

Chlamydomonas

Dr. Urmi Roy

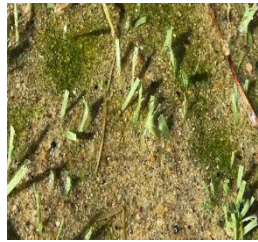
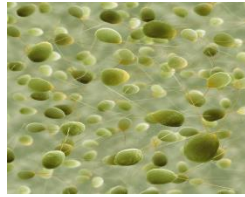
Systematic Position

- Class: Chlorophyceae
 - Order: Volvocales
 - Sub-Order: Chlamydomonadineae
 - Family: Chlamydomonaceae
 - Genus: *Chlamydomonas*



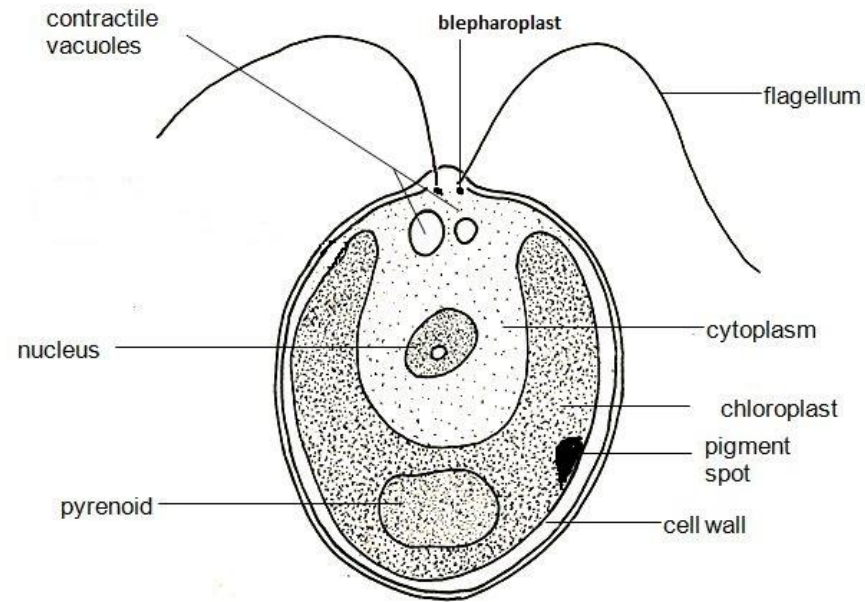
Occurrence

- It is simple, **unicellular**, **motile** fresh water algae
- Fresh water: rich in nitrogen salts and organic matter.
- Stagnant water of ponds, pools, ditches, water tanks, sewage tanks and in slow running water.
- It is planktonic algae and makes surface of water appear green.
- Terrestrial: Grow on moist soil surface, in rice fields and on banks of rivers and lakes.
- Palmella stages of genus make scum on soil surfaces.
- Salty brackish water e.g., *C. halophila*, *C. ehrenbergii*.
- Cryophytes (growing on snow):
 - *C. nivalis* causes red snow due to presence of red pigment haematochrome and
 - *C. yellowstonensis* imparts green colour to snow.

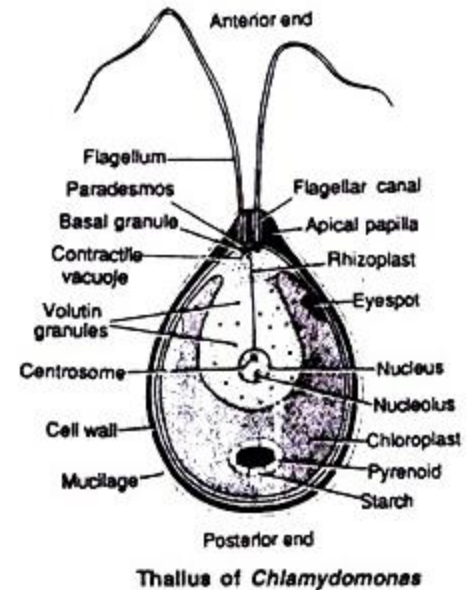


Structure

- Unicellular
- Motile green algae.
- Thallus can be
 - Oval,
 - Spherical,
 - Oblong,
 - Ellipsoidal or
 - Pyriform:
 - Most common
 - Have narrow anterior end and a broad posterior end



