Lecture -7-

Pyrrophyta (Dinoflagellates)

1-General features

A-species, including toxic forms, but toxic forms unknown in freshwater lakes Wide variety of marine.

B-Not commonly dominant in lakes but can be important, e.g. under ice in winter and at various times of year in large, oligotrophic lakes. Most are motile. Typically slow growing, some are mixotrophic (bacterivores).

C-Habitat: A majority of the dinoflagellates are marine, and they are often abundant in the plankton, but some occur in fresh water.

D-Forms: Mostly unicellular, branched filamentous and motile.

E-The cell wall has stiff cellulose plates on the outer surface.

F-Most of them have two flagella; one lies longitudinally and the other transversely in a furrow between the wall plates.

G-Nutrition: Photosynthetic and reserve food is starch and oil.

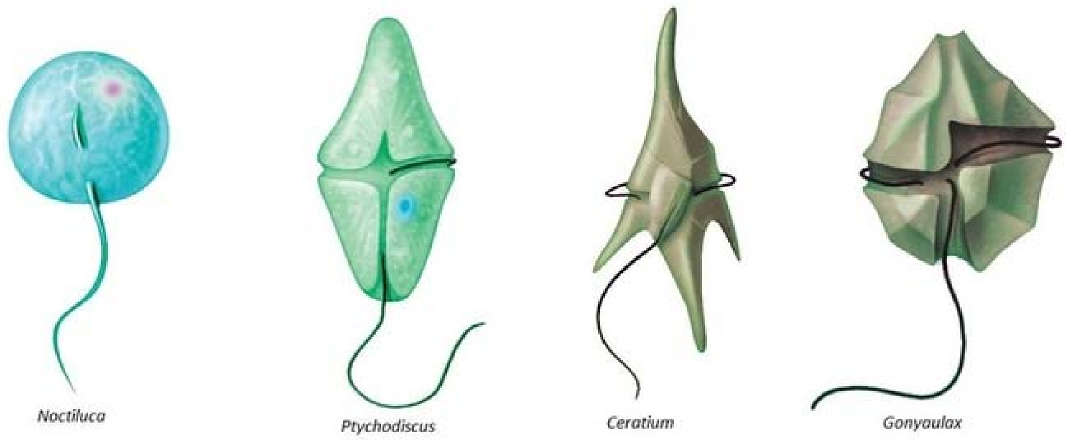
H-Pigments: They appear yellow, green, brown, blue or red depending on the main pigments present in their cells. Most have chlorophylls a and c, in addition to carotenoids.

I-Locomotion: Most of have two flagella. The flagella are usually located within grooves, one encircling the body like a belt, and the other perpendicular to it. By beating in their respective grooves, these flagella cause the dinoflagellate to rotate like a top as it moves.

J-Flagellates with hard ‘armour’ covering (tends to be inedible – large and spiny)

K-Reserve food material: Starch and Fat.

L- Reproduction: Sexual reproduction isogamous type (rare).



Dinoflagellates are a large group of flagellate protists. Most are marine plankton, but they are common in fresh water habitats as well. Their populations are distributed depending on temperature, salinity, or depth. Many dinoflagellates are known to be photosynthetic, but a large fraction of these are in fact mixotrophic, combining photosynthesis with ingestion of prey. In terms of number of species, dinoflagellates form one of the largest groups of marine eukaryotes, although this group is substantially smaller than the diatoms. Some species are endosymbionts of marine animals and play an important part in the biology of coral reefs. Other dinoflagellates are colorless predators on other protozoa, and a few forms are parasitic (see for example Oodinium, Pfiesteria). Some dinoflagellates produce resting stages, called dinoflagellate cysts or dinocysts, as part of their life cycles.

