**Lecture 4 - (7/10/2024)**

**Life Cycle:**

Most algae found in nature are haploid (n), but diatoms are diploid (2n). The haploid generation, commonly known as the gametophytic generation, is primarily the gamete-producing phase. In contrast, the diploid generation (2n), or sporophytic generation, is mainly the spore-producing phase. The presence of both phases is integral to the life cycle. Depending on whether the haploid or diploid phase is dominant, the life cycle is classified as haplontic or diplontic, respectively.

The sequence of events through which an organism passes from zygote to the zygote of the next generation is called the life cycle pattern. However, in higher plants, there is no regular and fixed alternation of generations. Blue-green algae and certain Chlorophyceae (e.g., Protococcus) are exceptions where sexual reproduction is completely absent, and they reproduce asexually only, resulting in no alternation of generations. In algae, the following types of life cycles are present, which we will study in detail:

**1. Haplontic Life Cycle:**

This is the simplest and most primitive type of life cycle. Other patterns of life cycles have originated from this type. In most members of Chlorophyceae, the haplontic type of life cycle is present. The main plant body is thalloid and may be unicellular, multicellular, or colonial. It bears gametes in the gametangium and is thus called the gametophyte (n).

In the haplontic life cycle, the major portion of the life cycle is haploid, while the diploid (2n) phase is only represented by the zygote, which is formed by the fusion of gametes. The zygote immediately undergoes meiosis, or reduction division, into four haploid zoospores or meiospores, which develop into individual plants. An example of a haplontic life cycle is seen in Chlamydomonas (a unicellular alga) and most multicellular algae like ***Oedogonium, Chara***

**2. Diplontic Life Cycle:**

As the name indicates, in a diplontic type of life cycle, the dominant phase is diploid or 2n, also known as the sporophyte. This type of life cycle is the reverse of the haplontic type. Here, the somatic phase or main plant body is diploid (2n). It bears sex organs (2n), which after reduction division, produce gametes. Thus, meiosis or reduction division occurs at the time of differentiation of gametes in the sex organs. Therefore, it is called gametogenic meiosis.

In these organisms, the haploid condition is limited to the gametes only. The zygote, after mitotic division, develops into the sporophyte. The adult or main plant is sporophytic (2n). The sporophytic plant in the life cycle alternates with a few haploid cells, the gametes. Such a life cycle is called diplontic. The characteristic of this life cycle is the presence of gametogenic meiosis. Immediately after gametic union, the sporophytic or diploid phase is re-established. This type of life cycle occurs in many diatoms (Bacillariophyceae), and other examples are Fucus, Sargassum (Brown algae), etc. According to Drew (1955), the haplontic and diplontic life cycles can be considered monomorphic or monogenic types, as only one vegetative type of individual is dominant as haploid or diploid in their life cycles.

**3. Diplohaplontic Life Cycle:**

In the previous life cycles, i.e., haplontic and diplontic, only one vegetative phase, either gametophytic or sporophytic, is present in the life cycle. However, in the diplohaplontic life cycle, there is an alternation of two distinct vegetative individuals with not only different chromosome numbers but also different functions. One of these individuals is haploid or gametophyte, concerned with sexual reproduction. The other is diploid or sporophyte, which after meiosis, produces meiospores. This type of life cycle, which consists of the alternation of two vegetative individuals, the gametophyte and the sporophyte, with sporogenic meiosis, is called the diplohaplontic life cycle. It is also called a diphasic life cycle.

The diplohaplontic life cycle is of two types:

**(a) Isomorphic Diplohaplontic Life Cycle:**

In this type of life cycle, there is an alternation of two generations that are externally similar, but one is haploid (gametophyte), producing gametes, and the other is diploid (sporophyte), producing zoospores. The zygote germinates directly into a 2n plant without undergoing reduction division or meiosis, forming a sporophytic plant morphologically similar to the gametophytic plant. Meiosis occurs in the sporangia present on the 2n plant. In Cladophorales and Ulvales, it occurs in zoosporangia, while in Ectocarpus, it occurs in unilocular or unicellular sporangia. This type of meiosis is also known as sporogenic meiosis as it occurs in zoosporangia. The haploid zoospores thus formed grow into new haploid plants. Sex organs (gametangia) develop on the haploid plant and give rise to haploid gametes. The haploid gametes fuse to form a diploid zygote (e.g., ***Ulva, Cladophora, Ectocarpus, Dictyota***, etc.).

**(b) Heteromorphic Diplohaplontic Life Cycle:**

In this life cycle, as the name indicates, both sporophyte (2n) and gametophyte (n) plants are morphologically distinct and alternate with each other. Mostly, the sporophytic plant is larger in comparison to the gametophytic plant. In Laminaria, the sporophyte is several meters long and bears diploid sporangia. This macroscopic diploid plant bears zoosporangia, which after sporogenic meiosis, produce haploid meiospores. These spores germinate into minute gametophytes or haploid plants that produce gametes. These gametes, after fusion, develop into a zygote that directly develops into a diploid sporophytic plant (2n).