Chlamydomonas



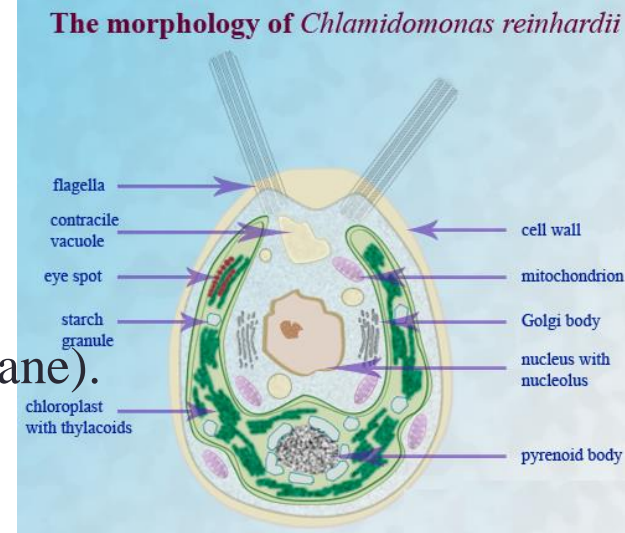
The structure of thallus:

1. Cell Wall:

- i. Smooth, thin, multilayered : cellulose fibrils.
- ii. At the anterior end it is extended - *apical papilla*.
- iii. Inner to the wall: the *plasma lemma* (plasma membrane).

2. Cytoplasm:

- i. Present in between the cell wall and the chloroplast.
- ii. It includes the nucleus, mitochondria, endoplasmic reticulum, dictyosomes, ribosomes etc.
- iii. Single large, dark nucleus lying inside the cavity of the cup shaped chloroplast.
- iv. The dictyosomes or Golgi bodies are found near the nucleus.
- v. Each cell contains two contractile vacuoles located at the base of flagella in a plane at right angle to them.
 - a) The contractile vacuoles are excretory or osmoregulatory in function.
 - b) They regulate the water contents of the cell by the process of osmosis.
- vi. The thallus contains 80S ribosomes.



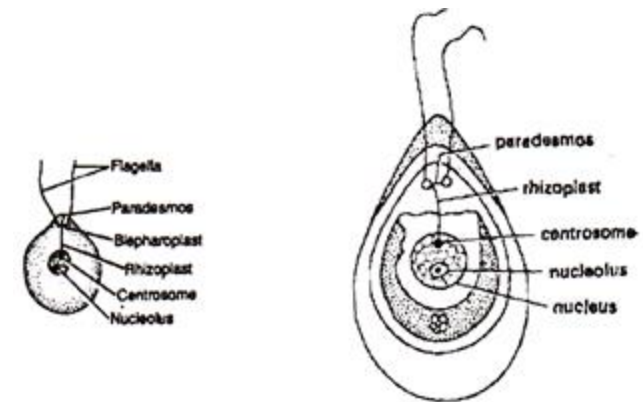
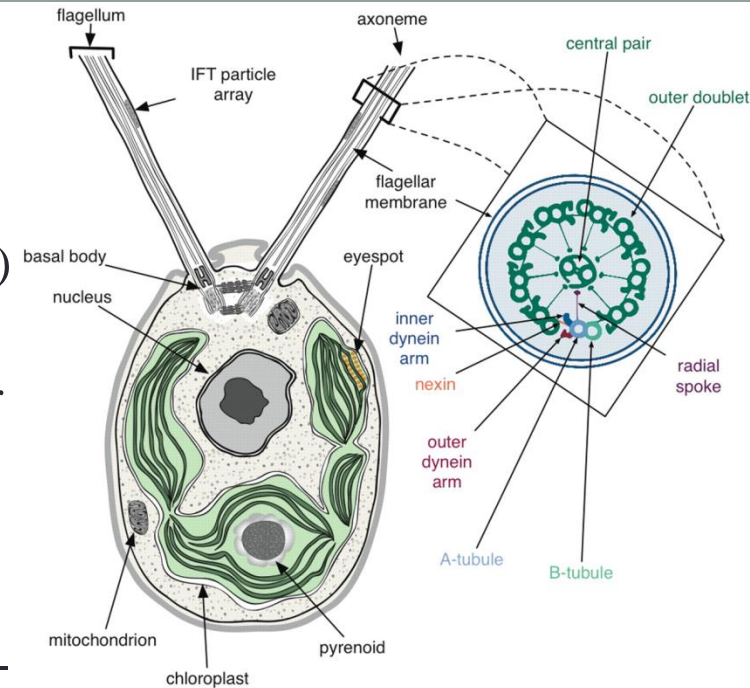
The structure of thallus...

3. Flagella:

- i. The anterior part bears two flagella.
- ii. Both the flagella are whiplash (*acronematic type*)
- iii. Equal.
- iv. Each flagellum originates from a basal granule or *blepharoplast*.
- v. Comes out through a fine canal in cell wall.

4. Neuromotor Apparatus:

- i. Some species (e.g., *C. nasuta*), a sensitive neuro-motor apparatus is present.
- ii. It controls movement of thallus in response to light, chemical and other stimuli.
- iii. It consists of
 - a) two basal granules (blepharoplasts),
 - b) a transverse cytoplasmic fibre (paradesmos) which connects two blepharoplasts,
 - c) a cytoplasmic fibre rhizoplast connecting one blepharoplast with the centrosome and
 - d) a small delicate fibre connecting centrosome with nucleolus.