2-Dinoflagellates Classification

Although classified as eukaryotes, the dinoflagellate nuclei are not characteristically eukaryotic, as they lack histones, nucleosomes and maintain continually condensed chromosomes during mitosis. In fact, Dodge (1966) termed the dinoflagellate nucleus as ‘mesokaryotic’, due to its possession of intermediate characteristics between the coiled DNA areas of prokaryotic bacteria and the well-defined eukaryotic nucleus. This group, however, does contain typically eukaryotic organelles, such as Golgi bodies, mitochondria and chloroplasts. Dinophyceae into following six orders: 1. Desmomonadales, 2. Thecatales, 3. Dinophysiales, 4. Dinoflagellata, 5. Dinococcales, 6. Dinotrichales

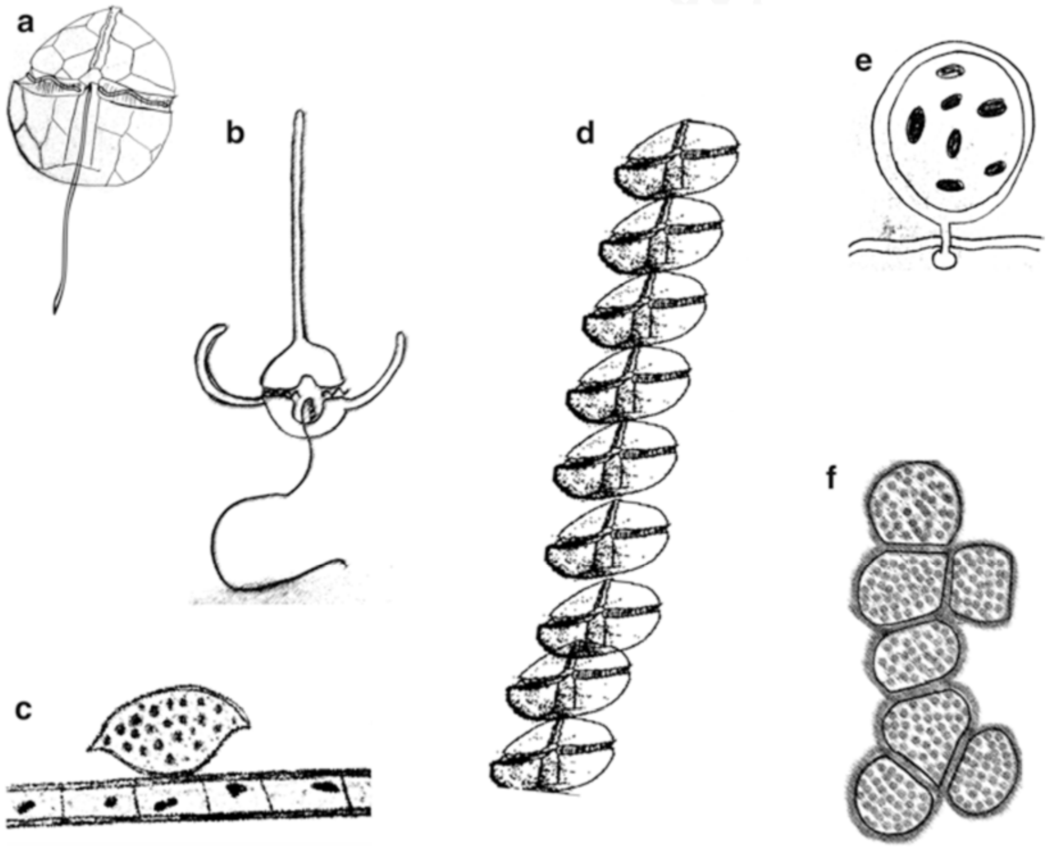


Figure 1: Thallus organization in Pyrrophyta: (a) Peridinium (b) Ceratium (c) Dinococ*cus* as an epiphyte on *Melosira* (diatom) (d) *Gonyaulax* (e) *Stylodinium* as an epiphyte on *Oedogonium* (f) *Dinothrix*

2-Dinoflagellates Morphology

Dinoflagellates cells consist of two parts, an anterior or top epicone/epitheca and a posterior hypocone/hypotheca which are separated by cingulum Dinoflagellate's beautiful and ornamental covering resemble superficially with diatoms as the two groups differ in both structure and chemical composition. The cell covering in dinoflagellates (also known as amphiesma or armour) is a useful means of subdivision this group. In many species each alveolus contains a flat thecal plate composed of cellulose (armored or thecate), whereas in other species alveoli are devoid such content (naked or unarmored). The distinction of naked and armored dinoflagellates is not absolute due to presence of some transitional types of cell covering. Basic structure of all dinoflagellate's amphiesma remain same, consisting of several layers of membrane: an outermost continuous membrane, flattened vesicles and an innermost continuous membrane sometimes interpreted to be the plasmalemma The dinoflagellates armour is divided into an upper (apical) and a lower (antapical) half, and consist of polygonal plates, which fit tightly against each other The wall of armored dinoflagellates is arranged in thecal plates followed by pellicle and plasmalemma. The number and arrangement of plates in the theca are one of the most useful criteria in the systematics of armored dinoflagellates. Although relatively rare, scales occur outside the plasma membrane in some dinoflagellates.

