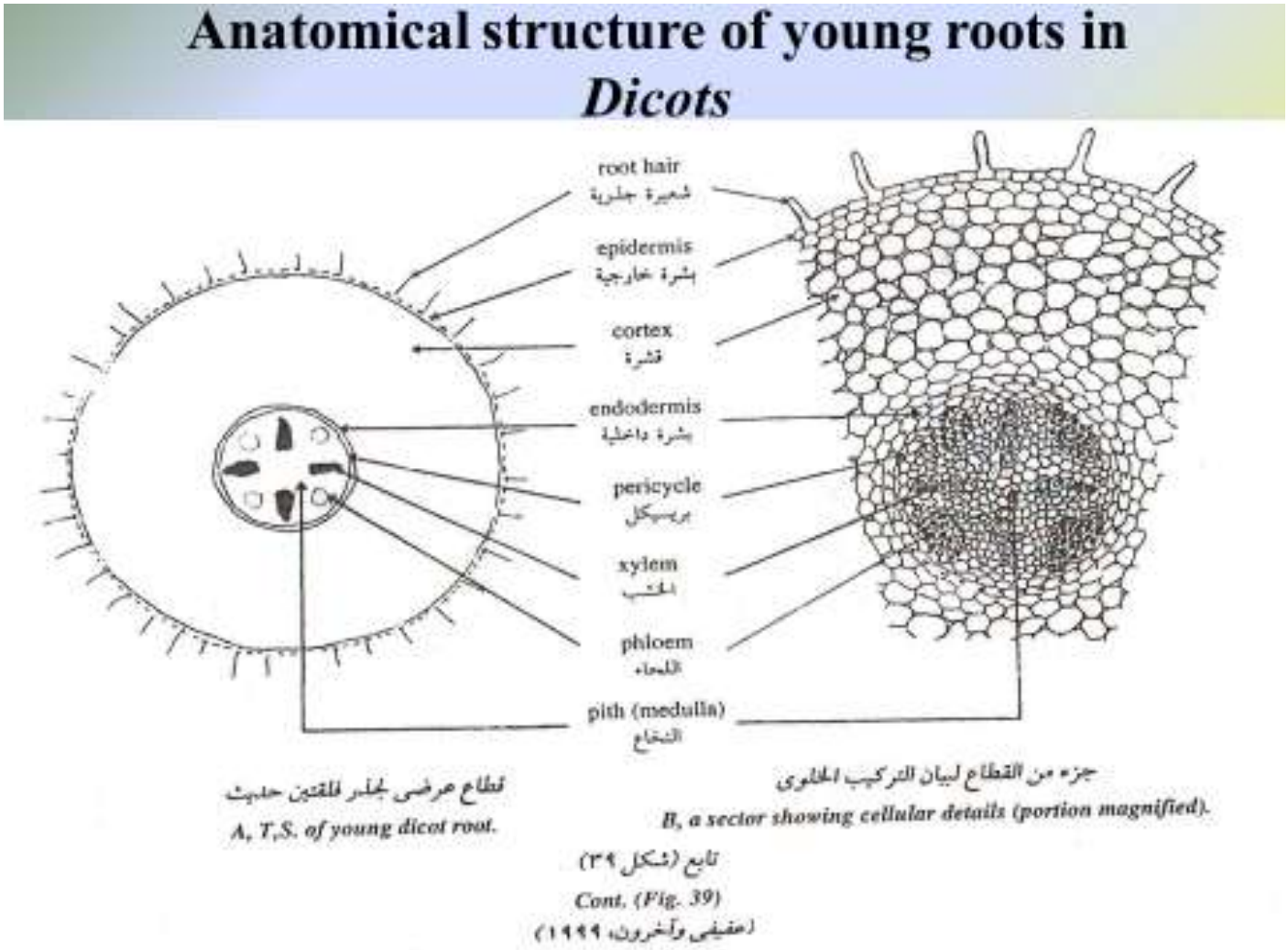
1. **Epiblema or Epidermis**: It is the outermost unlayered with several unicellular root hairs. It consists of thin-walled, compactly arranged living parenchymatous cells. Usually, epiblema is characterized by the absence of stomata and cuticles. Sometimes the epiblema may be less cuticularised. It provides protection to the roots due to the presence of unicellular root hairs it also helps in the absorption of water and minerals from the soil.

2. **Cortex:** It is a thin-walled, multilayered region made from circular or polygonal parenchymatous cells. they usually have intercellular spaces. The cortical cells have no chloroplast but may contain leucoplast for storage of starch grains. The cortex is responsible for the transportation of water and salts from the root hairs to the center of the root.

3. Endodermis – It is the innermost layer of the cortex and covers the stele. It consists of compactly arranged barrel-shaped parenchyma without intercellular spaces. Most of the cells are characterized by the presence of special thickening of suberin and lignin on their radial and tangential walls called casparian strips. Some endodermal cell near the protoxylem has no casparian strips and are called passage cells or transfusion cells. These cells allow the radial diffusion of water and minerals through the endodermis.

4. Pericycle – It is the outermost layer of the stele and is composed of a uniseriate layer of parenchymatous cells without intercellular spaces. Some dicots and hydrophytes do not bear pericycle. Several lateral roots and lateral meristem arise from the pericycle region (hence lateral roots are endogenous in origin). At the time of secondary growth, it produces secondary cambium or phellogens.

5. Vascular bundles – They are 2-8 in number, radial, and arranged in a ring. Xylem and phloem bundles are separated from each other by parenchymatous cells called conjuctive or **complementary tissue**.



تابع (شكل ٣٩)

Cont. (Fig. 39)

(حفيفى وآخرون، ١٩٩٩)