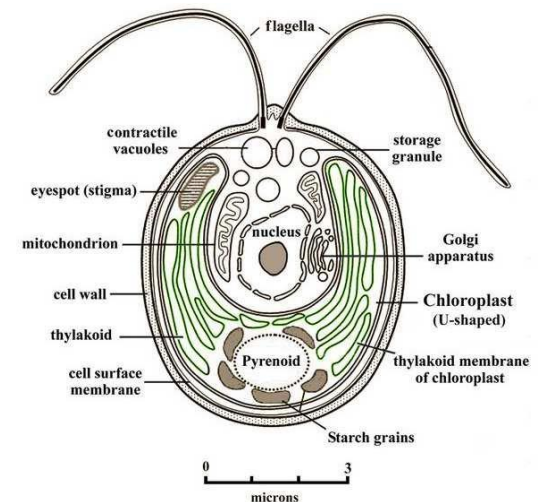
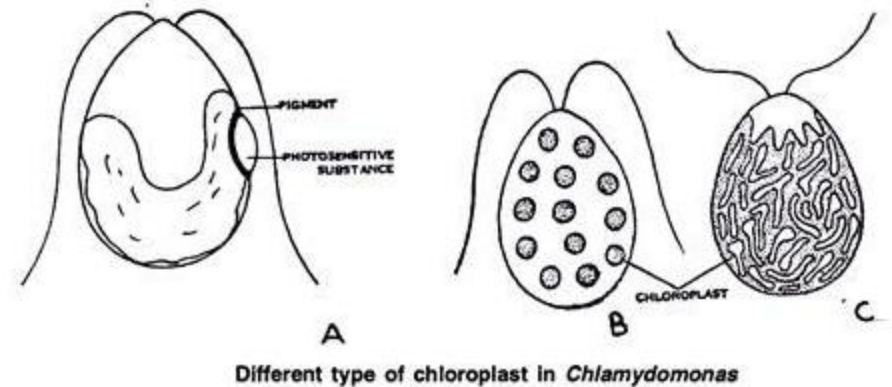


Neuromotor apparatus in *Chlamydomonas*.

The structure of thallus...

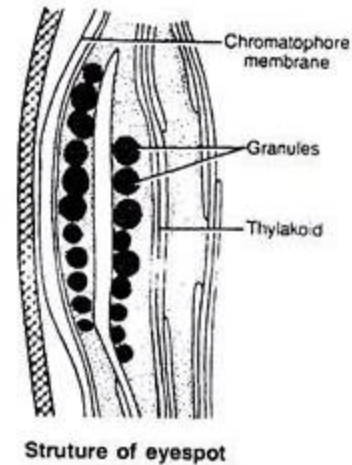
5. Chloroplast:

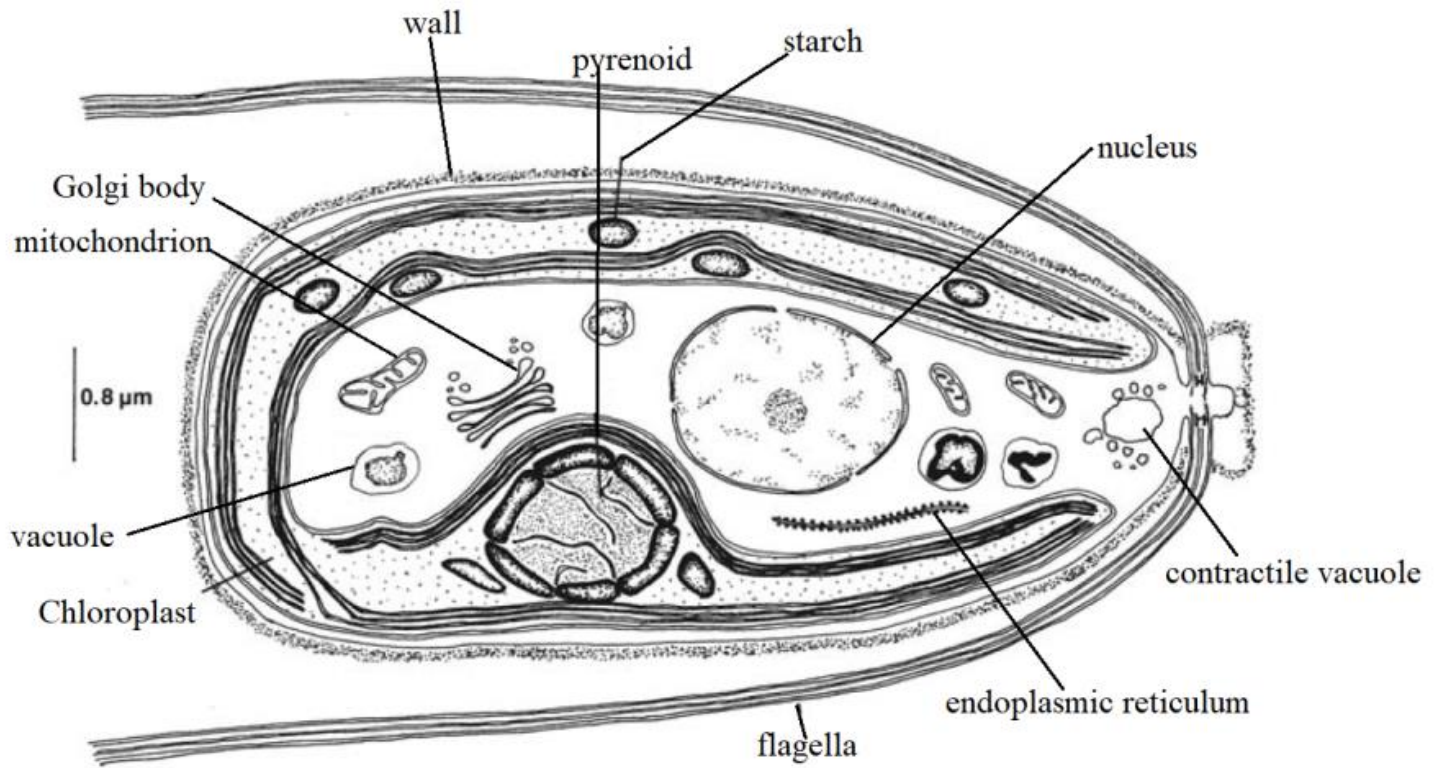
- i. A large, cup shaped parietal chloroplast is present in cytoplasm.
- ii. Can be of various shapes:
 - a. *C. bicilliata*: 'H' shaped in,
 - b. *C. reticulata*: reticulate,
 - c. *C. mucicola*: parietal
 - d. *C. arachne*: stellate
 - e. *C. steinii*: axile
- iii. Chloroplast is generally associated with pyrenoid covered with starch plates
 - a. Two pyrenoids: *C. debaryana* and
 - b. Many: *C. gigantea*.
 - c. The pyrenoids are concerned with synthesis of starch.
- iv. In chloroplast there are 2-6 thylakoids which join to form a granum.



6. Stigma or Eyespot:

- The anterior side of the chloroplast contains a tiny spot of **orange** or **reddish** colour called stigma or eyespot.
- It is photoreceptive organ concerned with the direction of the movement of flagella.
- The eye spot is made of curved pigmented plate.
- The plate contains 2-3 parallel rows of droplets or granules containing carotenoids





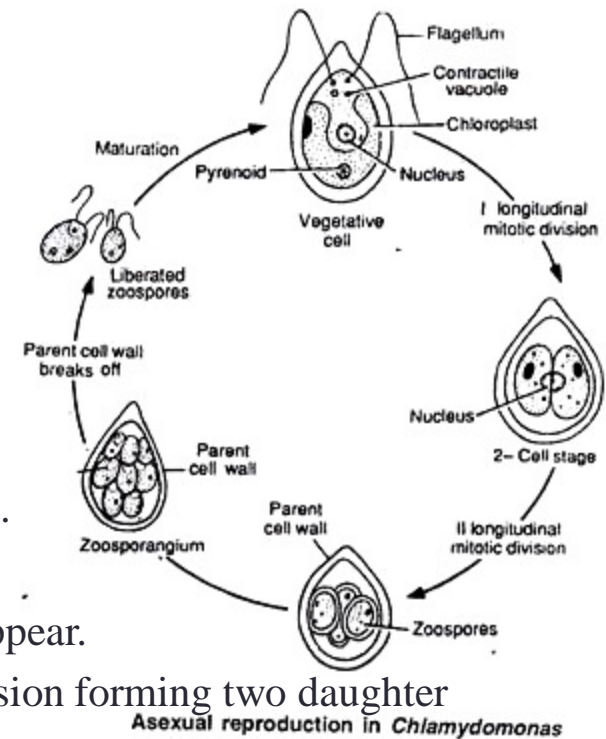
Reproduction

- The reproduction is both asexual and sexual.

- **Asexual Reproduction:**

1. Zoospores:

- During favourable conditions.
- The zoospore formation takes place as follows:
 - The protoplast contracts and gets separated from the cell wall.
 - The parent cell loses flagella.
 - The contractile vacuoles and the neuro-motor apparatus disappear.
 - The protoplasm divides longitudinally by simple mitotic division forming two daughter protoplasts.
 - The second longitudinal division of protoplasm takes place at right angle to the first
 - This makes four daughter chloroplasts.
 - The protoplasm may further divide to make 8-16-32 daughter protoplasts.
 - The pyrenoids and initials of neuro-motor apparatus also divide.
 - The contractile vacuoles also develop in daughter protoplasts.
 - Each daughter cell develops cell wall, flagella and transforms into zoospore.
 - The zoospores are liberated from the parent cell and are identical to the parent cell but smaller in size.
 - The zoospores simply enlarge to become mature *Chlamydomonas*.