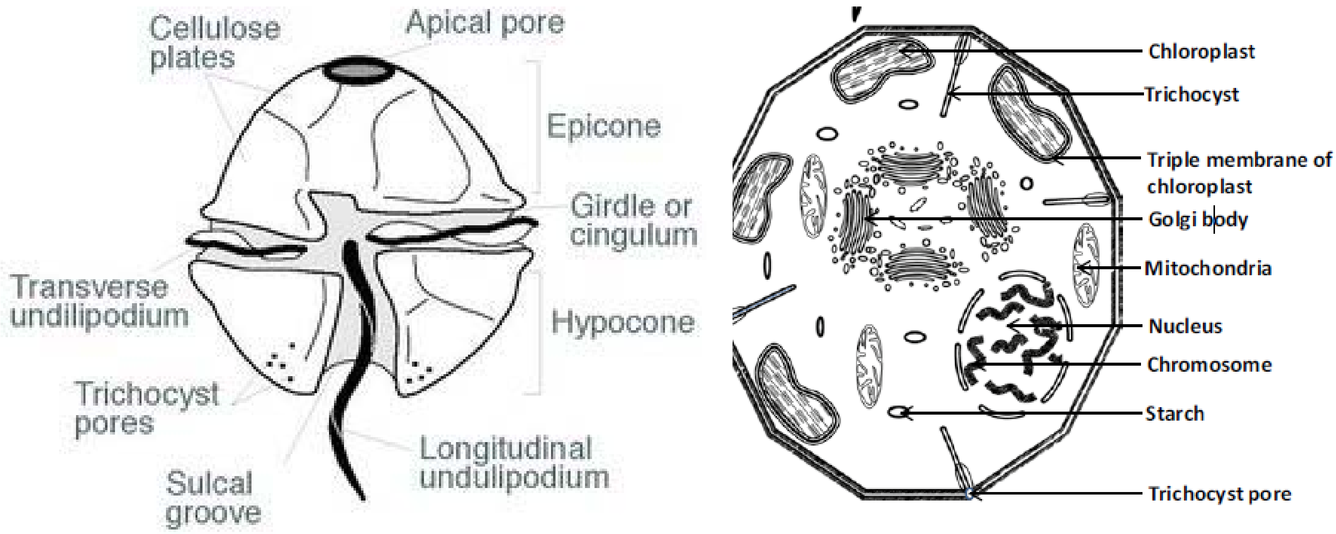


Figure2: General Structure of Dinoflagellates

3- some of the unusual features of dinoflagellates

1-**Trichocysts** :are rodlike, proteinaceous body and discharged into medium by a rapid hydration process. Trichocysts may be upto 100/cell. These structures are very similar to the Trichocysts of ciliate protozoa, except that the protozoan Trichocysts capped with a spine. Trichocysts develop within the Golgi apparatus and are produce within a sac. According to some experts trichocysts release cause a jet-propulsive response that is useful in escaping from predator because after discharge they become much longer and thinner. Relatively simple sacs that release mucilage to the cell exterior known as mucocysts .

2-**Nematocysts or cnidocysts**: (comparable structure to Coelenterata) are elaborate ejectile organelles of Nimatodinium and Polykrikos. They may be upto 8–10/cell.

3-**Peduncle**: an extendable organelle, composed of compact rows of microtubules and other structure, emerges at the junction of sulcus and cingulum.

4- **Muciferous bodies** are present just beneath the cell membrane

4-Life cycle and Reproduction

Dinoflagellates have a haplontic life cycle - with the possible exception of Noctiluca and its relatives. The life-cycle usually involves asexual reproduction by means of binary fission, either through desmoschisis or eleuteroschisis. More complex life cycles occur, more particularly with parasitic dinofagellates. Sexual reproduction also occurs and is only known in a small percentage of dinoflagellates. This takes place by fusion of two individuals to form a zygote, which may remain mobile in typical dinoflagellate fashion and is then called a planozygote. This zygote may later form a resting stage or hypnozygote, which are called dinoflagellate cyst ordinocyst. After (or before) germination of the cyst, the hatchling undergoes meiosis to produce new haploid cells.