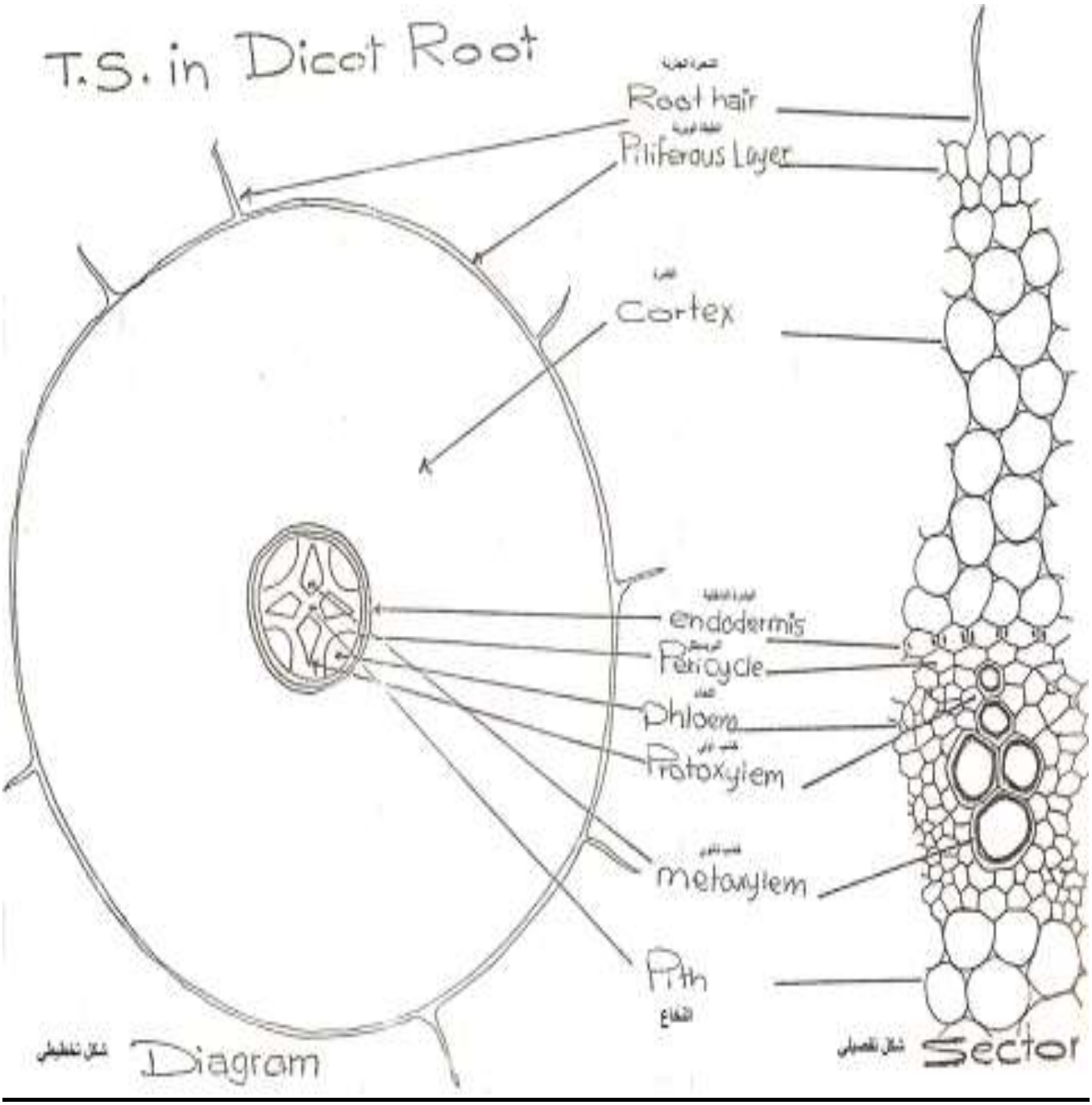
- Xylem is exarch (i.e. protoxylem towards the periphery and metaxylem towards the centre) and consists of tracheids, vessels, xylem parenchyma and xylem fibres.
- The pholem forms oval masses beneath the pericycle, alternating with xylem bundles. Pholem consists of sieve tubes, companion cells and pholem parenchyma. Usually pholem fibres are absent or reduced.

6. **Pith:** It is feebly developed and centrally located. It consists of thin-walled, polygonal parenchyma cells with intercellular spaces. In dicots roots, it may be reduced or absent. It helps in the storage of food materials.

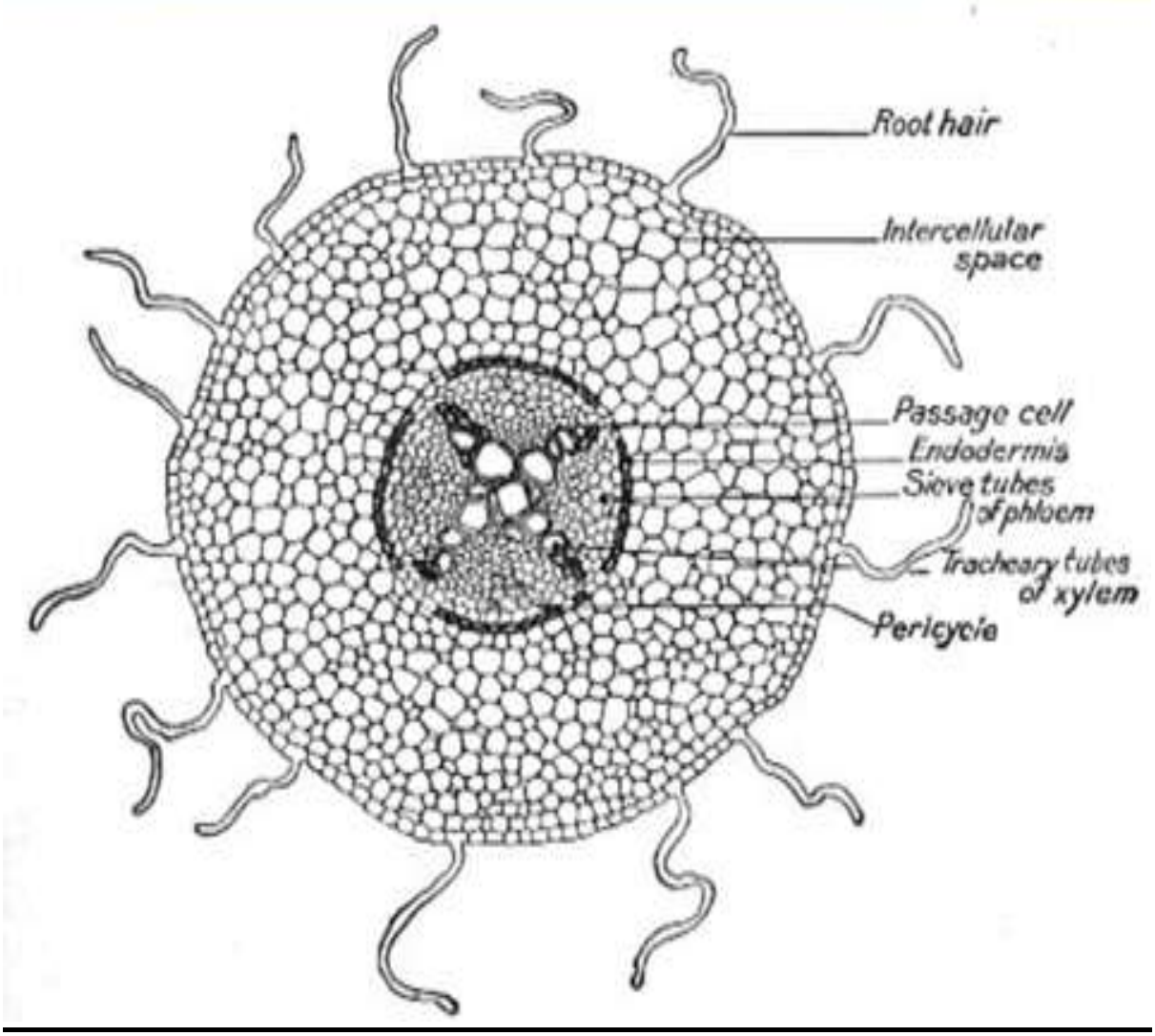
Distinguishing Features of Dicot Root:

The typical dicot roots show the following features.