In general, we can conclude that sexually reproducing algae complete their life cycle by passing through two distinct phases:

1. **The Gametophytic Phase (n):** Concerned with the production of gametes.
2. **The Sporophytic Phase (2n):** Concerned with the production of spores.

These two phases alternate with each other in a regular sequence, known as **alternation of generations**.

**Classification of Algae:**

For the classification of algae, certain suffixes have been recommended by the Committee of the International Code for Nomenclature. These are:

* **phyta** for division
* **phyceae** for class
* **ales** for order
* **aceae** for family
* **oideae** for sub-family

With advancements in techniques such as biochemistry, physiology, biotechnology, and electron microscopy, different criteria and modern concepts have been developed to classify algae. These include:

1. **Nuclear organization**
2. **Cell wall components**
3. **Pigmentation**
4. **Flagellation**
5. **Chemical nature of reserve food material**
6. **Type of life cycles**

G. M. Smith (1955) modified the classification of Pascher (1914-1931), dividing algae into **8** divisions, further divided into classes as follows:

1. **Cyanophyta** (one main class)
2. **Chlorophyta** (two main classes)
3. **Chrysophyta (**three main classes)
4. **Euglenophyta** (one main class)
5. **Pyrrophyta** (two main classes)
6. **Phaeophyta** (one main class)
7. **Rhodophyt**a (one main class)
8. **Rhodophyta** (one main class )

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**Division: Cyanophyta 0r Myxophyta (Cyanobacteria)**

**Class: Cyanophyceae (Blue-green algae)**

**Cyanophyceae** or **Myxophyceae** – The members are called blue-green algae. Mostly, the members of this division are freshwater in habitat. A few species are found in marine habitats. Some species like *Nostoc* and *Oscillatoria* grow in terrestrial habitats. Members are prokaryotic. The thallus is simple, comprising unicellular, colonial, or multicellular bodies. Pigments are not organized into bodies as in other cases. Principal pigments include chlorophyll a, α-carotene, β-carotene, xanthophylls, and phycobilins (c-phycocyanin and c-phycoerythrin). The color of the algae is due to the presence of excess c-phycocyanin. The reserve food material is cyanophycean starch. The cell wall is composed of mucopeptide. Most members are embedded in a mucilaginous sheath. False branching and special cells, heterocysts, are characteristics of several members. Sexual reproduction is absent; only vegetative and asexual reproduction occur. Motile cells are altogether absent in the life cycle, as in the vegetative cells. In some members of this division, a special type of cell known as heterocyst is present. Heterocysts are considered nitrogen-fixing in blue-green algae. The class Cyanophyceae is classified into five main orders:

a) **Order: Chroococcales**

b) **Order: Chamaesiphonales**

c) **Order: Pleurocapsales**

d) **Order: Nostocales**

e) **Order: Stigonematales**

**Description Some Common Genera**

**Order: Nostocales**

**Family: Oscillatoriaceae**

**Genus: *Oscillatoria***

1. Filaments occur either singly or interwoven to form a flat or spongy, free-swimming mat.
2. The filament consists of a recognizable sheath enclosing an unbranched trichome.
3. The trichome consists of a single row of cells.
4. The apical cell of the trichome may have calyptra – a thick wall on its outer free face.
5. The cells show no definite nucleus (prokaryotic cell).
6. Floating species show numerous gas vacuoles.
7. Methods of reproduction include vegetative reproduction by fragmentation and hormogone, which result from the separation discs.
8. Each hormogone develops into a new filament.

**Family: Nostocaceae**

**Genus: *Nostoc***

1. Thallus is colonial. Young colonies are microscopic, spherical, and solid.
2. It is terrestrial as well as aquatic.
3. The colonial envelope encloses many filaments.
4. A filament has a diffluent gelatinous sheath.
5. The trichomes are unbranched. Each trichome is made of cells of uniform size and shape, except for those called heterocysts.
6. Heterocysts are intercalary and slightly larger than the vegetative cells.
7. Only vegetative reproduction is reported in this genus, including fragmentation, hormogonia, akinetes, heterocysts, and endospores.
8. Akinetes are thick-walled, located between two heterocysts sometimes, rich in food reserves. They are liberated due to the decay of the colonial thallus and germinate into a new thallus.

**Family: Scytonemataceae**

**Genus: *Scytonema***

1. The trichomes are enveloped in a sheath.
2. Filaments show false branching, with branches being single or geminate (in pairs).
3. This genus is usually found in sub-aerial habitats such as damp walls and the bark of trees.
4. The trichome is covered by an individual sheath, which may be hyaline or colored. It may be homogeneous or lamellated.
5. Heterocysts occupy intercalary positions. They may be single, in twos, or threes. Lateral branches are generally produced between heterocysts.
6. Some species grow best on soil, while others thrive on rocky cliffs.

**Order: Chroococcales**

**Family: Chroococcaceae** (e.g., *Chroococcus*, *Merismopedia*)

**Order: Chamaesiphonales**

**Family: Chamaesiphonaceae** (e.g., *Chamaesiphon*)

**Order: Pleurocapsales**

**Family: Pleurocapsaceae** (e.g., *Pleurocapsa*)

**Order: Stigonematales**

**Family: Stigonemataceae** (e.g., *Stigone*ma)