Asexual Reproduction....

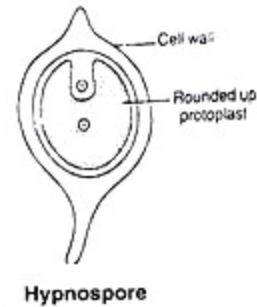
2. Aplanospores:

- Formed slightly under unfavorable conditions (e.g. *C. caudata*).
- The parent cell loses flagella.
- The protoplast rounds off and secretes a thin wall outside
- These non-motile structures are called aplanospores.
- On favourable conditions: May germinate either directly or divide to produce zoospores.



2. Hypnospores:

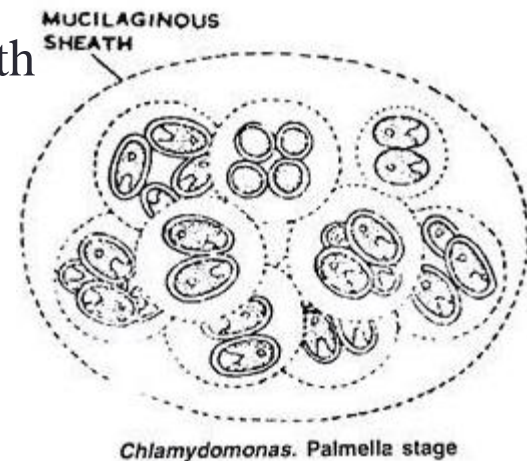
- In extreme unfavorable conditions the protoplast develops thick wall
- The structure developed is called Hypnospore (e.g. *C. nivalis*).
- On favourable conditions: germinate like aplanospores.



Asexual Reproduction....

4. Palmella Stage:

- Under unfavorable conditions (shortage of water, excess of salts etc), the protoplast of parent cell divides to make many daughter protoplasts but they **do not form zoospores**.
- The parent cell wall gelatinizes to make mucilaginous sheath around daughter protoplasts.
- The daughter protoplasts also develop **gelatinous wall** around themselves but do not develop flagella.
- These protoplast segments are called *palmellospores*.
- The division and redivisions of these protoplast ultimately forms amorphous colony with indefinite number of spores and it is called *palmella stage*.
- Under favourable conditions:
 - the gelatinous wall is dissolved,
 - palmellospores develop flagella, and
 - the spores are released to make new thalli.

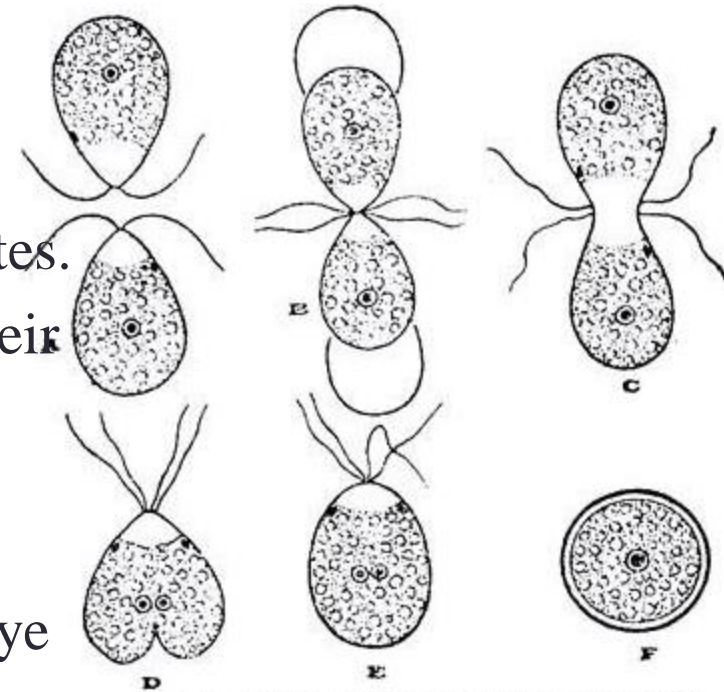


Sexual Reproduction:

- It can be isogamous, anisogamous or oogamous.
- Thallus can be
 - Homothallic: both types of gametes are produced in same thallus e.g., *C. mogama* and *C. media* or
 - Heterothallic i.e., (+) and (-) gametes come from different parents,
- The gametes may be
 - Naked: called *gymnogametes* e.g., *C. debaryana* or
 - Covered by cell wall called *calyptogametes* e.g., *C. media*.