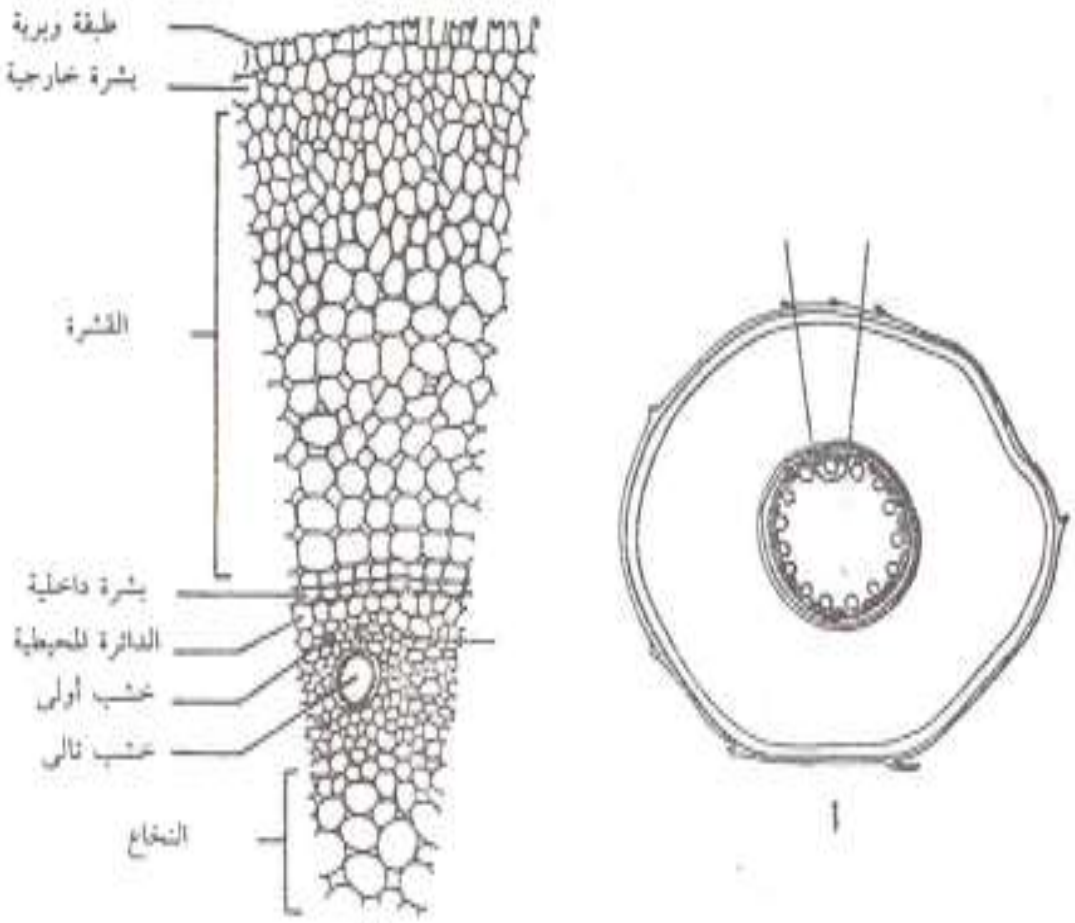
- Epiblema is uniseriate, thin walled, colourless without intercellular spaces and produce unicellular root hairs, hence also called as piliferous layer or rhidodermis.
- Cortex is homogenous (without differentiation).
- Endodermis consists of barrel shaped compact parenchymatous cells. It contains both casparian stripes and passage cells.
- Pericycle uniseriate and become meristematic to give secondary roots and secondary tissues.
- Vascular bundles are radial; Xylem is exarch; number of xylem bundles varies from 2 to 4 rarely more (up to 6-8). Metaxylems are angular arranged in linear.
- Usually conjunctive tissues are well developed.
- Pith is very small or completed obliterated.


T.S. in Dicot Root
Root hair
Piliferous Layer
Cortex
endodermis
Pericycle
Phloem
Protoxylem
metaxylem
Pith
Diagram
Sector

Anatomical structure of young roots in *Dicots*



Anatomical structure of young roots in *Monocots*



(شكل ٣٩): رسومات لقطاع عرضى فى جذر حديث نبات من ذوات الفلقة الواحدة.
أ- رسم تخطيطى للقطاع. ب- رسم لجزء تفصيلى للقطاع.

(Fig. 39) T.S. in monocot young root A- diagram B- sector

(المصدر : دين ١٩٨٢م، *Dean, 1982.*)

The typical monocot roots show the following features:

- **Epiblema** is single layered, thin walled, colorless, polygonal without intercellular spaces, with presence of unicellular root hairs, hence also called as piliferous layer or rhizodermis.
- **Cortex** may be heterogeneous with outer dead exodermis.
- **Endodermis** consists of barrel shaped parenchyma without intercellular spaces. Casparian stripes are little present but passage cells are absent.
- **Pericycle** gives lateral roots only, secondary growth is absent.
- **Vascular bundles** are radial; Xylem is exarch, bundles more than six. Metaxylem elements are oval or circular.
- **Conjunctive tissues** are limited or even absent.
- **Pith** is large or rarely reduced.

2. Features of Different Regions of Monocot Root

1. **Epiblema** is the outermost single layer made from compactly arranged parenchymatous cells without intercellular space. Usually Epiblema has no stomata but bears unicellular epidermal root hairs and less amount of cutin. It contains more cuticle than dicot roots. The root hairs and thin walled epidermal cells take part in the absorption of water and minerals from the soil. The epiphytes have several layered hygroscopic epidermis, called **velamen tissues**. It is made from spongy dead cells which helps in absorption of water from atmosphere. It also checks excessive loss of water from cortex. Usually the wall of velamen has spiral or reticulate secondary thickening of cellulose, pectin and lignin.
1. **Cortex** is a multi-layered well developed and made from oval parenchymatous cells with intercellular spaces. The intercellular spaces usually help in gaseous exchanges, storage of starch, etc. In monocots and several old roots, few layers of cortex just below epiblema give rise to a single or multilayered cuticularised sclerenchymatous region called **exodermis**. Cortex helps in mechanical support to the roots (like hypodermis to stem).
2. **Endodermis** is innermost layer of cortex made from barrel shaped parenchyma. It forms a definite ring around the stele. These cells are characterized by the presence of casparian stripes. It is deposition of suberin and lignin, and their radial and tangential walls. Usually passage cells are absent in monocot roots. Due to presence of **casparian stripes**, endodermis forms water tight jacket around the vascular tissues, hence it is also

called biological barrier. It regulates the inward and outward flow of water and minerals and prevents diffusion of air into xylem elements.

3. **Pericycle** is uniseriate (multiseriate in Smilax) and made from thin walled parenchymatous cells. It is outermost layer of stellar system. Usually it is made from parenchymatous cells but it may become sclerenchymatous in older roots. Several lateral roots arise from this layer. Hence, lateral roots are endogenous in origin.
4. **Vascular bundle** is radial, arranged in a ring (except mangrove, which also contains lenticels), **polyarch** (presence of many alternating xylem and phloem bundles). Xylem and phloem are found at different radii alternating with each other (radial). The number of xylem and phloem vary from, 8 to 46 (100 in *pandanus*). The xylem is exarch, i.e. the protoxylem lies towards periphery and metaxylem toward center. The protoxylem has smaller vessels with spiral or annular thickening, whereas the walls of metaxylem contains pitted thickening. Phleom consists of seive tubes, companion cells and phloem parenchyma. Usually phleom sclerenchyma or fibers are absent. The phloem is also exarch (protophloem towards the periphery and metaphloem towards the center). Secondary growth is absent in monocot roots due to lack of vascular and cork cambium. **Conjunctive tissue** is parenchymatous tissues which separates xylem and phloem bundles. It may become sclerenchymatous in older roots.
5. **Pith** is large, well developed portion of monocot root. It occupies the central portion and made from thin walled parenchymatou tissue with intercellular spaces. It contains abundant amount of starch grains.

