Course- M.Sc. Botany Part -I Paper -I

Topic - **Algal Pigments and algal Classification(ALGAE)**

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The algae were broadly divided by F.F.Fritsch (1935) into eleven classes according to their colour -

1. Chlorophyceae or green algae
2. Xanthophyceae or yellow-green algae
3. Chrysophyceae
4. Bacillariophyceae or golden-brown algae
5. Cryptophyceae
6. Dinophyceae
7. Chloromonadineae
8. Eugleninae
9. Phaeophyceae or brown algae
10. Rhodophyceae or red algae, and
11. Myxophyceae or blue-green algae

Normally, classification of algae is based on -

1. Nuclear Organization
2. Nature of Cell Wall Components
3. Pigmentation and Photosynthetic Apparatus

The pigment is one of the most important criteria used in differentiation of classes in algae. The pigments in algae can be chlorophylls, carotenoids and biloproteins.

These pigments are present in sac like structures called thylakoids. The thylakoids are arranged in stacks in the granum of the chloroplasts. Different groups of algae have different types of pigments and organization of thylakoids in chloroplast.

The chlorophylls in algae are chlorophyll a, b, c, d and e types.

Chlorophyll a is present in all classes of algae.

Chlorophyll b is primary pigment of Chlorophyceae and Euglenineae.
Chlorophyll c is found in Phaeophyceae and Cryptophyceae.
Chlorophyll d is found in Rhodophyceae.
Chlorophyll e is confined to *Tribonema* of Xanthophyceae.
Pigments are chemical compounds which reflect only certain wavelengths of visible light. This makes them appear colourful. More important than their reflection of light is the ability of pigments to absorb certain wavelengths. Since each pigment reacts with only a narrow range of the spectrum, it is important for algae to produce pigments of different colours to capture more of the sun's energy.
The pigments found in algae are –

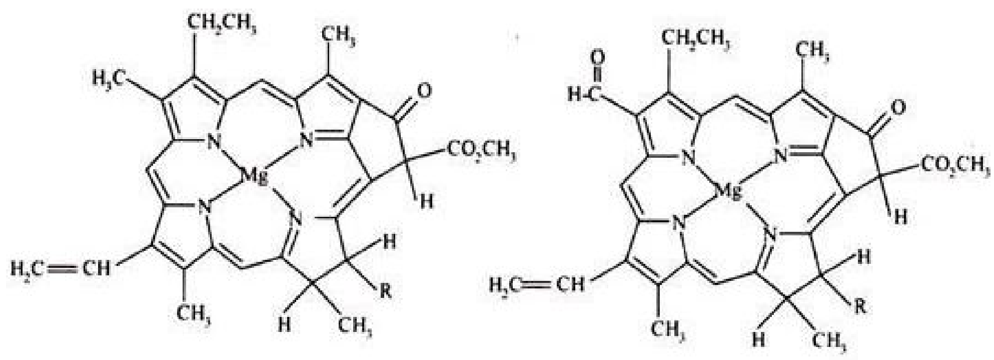
1. Chlorophyll
2. Xanthophyll
3. Fucoxanthin
4. Phycocyanin
5. Phycoerythrin

Chlorophylls are green pigments found in cyanobacteria and the chloroplasts of different algae. Chlorophylls absorb light most strongly in the blue portion of the electromagnetic spectrum followed by the red portion. There are different types of Chlorophyll pigments.Their structures are based on a chlorin ring at the center of which is a magnesium ion. The structure can have different side chains depending on the type of Chlorophyll.
Cholrophyll a: Chlorophyll a is the most widely occurring and universal type of Chlorophyll. Molecular formula of Chlorophyll a is C55H72O5N4Mg. Chlorophylls are green pigments with a porphyrin ring. Molecular structure consists of a chlorin ring with Mg center. The chlorin ring is a heterocyclic compound derived from pyrrole. Four nitrogen atoms from the chlorin surround and bind the magnesium atom. This is a stable ring-shaped molecule around which electrons are free to migrate. It also has side chains and a hydrocarbon trail. It ontains only methyl groups (CH3) as side chains with a long hydrophobic tail, which anchors the molecule to other hydrophobic proteins in the thylakoid membrane of the chloroplast. It absorbs light from red, blue and violet wavelengths and gets its colour by reflecting green.
It is used in oxygenic photosynthesis. This photosynthetic pigment is essential for photosynthesis in eukaryotes, cyanobacteria and prochlorophytes because of its

role as primary electron donor in the electron transport chain. Chlorophyll a also transfers resonance energy in the antenna complex, ending in the reaction center where specific chlorophylls P680 and P700 are present. Within the reaction centers of both photosystems, there are a pair of chlorophyll a molecules that pass electrons on to the transport chain through redox reactions