Isogamy:

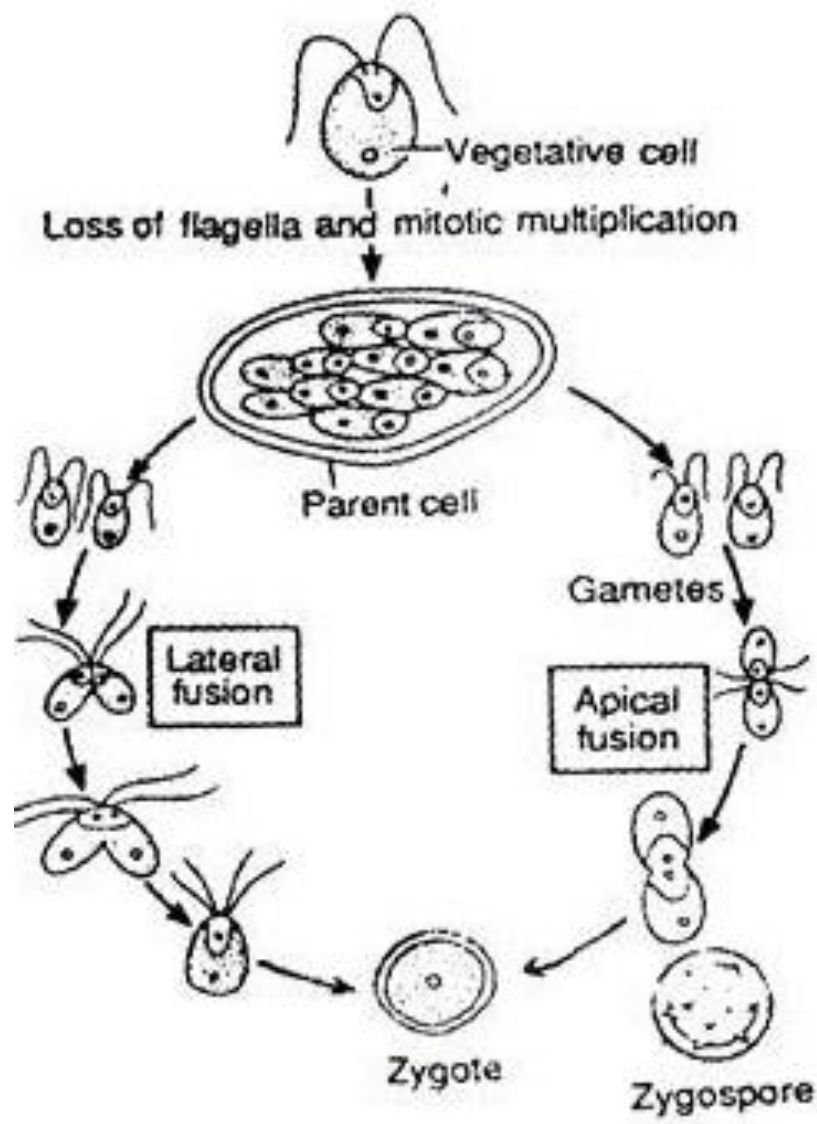
- Most are isogamous in nature.
- The fusing gametes are similar in size, shape and structure (morphologically similar).
- The vegetative cells may directly function as gametes without undergoing any division: *C. snowiae* (hologamy).
- The thalli shed their walls and function as gametes.
- The two gametes come close to each other by their anterior ends and later fusion proceeds to lateral sides.
- The fusion product is quadri flagellate and binucleate structure with two pyrenoids and two eye spots.
- The quadri flagellate zygote remains motile for several hours to few days.



Chlamydomonas. Isogamous sexual reproduction

- **Process:**

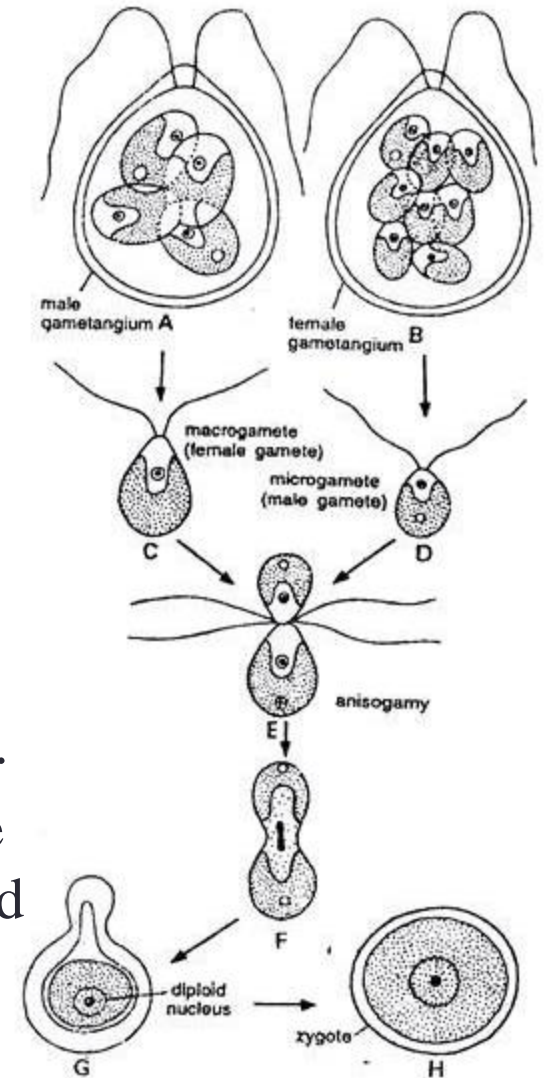
- The protoplast divides by repeated longitudinal mitotic divisions to produce 8-16-32 or 64 daughter protoplasts.
- Each daughter protoplast develops a pair of flagella and transforms into gamete.
- The gametes are liberated by breaking the wall of gametangium.
- The flagella of gametes are covered by agglutins and secrete a hormone called ***gamone***.
- These chemical substances are involved in the recognition of gametes of the opposite strains.
- In heterothallic species (+) and (-) strain gametes cluster together and this phenomenon is called **clumping**.
- The gametes of opposite strain fuse by anterior end i.e., apical fusion or laterally i.e., lateral fusion.
- The paired gametes move away from the clump.
- The wall at the place of contact dissolves and fertilization takes place in two steps—plasmogamy and karyogamy.
- In plasmogamy the fusion of cytoplasm and in karyogamy the fusion of nuclei takes place.
- After fertilization a quadriflagellate zygote is formed.
- The zygote later on loses flagella and gets covered by a thick wall and is now called **zygospore**.