Monocot roots of maize have bands of vascular bundles. Bundles are not separate and vessels are not found in linear rows but arranged in V-shaped structure.

General Characters of Roots:

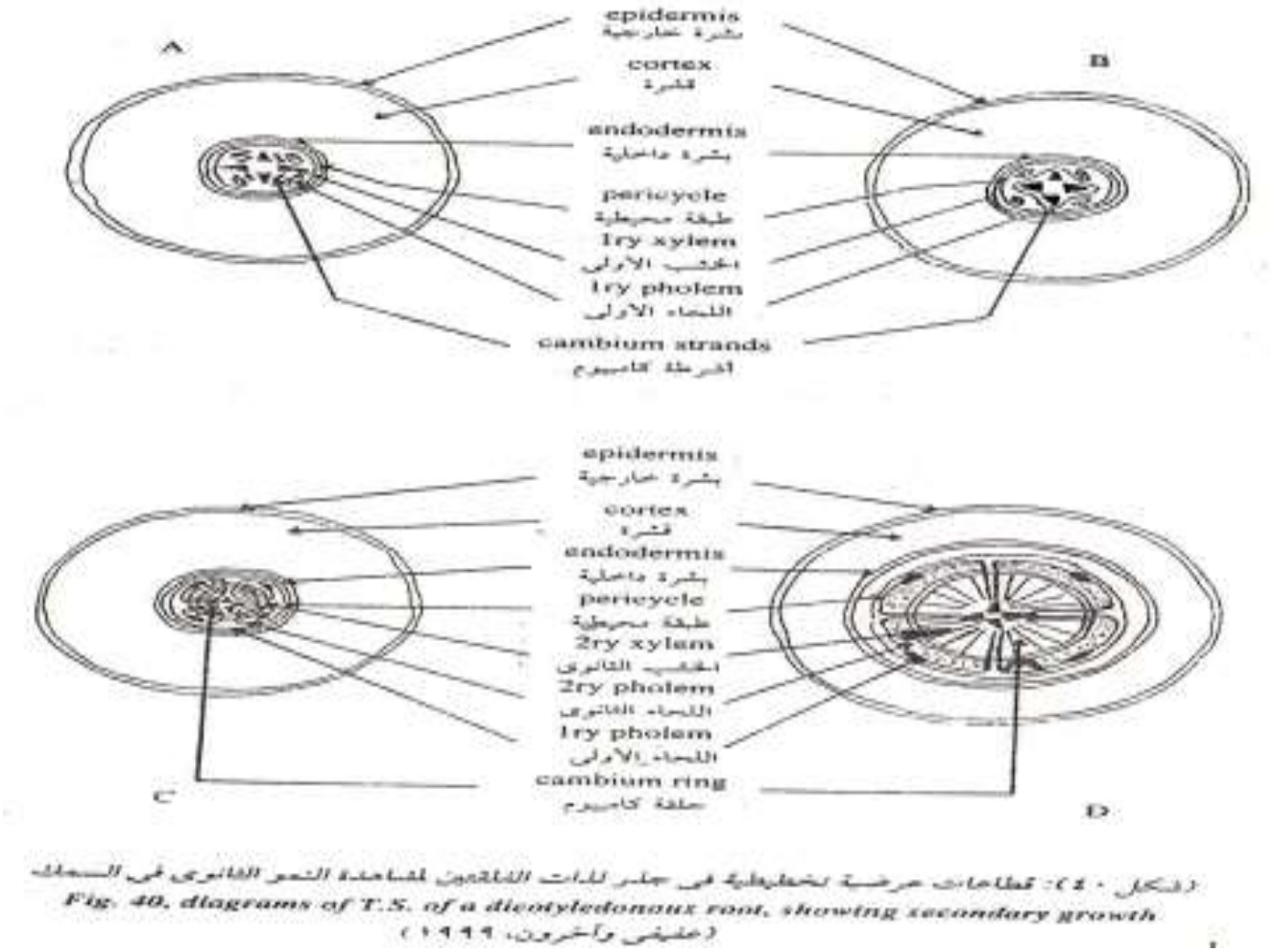
1. A piliferous layer is found in young roots which is replaced by an Exodermis known as the periderm during secondary growth.
2. The ground tissue is characterized into cortex and pith.
3. The cortex is wider than the pith.
4. Presence of a single layer of Endodermis.
5. Suberin (impermeable to water) is deposited on the walls of Endodermis forming The Casparian Strip which is in the form of an O or U –shaped (Monocots), or in the form of lateral strips on their radial and tangential walls (Dicots). Walls that are not impregnated with Suberin are called passage cells.
6. Radial arrangement of the vascular cylinder (Xylem and Phloem are arranged on alternating radii).
7. The Xylem is Exarch.

Comparison between *Dicot* and *Monocot* roots

Points of Comparisons	*Dicot* Root	*Monocot* Root
***Xylem* archs**	Limited in number (2-8)	Unlimited in number (30)
Phloem	Irregular (presence of *Phloem Parenchyma*)	Regular (absence of *Phloem Parenchyma*)
Pith	Narrow	Wide
***Xylem* Vessels**	Angular	Circular
Casparian Strips	Lateral Strips	U or O - shaped
Secondary Growth	Always happens	Rarely happens

Secondary Growth in Old Roots

- **Secondary growth**: It always occurs in *Dicots*, but rarely happens in *Monocots*.



(شكل ٤٠: قطاعات عرضية تخطيطية في جذر لذات الفلقتين لمشاهدة النمو الثانوي في السمك
Fig. 40, diagrams of T.S. of a dicotyledonous root, showing secondary growth
(عفيفي وآخرون، ١٩٩٩)

The secondary growth in root also takes place by the activity of the cambium and cork cambium. It is a usual feature of dicotyledonous and gymnospermous roots, where it generally starts at a very early stage, so much so that it is difficult to get the roots without secondary growth in most of the cases.

1. Activity of Cambium:

Certain of the cells of conjunctive tissue just beneath the phloem become meristematic and form strips of cambium. The number of strips produced depends upon thus number of phloem bundles present. In a diarch root two, in triarch root three and in tetrarch root four such strips are formed. These strips exertend both ways in between phloem and xylem and ultimately unite with the pericyclic cells lying just outside the protoxylem.

The pericyclic cells divide tangentially and produce two layers of which the cells of inner layer also become meristematic and unite with the strips of cambia and thus, a continuous wavy

band of cambium is produced extending down the phloem and over the xylem. It becomes active and forms new cells.

It divides by periclinal divisions and then by anticlinal divisions for increase in circumference. The strip of cambium below the phloem becomes active earlier and the activity is much faster on the inner side. Because of this, phloem and cambium strip below it are pushed outward and the wavy band of cambium now becomes circular to form a cambium ring. Now the entire of the cambium becomes active.

