**Lecture – 3 (30/9/2024)**

**Reproduction in Algae**

Before discussing the life cycle patterns in algae, it is necessary to understand the various processes of reproduction, especially sexual reproduction. Algae reproduce through three primary methods: vegetative, asexual, and sexual.

**A) Vegetative Reproduction:**

Vegetative reproduction generally occurs under favorable conditions. Any portion of the thallus (plant body) may detach from the parent and develop into a new individual without any apparent change in genetic constitution. It occurs through the following mechanisms:

1. **Cell Division:**

This is the simplest method of propagation and is usually common in unicellular forms of algae (e.g., *Microcystis*, *Chlorococcus*). In this process, the algal cell divides mitotically to form two daughter cells, each of which eventually grows into an independent organism.

1. **Fragmentation:**  
   This process is common in filamentous forms where the thallus breaks into small fragments (e.g., *Spirogyra*, *Ulothrix*). Fragmentation may result from mechanical pressure, accidental breakage, or the formation of a separation disc.
2. **Hormogonia:**  
   This is a specialized method of vegetative propagation characteristic of blue-green algae. The trichomes (filaments) of many filamentous genera regularly multiply by breaking into short fragments called hormogonia. The formation of hormogonia occurs either due to the formation of heterocysts or the formation of a separation disc (e.g., *Oscillatoria*, *Nostoc*).
3. **Amylum Star:**

Some nodal cells on the lower node of the plant proliferate and develop special star-shaped, starch-filled bodies known as amylum stars (e.g., *Chara*), which are capable of forming a new plant.

1. **Protonema:**  
   Secondary protonema develops either from the rhizoidal node of primary protonema or from the basal node of the primary rhizoid. Secondary protonema develops into a new plant, similar to the primary protonema (*Chara*).
2. **Adventitious Branches:**

In some genera, adventitious branches develop from the nodal cell or storage part of the thallus. When detached from the parent plant, they can form a new plant (e.g., *Chara* and *Fucus*).

**B) Asexual Reproduction:**

Asexual reproduction generally occurs under favorable conditions. In prokaryotic algae (Cynophyceae), sexual reproduction is absent, and asexual reproduction is the only means of propagation. It is uniparental, meaning that male and female parents are not required, and cell division is always mitotic. In asexual reproduction, the protoplast is released from the cell to form spores, which develop into new individuals. The cell that produces the spores is called the sporangium. Ordinary vegetative cells (e.g., *Chlamydomonas*) or specially modified cells can become sporangia. Spores inside sporangia may be motile or non-motile.

Based on their structure, spores can be classified as follows:

1. **Zoospore:**  
   Zoospores are motile, naked structures with two, four, or many flagella. These flagella are usually inserted anteriorly but may be lateral in some brown algae. Zoospores are produced in a zoosporangium and can form in both unicellular and filamentous algae (e.g., *Chlamydomonas*, *Ulothrix*, *Oedogonium*, *Ectocarpus*). In Xanthophyceae, the zoospore is known as a synzoospore, which is a multinucleated structure with numerous pairs of flagella. Motile spores are absent in classes Cyanophyceae and Rhodophyceae.
2. **Aplanospore:**  
   Aplanospores are non-motile spores commonly found in terrestrial algae and some aquatic algae. Each cell may form a single aplanospore, or its protoplast may divide to form many aplanospores (e.g., *Ulothrix*, *Vaucheria*).
3. **Hypnospore:**  
   Aplanospores of some algae secrete thick walls to withstand prolonged desiccation. These thick-walled aplanospores are called hypnospores. Under favorable conditions, hypnospores germinate and grow into new individuals, or their protoplasts may form zoospores. The hypnospores of *Chlamydomonas nivalis* are red due to the deposition of the pigment haematochrome in their cell walls (e.g., *Chlamydomonas*, *Sphaerella*).
4. **Tetraspores:**  
   Diploid plants (sporophytic stage) of some algae form aplanospores that are four in number and are called tetraspores (e.g., *Polysiphonia*).
5. **Autospore:**  
   When aplanospores are morphologically similar to the parent cell, except in size, they are called autospores (e.g., *Chlorella*).
6. **Akinete:**  
   In some algae, vegetative cells develop into thick-walled, spore-like structures with abundant food reserves. These are called akinetes. They are resting cells meant for perennation rather than multiplication. Akinetes always have an additional wall layer and are resistant to unfavorable environmental conditions (*Anabeana*, *Pithophora*).
7. **Exospores:**  
   Exospores are formed externally. The protoplast of the cell emerges through a terminal pore and successively forms spherical spores (e.g., *Chamaesiphon*).
8. **Endospore:**  
   Endospores are non-motile and produced inside the sporangium by division of protoplasts. These are formed in certain members of the Cyanophyceae, such as *Dermocarpa*.

**C) Sexual Reproduction:**

Sexual reproduction in algae occurs under certain conditions:

* It takes place after considerable accumulation of food material, typically when the climax of vegetative activity is over.
* Bright light is a major factor for the production of gametes.
* A suitable pH value is required.
* The optimum temperature must be met.

Sexual reproduction involves the fusion of two specialized reproductive cells called gametes. The fusing gametes may come from the same parent (monoecious) or from two different parents (dioecious). The process of gamete fusion is called fertilization, and the product is called a zygote (a diploid structure).

Sexual reproduction involves three phases:

1. **Plasmogamy:**  
   Fusion of the cytoplasm.
2. **Karyogamy:**  
   Fusion of the nuclei of two different gametes/cells.
3. **Meiosis:**  
   Meiotic division in the zygote (a product of karyogamy) produces haploid cells.

Based on the structure and physiological behavior of the sex organs, three types of sexual reproduction have been reported in algae:

1. **Isogamy:**  
   The simplest type of sexual reproduction in algae is isogamy, where the fusion of two morphologically similar gametes occurs. Gametes are usually naked and always haploid. Gametes may be motile or non-motile.
2. **Heterogamy:**  
   In this process, the fusion occurs between morphologically and physiologically different gametes. Heterogamy is of two types:
   1. Anisogamy involves the fusion of dissimilar gametes, where the male gamete is more active and smaller (microgamete), while the female gamete is less active and larger (macrogamete) (e.g., *Chlamydomonas braunii*).
   2. Physiological anisogamy (Conjugation): Sometimes the fusing gametes are morphologically similar but physiologically different, (e.g., *Spirogyra*, *Zygnema*).
3. **Oogamy:**  
   Oogamy is the most advanced stage of sexual reproduction. In this process, the male gamete develops within the antheridium. The male gametes are active and smaller in size, while the female gamete or egg is formed within the oogonium, which is large and non-motile. The male gamete (antherozoid) fuses with the egg to form a zygote (e.g., *Chara*, *Vaucheria*).