Chlorophyll b: Chlorophyll b occurs only in green algae. It absorbs most effectively at blue 470 but also at 430 and 640. Molecular formula is C55H70O6N4Mg. It is an accessory photosynthetic pigment. Molecular structure consists of a chlorin ring with Mg center. It also has side chains and a hydrocarbon (phytol) tail. Pyrrole ring II contains an aldehyde group (- CHO).

It absorbs energy that chlorophyll a does not absorb. It functions as a Light harvesting Antenna in Photosystem I.



Chlorophyll a

Chlorophyll b

Where R= $CH_2CH_2CO_2CH_2CH{=}C(CH_2CH_2CH_2CH)_3CH_3$ (with CH_3 branches)

Xanthophylls: They are yellow pigments that form one of the two major groups of the carotenoids. They are generally a C40 terpenoid compounds formed by condensation of isoprene units. They contain oxygen atoms. They contain their oxygen either as hydroxyl groups and/or as pairs of hydrogen atoms that are substituted by oxygen atoms acting as a bridge.

Xanthophyll acts as an accessory light harvesting pigment. They have critical structural and functional role in the photo synthesis of plants and algae. They also serve to absorb and dissipate excess light energy or work as antioxidants. They may be involved in inhibiting lipid peroxidation.

Fucoxanthin: It is a carotenoid which performs a limited role in the photosynthesis in Brown Algae (Phaeophyta). It is responsible for the brown or olive-green colour of these algae. Molecular formula is C42H58O6.

Fucoxanthin absorbs red light to perform photosynthesis. It is produced abundantly by *Laminalia japonica, Undaria pinnatifida, Sargassum fulvellum* etc.

It is a kind of xanthophyll being an oxygenated carotene. Brown algae have most species living in the ocean. They employ fucoxanthin for photosynthesis. The pigment is sensitive to shorter wavelengths of light. It is the main carotenoid produced in the brown algae as a component of the light harvesting complex.

Phycocyanin: It is a pigment-protein complex from the light- harvesting phycobiliprotein family along with the allophycocyanin and phycoerythrin. It is an accessory pigment to chlorophyll. Being water-soluble, these pigments cannot exist within the membrane like carotenoids.

Phycocyanin has a characteristic light blue color, absorbing orange and red light near 620 nm depending on its type and emits fluorescence at about 650 nm. Phycocyanins are found in Cyanobacteria.

Phycocyanin is related to the human pigment bilirubin which is important to healthy liver function and digestion of amino acids.

Phycoerythrin: It is a red protein-pigment complex from the light-harvesting phycobiliprotein family present in red algae and cryptophytes. It is accessory to the main chlorophyll pigments responsible for photosynthesis. It is composed of a protein part covalently binding chromophores called phycobilins. In the phycoerythrin family, the most known phycobilins are phycoerythrobilins which are typical Phycoerythrin. Other is phycourobilin.

Phycoerythrins are composed of (αβ) monomers usually organized in a disk-shaped trimer (αβ)3 or hexamer (αβ)6. In red algae, they are anchored to the stromal side of the thylakoid membranes of chloroplasts whereas in Cryptophytes, phycobilisomes are reduced and are densely packed inside the lumen of thylakoids.

Phycoerythrin is an accessory pigment to the main chlorophyll pigments responsible for photosynthesis. The light energy is captured by it and then passed on to the reaction centre chlorophyll pair usually via the phycobiliproteins phycocyanin and via allophycocyanin. R-Phycoerythrin and B- Phycoerythrin are among the brightest fluorescent dyes.