The cells formed on the inner side get differentiated into secondary xylem. It consists of comparatively large vessels, tracheids, a little wood fibres and well evolved xylem parenchyma. The activity of cambium is so fast on the inner side that after secondary growth xylem forms the main bulk of the root and is present in the form of solid core.

The primary xylem bundles can remain intact up to the last or the crushed. The annual rings like the stem are not visible in roots. The pith is entirely crushed, or if some part is left the cells become thick walled.

The secondary vascular tissues produced by the activity of cambium do not form a continuous ring but are interrupted by the bands of radially-elongated, parenchymatous cells, known as primary medullary rays. These are formed above each primary xylem patch and extend up to the phloem. Sometimes, other smaller medullar rays can also develop from other parts of cambium and may be known as secondary medullary rays. The number of rays goes on increasing with the increase in the size of the vascular cylinder.

The secondary xylem cells vary in quantity if different roots, they have only tracheids in gymnosperms, only vessels in willow and both tracheids and vessels in most of the plants. In some storage roots storage parenchyma develops in the secondary xylem. The cells of secondary xylem are arranged in definite rows when first produced become irregularly disposed due to differential enlargement of various tracheid elements.

Like the stem, in roots of perennial trees, shrubs and woody climbers also, the xylem elements produced in the bringing of each season are larger and thin walled, while those formed during late are smaller in size and are thick walled. Thus, annual rings are produced.

2. Activity of Cork Cambium:

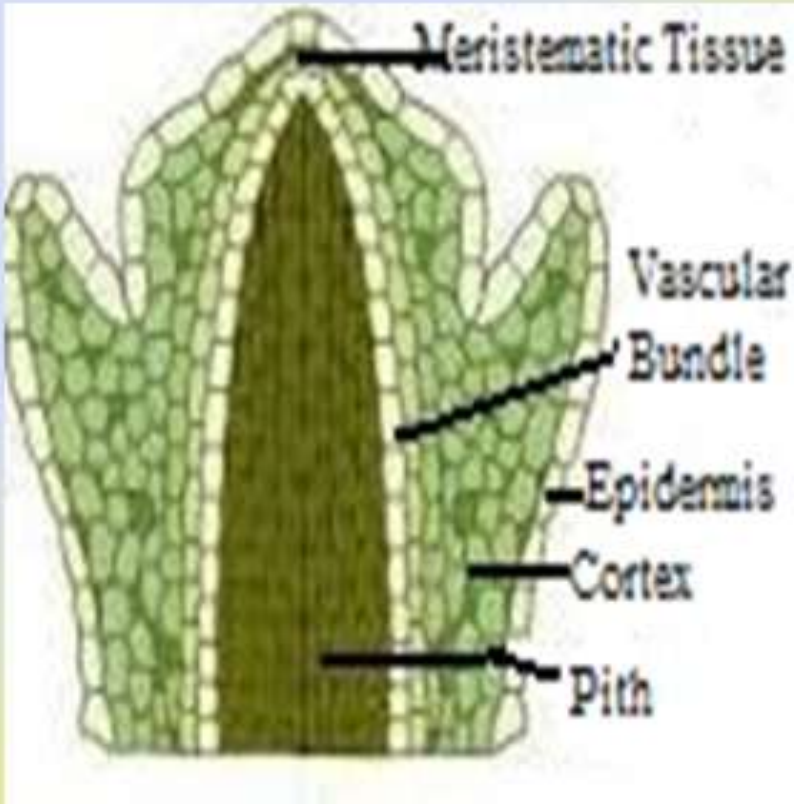
The secondary tissues produced by the activity of cambium exert a pressure on the outer tissue. To withstand this pressure, the cells of pericycle become meristematic and function as the phellogen or cork cambium. The cells of pericycle divide tangentially. Similar to stem, here also it produces layers of cork or phellem on the outside and secondary cortex or phelloderm on the inner side.

The bark in the case of roots includes cork, endodermis, cortex and epiblema. In certain cases, the cork cambium may be formed from the phloem cells. In this case, the pericycle also produces the part of bark. Subsequent barks have only cork. Lenticels can also be formed here and there. When the bark is removed, the new cork cambium layer is formed from the parenchyma produced by the previous cork cambium.

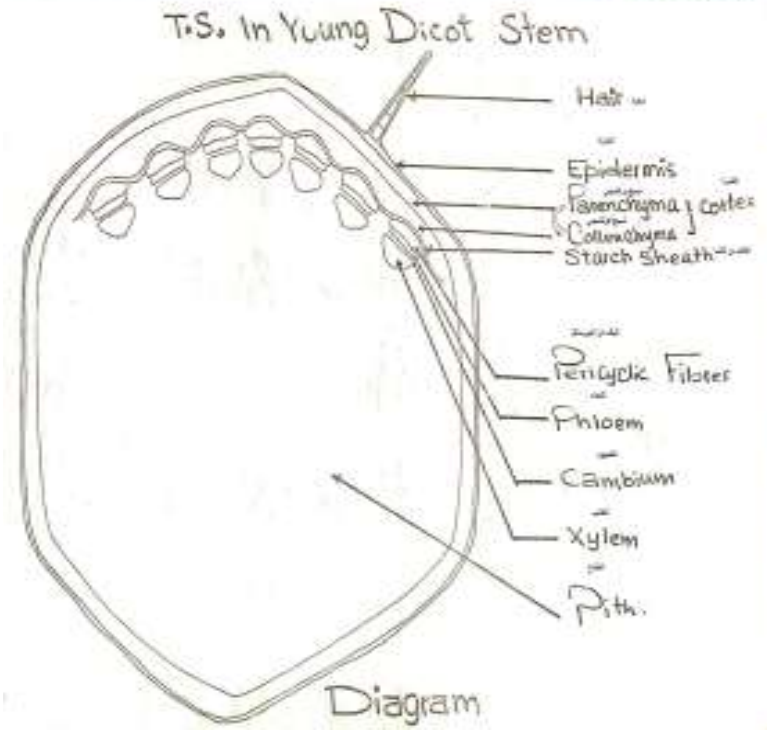
Anatomical structure of young stems

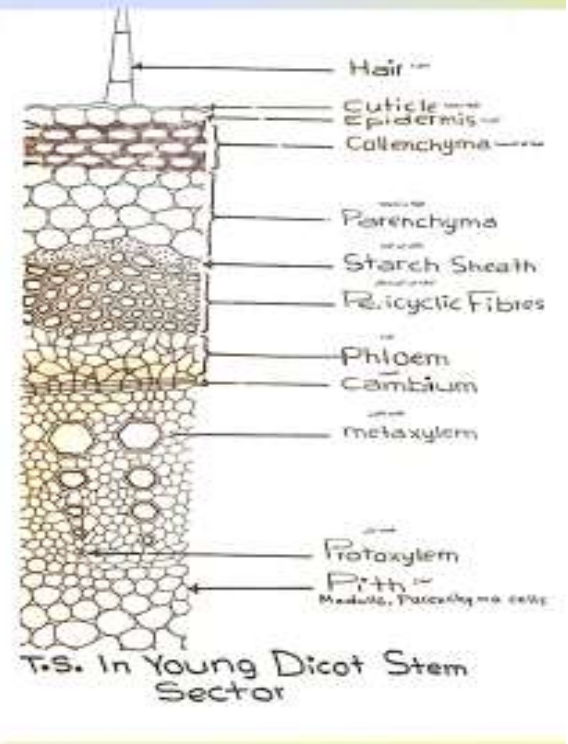
L.S. in stem apex, showing from outside to inside the following:

1. Growing Apex (Meristematic tissue).
2. *Protoderm* (*Epidermis*)
3. *Cortex*
4. Vascular bundle: *Xylem*, *phloem* & *Cambium*.
5. Pith



Anatomical structure of young stems in *Dicots*



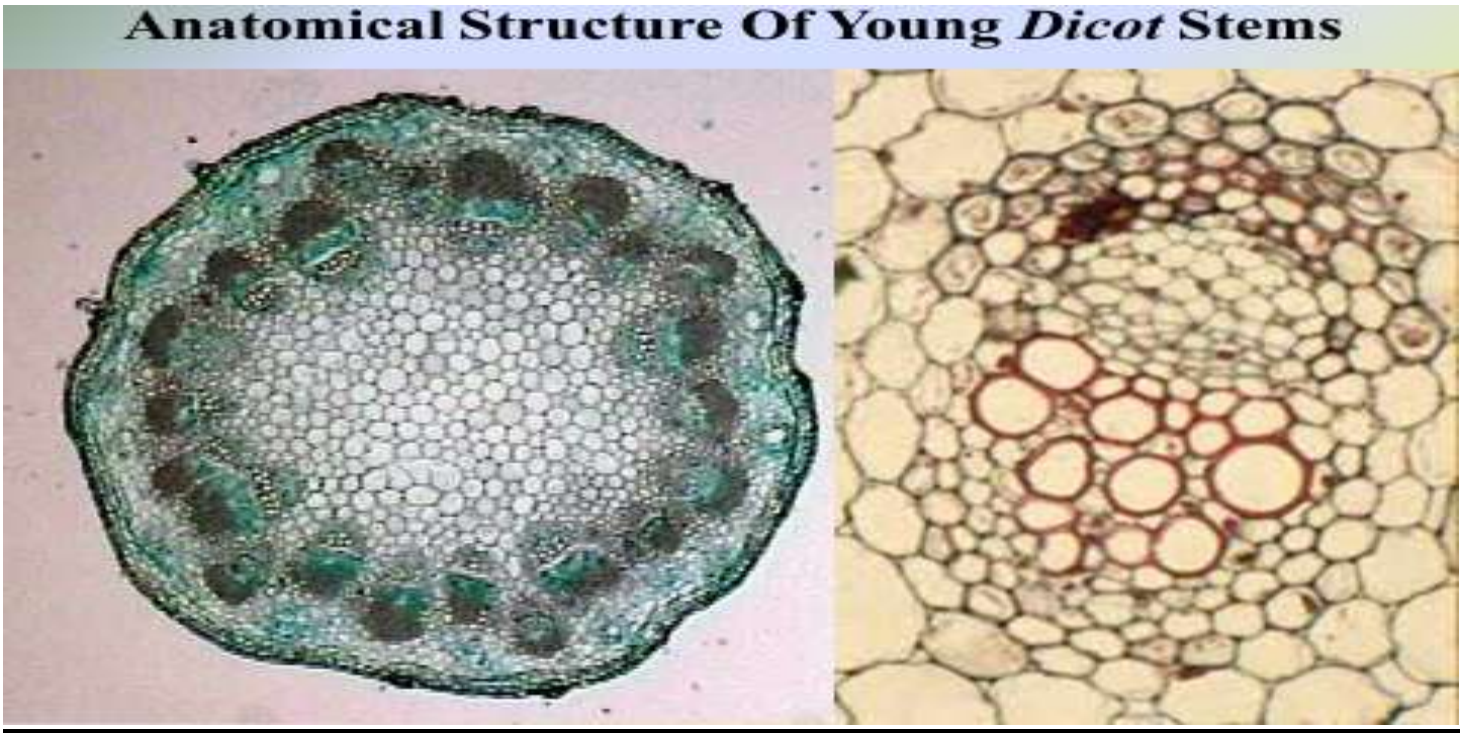


Dicotyledonous and Monocotyledonous Stem

Dicot Stem

The dicotyledonous stem is usually solid. The transverse section of a typical young dicotyledonous stem consists of the following parts:

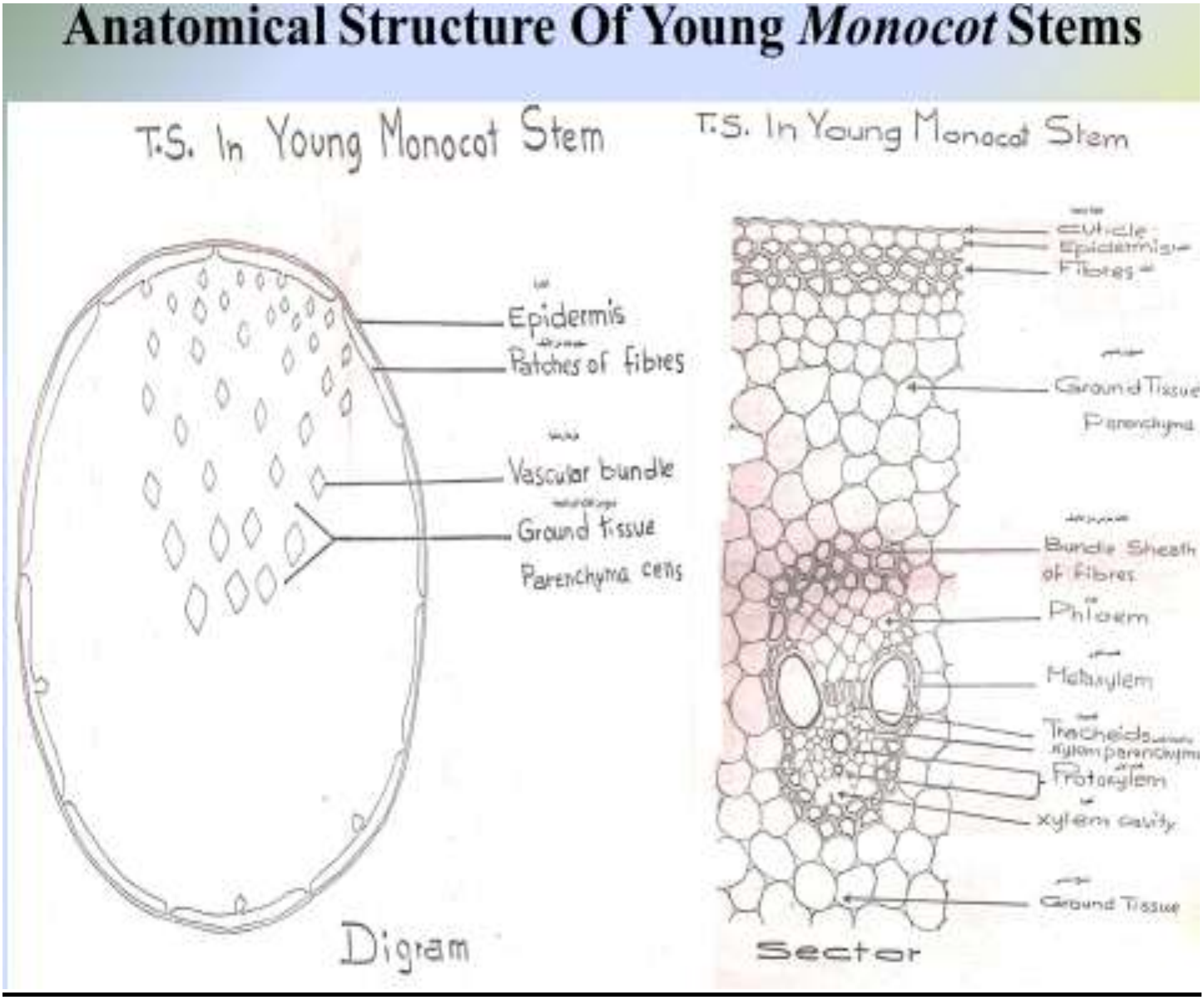
- The epidermis is the outermost protective layer, which is covered with a thin layer of cuticle.
- Epidermis possesses trichomes and a few stomata.
- Cortex is multi-layered cells sandwiched between epidermis and pericycle.
- The outer layer, hypodermis (collenchymatous cells), the cortical layers (parenchymatous cells) and the inner layer, endodermis together make up the three subzones of the cortex.
- Next to endodermis is the pericycle, which is constituted of semi-lunar patches of sclerenchyma.
- 'Circled'/ 'ring' arrangement of vascular bundles is present only in dicot stem.
- The Vascular bundle is conjoint, open and with endarch protoxylem.
- Pith is evident and is made of parenchymatous cells.