Chlamydomonas. Isogamous reproduction.

Anisogamy

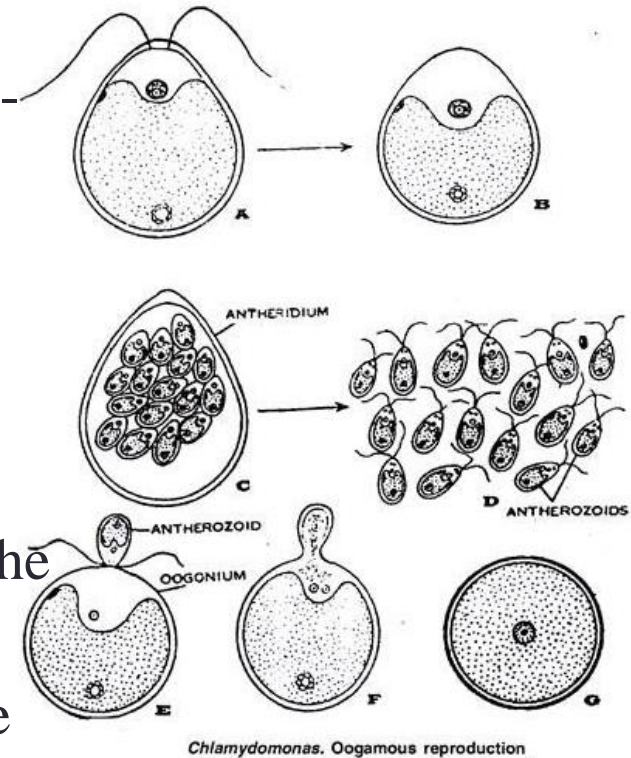
- The gametes are unequal in size.
- in *C. braunii* and *C. suboogama*
 - The male gametes (microgametes): smaller
 - The female gametes (macrogametes): are larger
- The macrogametes: formed in female gametangium in which the protoplast divides to make 2 to 4 gametes only.
- The microgametes: formed in male gametangium where the protoplast divides to make 8-16 gametes.
- The microgametes are more active than macrogametes.
- The microgametes come close to the macrogamete, the protoplast of microgamete enters into macrogamete and after fusion a diploid zygote is formed.
- The zygote secretes a thick wall and transforms into zygospore.



Chlamydomonas Anisogamous reproduction.

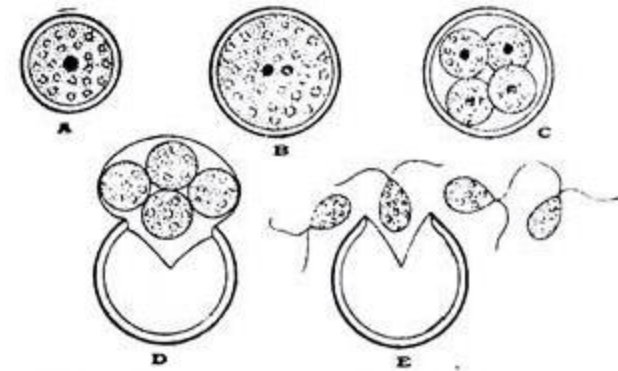
Oogamy:

- *C. coccifera* and *C. ooganum*.
- The vegetative thallus functioning as female cell withdraws its flagella and directly functions as non-motile macrogamete or egg.
- The female gamete contains many pyrenoids.
- The microgametes: formed by four divisions of protoplast.
- The microgamete reaches the female gamete and unites by anterior ends. The contact wall between the two dissolves.
- After plasmogamy and karyogamy a diploid zygote is formed.
- The zygote secretes a thick wall and transforms into zygospore.



