ALGAL PIGMENTS

Photosynthetic Pigments

Pigments are colorful compounds

- Pigments are chemical compounds which reflect only certain wavelengths of visible light. This makes them appear "colorful". Flowers, corals, and even animal skin contain pigments which give them their colors. More important than their reflection of light is the ability of pigments to absorb certain wavelengths
- Because they interact with light to absorb only certain wavelengths, pigments are useful to plants and other autotrophs - organisms which make their own food using photosynthesis
- In plants, algae and cyanobacteria, pigments are the means by which the energy of sunlight is captured for photosynthesis. However, since each pigment reacts with only a narrow range of the spectrum, there is usually a need to produce several kinds of pigments, each of a different color, to capture more of the sun's energy.

Basic classes of pigments

There are three basic classes of pigments

- ✓ **Chlorophylls (a, b, c)**
- ✓ **Carotenoids (carotin, xenthophyll)**
- ✓ **Phycobilins (phycocyanin, allophycocyanin, phycoerythrin)**

Chlorophylls

These are greenish pigments which contain a porphyrin ring

- This is a stable ring-shaped molecule around which electrons are free to migrate. Because the electrons move freely, the ring has the potential to gain or lose electrons easily, and thus the potential to provide energized electrons to other molecules
- This is the fundamental process by which chlorophyll "captures" the energy of sunlight

Chlorophylls

- There are several kinds of chlorophyll, the most important being chlorophyll "a". This is the molecule which makes photosynthesis possible, by passing its energized electrons on to molecules which will manufacture sugars
- All plants, algae, and cyanobacteria which photosynthesize contain chlorophyll "a"
- A second kind of chlorophyll is chlorophyll "b", which occurs only in "green algae" and in the plants
- A third form of chlorophyll which is common is (not surprisingly) called chlorophyll "c", and is found only in the photosynthetic members of the Chromista as well as the dinoflagellates

Carotenoids

- These are usually red, orange, or yellow pigments, and include the familiar compound carotene, which gives carrots their colour
- These compounds are composed of two small six-carbon rings connected by a "chain" of carbon atoms
- As a result, they do not dissolve in water, and must be attached to membranes within the cell
- Carotenoids cannot transfer sunlight energy directly to the photosynthetic pathway, but must pass their absorbed energy to chlorophyll. For this reason, they are called accessory pigments

Carotenoids

- These are chemically isoprenoid polyene pigments which are derived from mevalonic acid.
- β Carotenes are formed by enzymatic cyclization and biosynthetic alterations (hydroxylation, epoxidation, inchain oxidation)
- Green algae generally contain βcarotene, violaxanthin, antheraxanthin, zeaxanthin and neoxanthin. Some may contain α carotene and lutin also
- Siphonaceous green algae also accumulate α carotene derivative siphonaxanthin and its fatty acid ester siphonein

Carotenoids

- One very visible accessory pigment is fucoxanthin the brown pigment which colors kelps and other brown algae as well as the diatoms
- Some brown algae accumulates βcarotene, violaxanthin, neoxanthin and fucoxanthinol as minor componant
- Most red seaweeds have mainly β Carotene, α carotene, and their dihydroxy derivatives, zeaxanthin and lutein

Phycobilins

Phycobilins are water-soluble pigments, and are therefore found in the cytoplasm, or in the stroma of the chloroplast. They occur only inCyanobacteria and *Rhodophyta*

- These are open chain (linear) tetrapyrrole pigments
- These are not found as free pigment as they form a complex with protein, also called biliproteins
- They differ in Cyanophyceae and Rhodophyceae and reffered as C -type and –type

Phycobilins

The two classes of phycobilins which may be extracted from these "algae"

1. The bluish pigment phycocyanin, which gives the Cyanobacteria their name
2. The reddish pigment phycoerythrin, which gives the red algae their common name.

- These bilins are covalently attached to polypeptides to form major classes α, β and γ

Importance of pigments

- Phycobilins are not only useful to the organisms which use them for soaking up light energy; they have also found use as research tools. Both phycocyanin and phycoerythrin fluoresce at a particular wavelength
- That is, when they are exposed to strong light, they absorb the light energy, and release it by emitting light of a very narrow range of wavelengths. The light produced by this fluorescence is so distinctive and reliable, that phycobilins may be used as chemical "tags"

Importance of pigments

- The pigments are chemically bonded to antibodies, which are then put into a solution of cells
- When the solution is sprayed as a stream of fine droplets past a laser and computer sensor, a machine can identify whether the cells in the droplets have been "tagged" by the antibodies
- This has found extensive use in cancer research, for "tagging" tumor cells.

What is the advantage of having multiple pigments in algae

- If one is destroyed the others can still function
- Each will absorb different wavelengths of light
- They can change colours to hide from predators
- They can photosynthesize even on cloudy days

Blue green algae

- Chorophyll a
- Chorophyll b
- Chlorophyll c
- Phycobiliproteins (phycobilisomes)

Green algae

- Chorophyll a
- Chorophyll b

Diatoms

- Chorophyll a
- Chorophyll b
- Carotenoids

Euglenoids

- Chorophyll a
- Chorophyll b
- Carotenoids

The Main Pigments, Storage Products, and Cell Coverings of the Algal Divisions

Division	Pigments: Chlorophylls	Phycobilins	Carotenoids	Xanthophylls	Storage Products
Cyanophyta	*a*	*c*-Phycoerythrin *c*-Phycocyanin Allophycocyanin Phycoerythrocyanin	β-Carotene	Myxoxanthin Zeaxanthin	Cyanophycin (argine and asparagine polymer) Cyanophycean starch (α-1,4-glucan)
Prochlorophyta	*a*, *b*	Absent	β-Carotene	Zeaxanthin	Cyanophycean starch (α-1, 4-glucan)
Glaucophyta	*a*	*c*-Phycocyanin Allophycocyanin	β-Carotene	Zeaxanthin	Starch (α-1,4-glucan)
Rhodophyta	*a*	*r,b*-Phycoerythrin *r*-Phycocyanin Allophycocyanin	α- and β-Carotene	Lutein	Floridean starch (α-1,4-glucan)
Cryptophyta	*a*, *c*	Phycoerythrin-545 *r*-Phycocyanin	α-, β-, and ε-Carotene	Alloxanthin	Starch (α-1,4-glucan)
Heterokontophyta	*a*, *c*	Absent	α-, β-, and ε-Carotene	Fucoxanthin, Violaxanthin	Chrysolaminaran (β-1,3-glucan)
Haptophyta	*a*, *c*	Absent	α- and β-Carotene	Fucoxanthin	Chrysolaminaran (β-1,3-glucan)
Dinophyta	*a*, *b*, *c*	Absent	β-Carotene	Peridinin, Fucoxanthin, Diadinoxanthin Dinoxanthin Gyroxanthin	Starch (α-1,4-glucan)
Euglenophyta	*a*, *b*	Absent	β- and γ-Carotene	Diadinoxanthin	Paramylon (β-1,3-glucan)
Chlorarachniophyta	*a*, *b*	Absent	Absent	Lutein, Neoxanthin, Violaxanthin	Paramylon (β-1,3-glucan)
Chlorophyta	*a*, *b*	Absent	α-, β-, and γ-Carotene	Lutein Prasinoxanthin	Starch (α-1,4-glucan)