Fig. 3: Examples of planozyotes, which are characterized by two longitudinal flagella (arrows) instead of one, in *Alexandrium minutum* (left) and *Alexandrium taylori* (right)

Asexual reproduction can happen much more quickly, and therefore is the predominant way of reproduction during optimal environmental conditions, but sexual reproduction is essential for species adaptation and survival because it allows for genetic recombination (i.e. genetic variability). During the sexual phase, two haploid cells called gametes fuse to form a diploid mobile zygote (planozygote) that will undergo meiosis to restore the vegetative stage.

The most common pathway reported until very recently was the transition of the planozygote to a quiescent, environmentally resistant stage known as resting cyst (a dormant not motile hypnozygote with a thick wall). Other types of quiescent stages are cysts with a thin wall and less capacity to withstand adverse environmental conditions than the resting cysts. These cysts - found in the bibliography with different names such as temporal, pellicle or ecdysal cysts - can be sexual or asexual, this last case being the fastest way to produce a cyst.

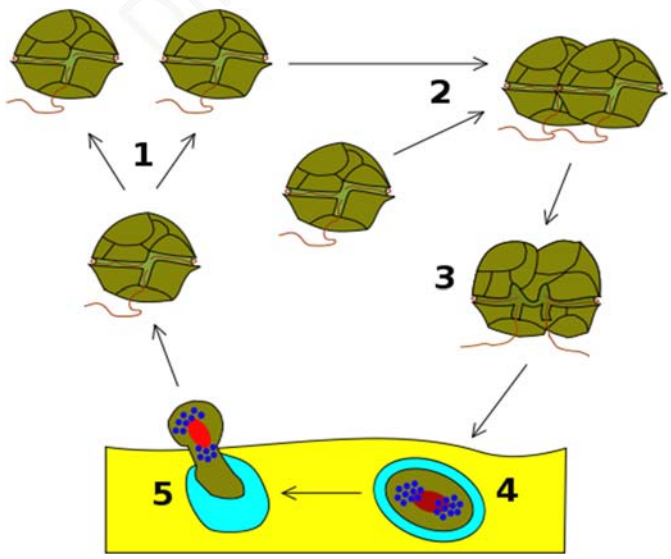


Fig.4:Dinoflagellates Life Cycle. 1-Binary fission, 2-Sexual reproduction, 3-planozygote, 4-hypnozygote, 5-planomeiocyte.