Anatomical Structure Of Young *Dicot* Stems

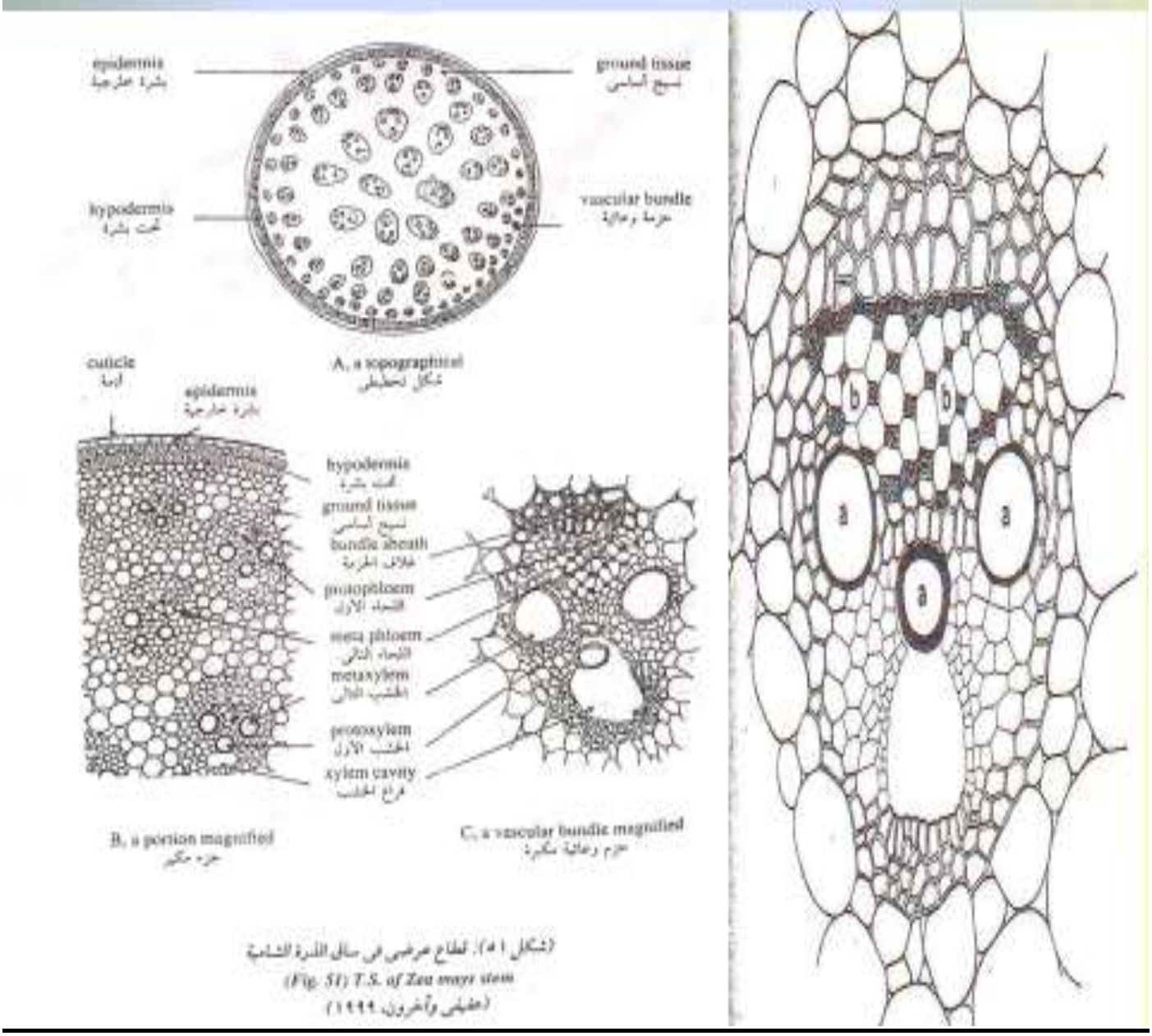
Monocot Stem

Monocot stem is usually hollow with no secondary growth. The anatomy of monocot and dicot stem are similar, however, some notable differences are as follows:

- The hypodermis of the cortex in monocots is made of sclerenchymatous cells.
- Vascular bundles are numerous, but scattered, conjoint and closed, surrounded by the ground tissue.
- Phloem parenchyma is absent.



Anatomical Structure Of Young *Monocot* Stems



(شكل ٥١): قطاع عرضي في ساق الذرة الشامية
(Fig. 51) T.S. of Zea mays stem
(حطيبي وآخرون، ١٩٩٩)

Plant Leaf

Leaf tissues are composed of layers of plant cells. Different plant cell types form three main tissues found in leaves. These tissues include a mesophyll tissue layer that is sandwiched between two layers of epidermis. Leaf vascular tissue is located within the mesophyll layer.

Epidermis

The outer leaf layer is known as the epidermis. The epidermis secretes a waxy coating called the **cuticle** that helps the plant retain water. The epidermis in plant leaves also contains special cells called **guard cells** that regulate gas exchange between the plant and the environment. Guard cells control the size of pores called **stomata** (singular stoma) in the epidermis. Opening and closing the stomata allows plants to release or retain gases including water vapor, oxygen, and carbon dioxide as needed.