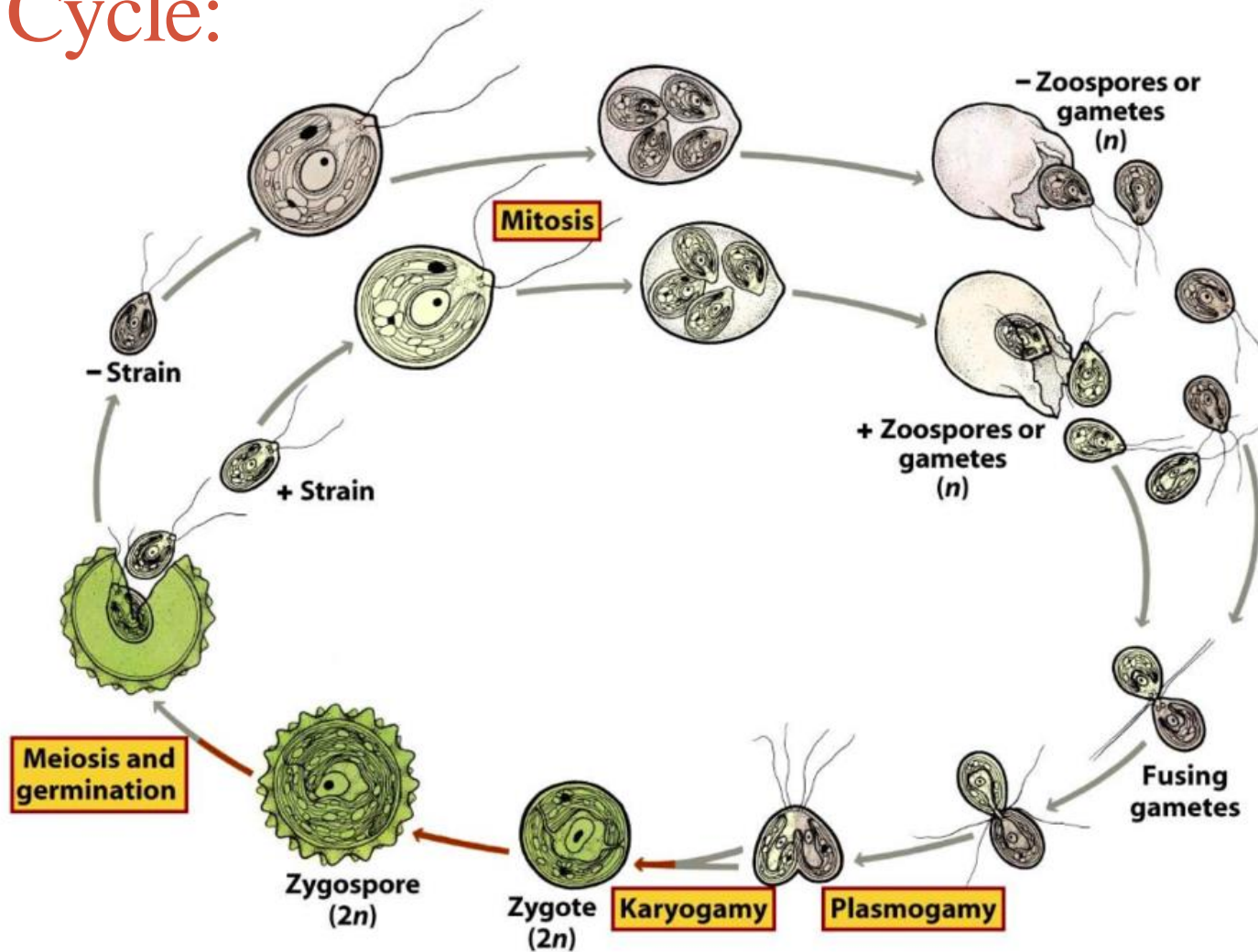
Zygote/Zygospore:

- The zygote secretes a thick wall which is smooth or ornamented.
- It accumulates large amount of oils and starch.
- The zygospores are red in colour due to the presence of **haematochrome**.
- The zygospore survives long period of unfavorable conditions and germinates on approach of favourable season.
- When the resting period is over and the favourable conditions reappear the zygospore germinates.
- Its diploid nucleus divides by **meiosis** to make four haploid nuclei.
- The four daughter protoplasts, each with one haploid nucleus, form four haploid zoospores or meiozoospores.
- Each zoospore contains neuro-motor apparatus, eye spot, two flagella and contractile vacuoles.
- In 4 zoospores two may be of (+) type and two (-) type in heterothallic forms.



Chlamydomonas. Germination of zygospore

Life Cycle:



Chlamydomonas life cycle