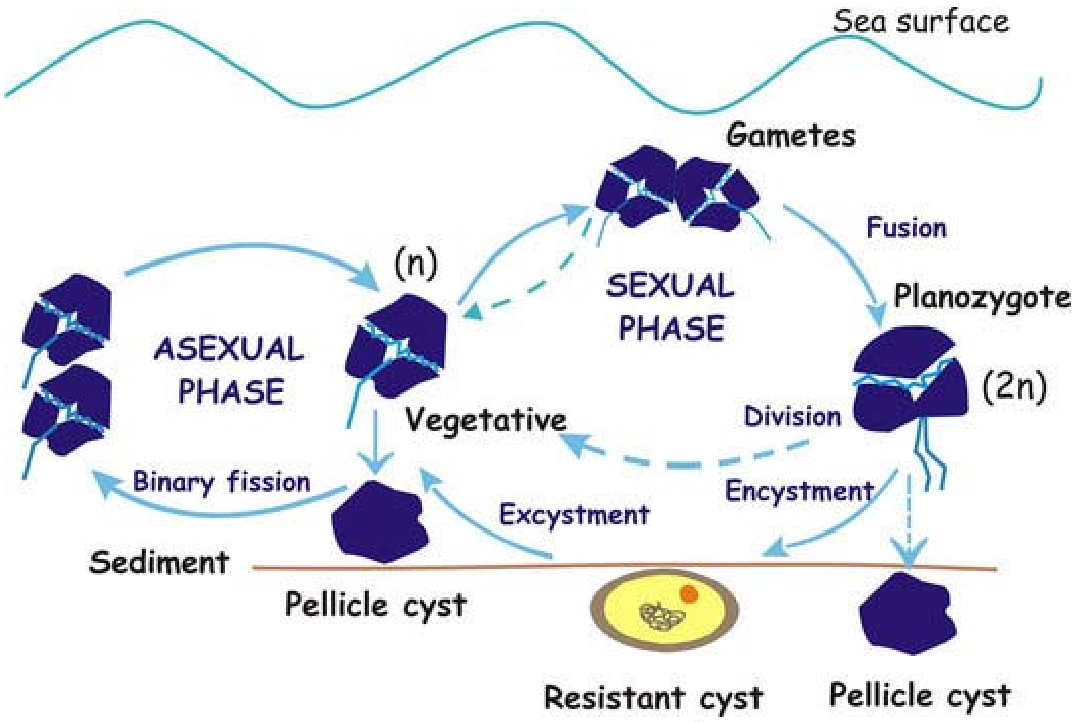


Figure 5 : Dinoflagellates Life Cycle in details.

4-Dinoflagellates harmful blooms

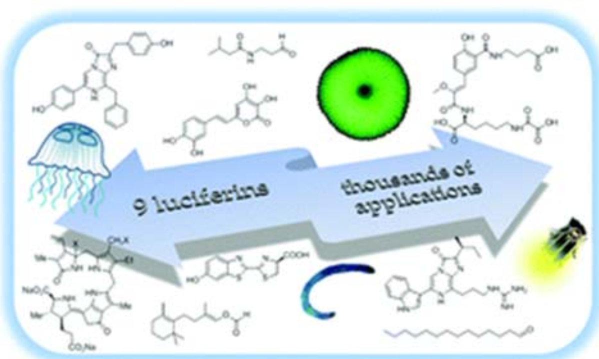
Dinoflagellates sometimes bloom in concentrations of more than a million cells per millilitre. Some species produce neurotoxins, which in such quantities kill fish and accumulate in filter feeders such as shellfish, which in turn may pass them on to people who eat them. This phenomenon is called a red tide, from the color the bloom imparts to the water. Some colorless dinoflagellates may also form toxic blooms, such as Pfiesteria. Some dinoflagellate blooms are not dangerous. Bluish flickers visible in ocean water at night often come from blooms of bioluminescent dinoflagellates, which emit short flashes of light when disturbed. red tide mentioned is more specifically produced when dinoflagellates are able to reproduce rapidly and copiously on account of the abundant nutrients in the water. Although the resulting red waves are an unusual sight, they contain toxins that not only affect all marine life in the ocean, but the people who consume them, as well. A specific carrier is shellfish. This can introduce both nonfatal and fatal illnesses. One such poison is saxitoxin, a powerful paralytic. Human inputs of phosphate further encourage these red tides, so there is a strong interest in learning more about dinoflagellates, from both medical and economic perspectives.

Figure 6:Red tide

4-Dinoflagellates Bioluminescence

At night, water can have an appearance of sparkling light due to the bioluminescence of dinoflagellates. More than 18 genera of dinoflagellates are bioluminescent, and the majority of them emit a blue-green light.

These species contain scintillons, individual cytoplasmic bodies (ca. 0.5 µm in diameter) distributed mainly in the cortical region of the cell, outpockets of the main cell vacuole.



They containdinoflagellate luciferase, the main enzyme involved in dinoflagellate bioluminescence, and luciferin, a chlorophyll-derived tetrapyrrole ring that acts as the substrate to the light-producing reaction. The luminescence occurs as a brief (0.1 sec) blue flash (max 476 nm) when stimulated, usually by mechanical disturbance. Therefore, when mechanically stimulated—by boat, swimming or wavesThe luciferin-luciferase reaction responsible for the bioluminescence is pH sensitive. When the pH drops, luciferase changes its shape, allowing luciferin, more specifically tetrapyrrole, to bind. Dinoflagellates can use bioluminescence as a defense mechanism. They can startle their predators by their flashing light or they can ward off potential predators by an indirect effect such as the burglar alarm. The dinoflagellate can use its bioluminescence to attract attention to itself, thereby bringing attention to the predator and making the predator more vulnerable to predators from higher trophic levels.

$$\text{Luciferin} + O2 \xrightarrow{\text{Luciferin}} (P)^{*} \rightarrow P + h\nu$$

Figure 7: Dinoflagellates Bioluminescence

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