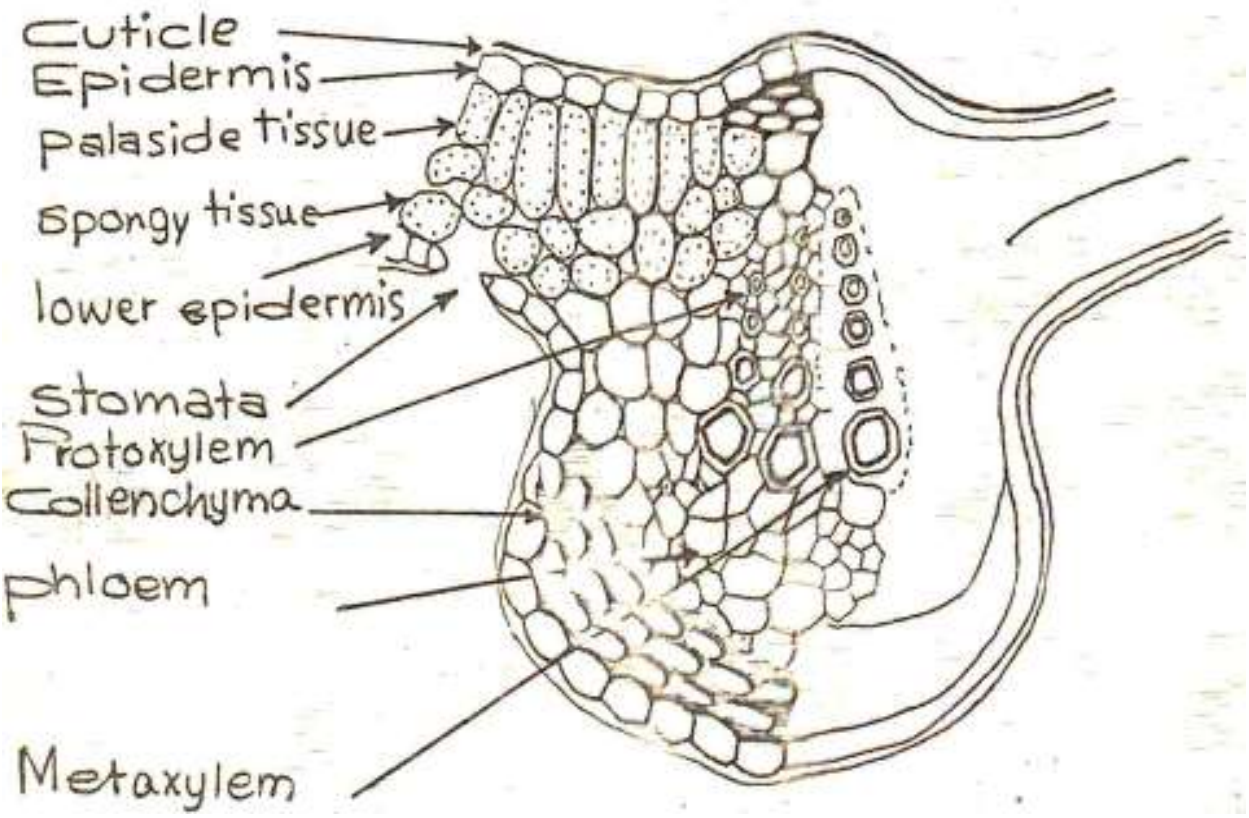
Mesophyll

The middle mesophyll leaf layer is composed of a palisade mesophyll region and a spongy mesophyll region. **Palisade mesophyll** contains columnar cells with spaces between the cells. Most plant chloroplasts are found in palisade mesophyll. Chloroplasts are organelles that contain chlorophyll, a green pigment that absorbs energy from sunlight for photosynthesis. **Spongy mesophyll** is located below palisade mesophyll and is composed of irregularly shaped cells. Leaf vascular tissue is found in the spongy mesophyll.

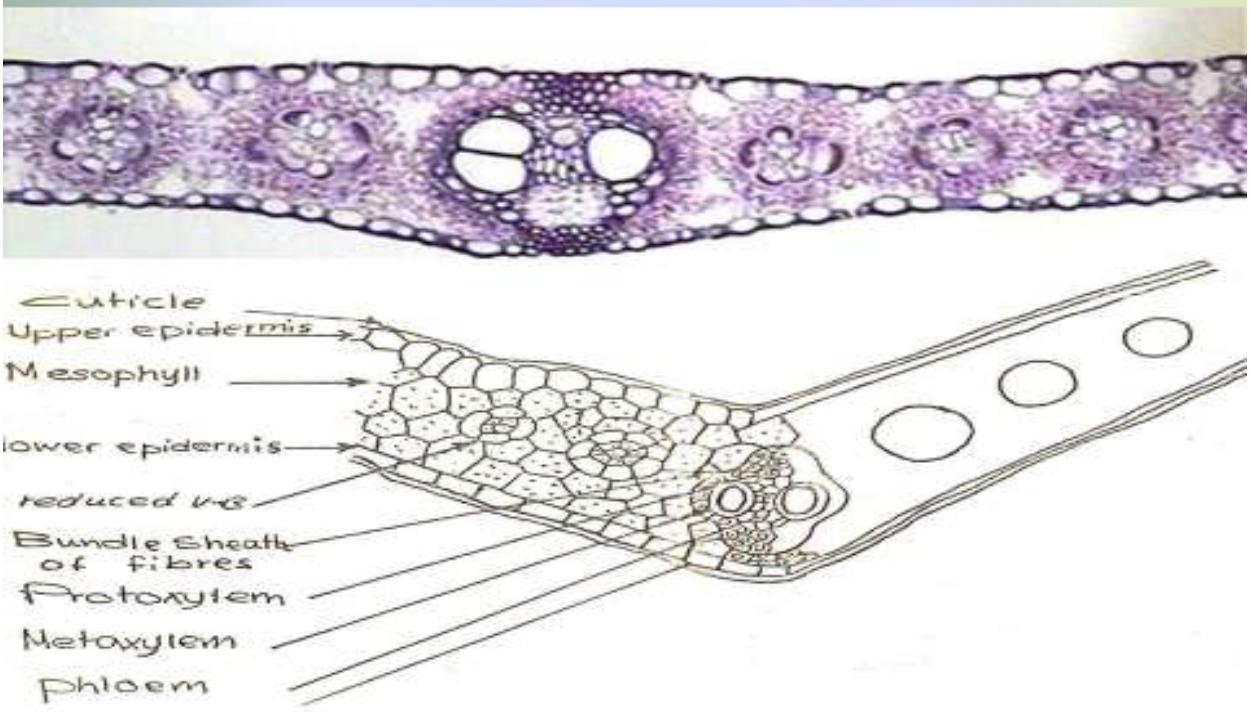
Vascular Tissue

Leaf veins are composed of vascular tissue. Vascular tissue consists of tube-shaped structures called **xylem and phloem** that provide pathways for water and nutrients to flow throughout the leaves and plant.

T.S. in *Dicot* leaf



T.S. in *Monocot* leaf



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GRADING

1. **Student activities & attendance (30 marks): 2 lab notebook+2quiz+1attendance**
2. **Practical exam: 90 marks**
3. **Final written exam: 180 marks**

TEACHING HOURS

1. **Lectures: 5 hours**
2. **Lab: 4 hours**