The Algae

Characteristics and Classification of the Algae

We will not be covering these subjects in detail; from an earlier lecture, you should know the following:

Kingdom Eubacteria

Prokaryotic (organized nucleus and membrane-bound organelles not present)

Single-celled

Bacteria and cyanobacteria (blue-green "algae")

Autotrophic and heterotrophic

Kingdom Protista

Eukaryotic (organized nucleus and membrane-bound organelles present)

Single-celled and simple multi-celled

Protozoans, algae, slime molds

Autotrophic and heterotrophic

Hence, the cyanobacteria (once called blue-green algae) are prokaryotic organisms and not closely related to the true algae; they are autotrophic (photosynthetic)

The organisms known as algae are a heterogeneous lot classified into six divisions; they are autotrophic (photosynthetic)

Algae in Our Diet

Cyanobacteria

Some people speculate that the biblical “manna” was the cyanobacterium *Nostoc*

Spirulina (see fig. 22.12a and b)

Spirulina is a corkscrew-shaped filamentous cyanobacterium that has significant quantities of protein, vitamins, and minerals and is sold in the U.S. as a health food

The ancient Aztecs cultivated mats of *Spirulina* in shallow ponds and lakes; once dried and cooked, it was eaten like a vegetable

It has also been a traditional part of meals in Chad, where it is made into a sauce

Today it is used to prepare a high-protein food additive that has been considered one solution to the malnourishment problems in developing countries

Seaweeds (see fig. 22.12c)

It has been estimated that more than 100 species of marine algae are eaten in one form or another

Among the brown algae, the most popular is kombu (*Laminaria*)

The source of wakame is the brown alga *Undaria pinnatifida*; it is usually boiled and salted, transforming into a green product that is used in soups, salads, and noodles

Some favorite red seaweeds are dulse (*Rhodymenia* and *Palmaria*) and nori (*Porphyra*), which can be eaten as a confection, as a relish, with rice, or in soups and salads

The nutritional value of seaweeds lies in their high protein content as well as their essential vitamin and mineral content, particularly iodine and potassium

Porphyra is used more extensively and by more cultures than any other seaweed

The Chinese call it zicai, the Japanese call it amanori or nori, the Koreans call it kim, the British call it laver, and the Maoris of New Zealand call it karengo

Nori is a primary constituent of Japanese sushi; the outer wrap of sushi is nori

Other Economic Uses of Algae

Carrageenan, obtained from a red alga, is a common ingredient in ice cream, pudding, cottage cheese, weight-loss products, toothpaste, lotions, and paints; it imparts a creamy texture

Agar, also obtained from a red alga, is used mainly as a solidifying agent in culture media; agarose, derived from agar, is used to form gels that are used in DNA technology

Alginic acid is used in the treatment of latex during tire manufacturing, as a binding agent for charcoal briquettes, and to give a creamy texture to confections, ice cream, and other products

Diatomaceous earth (see fig. 22.13), composed of the fossilized remains of diatom frustules (silicon-based walls), is used as a polishing agent in silver polish, as a filter in the wine and petroleum industries, as a reflective material in highway paint, and as a soil additive to discourage microscopic garden pests

Toxic and Harmful Algae

Algal blooms, sudden population explosions of certain algal species, are triggered by changes in environmental conditions, principally the availability of nutrients

Blooms occur naturally, but there is good evidence that many are caused by nutrient pollution (especially nitrogen and phosphorus) of waterways by agricultural runoff, human sewage, and animal wastes

Blooms can cause problems that result from depletion of oxygen in the water, including extensive death of organisms and taste and odor problems with human water supplies; some algae can produce harmful toxins

Toxic cyanobacteria

In freshwater environments, cyanobacteria have been responsible for the deaths of large populations of wild and domestic animals

The toxins are normally released only when cells die or become old and leaky, so animals usually die from ingesting whole cells; it is also possible for fatal levels of toxin to be released into the water if it is treated to break up the bloom

Neurotoxins

Neurotoxins interfere with the normal functioning of the neurotransmitter acetylcholine and can lead to death in minutes by causing paralysis of muscles of the respiratory system (recall that curare works in this way)

One of the neurotoxins produced by cyanobacteria is saxitoxin; it is also produced by certain dinoflagellate species and is more commonly associated with red tides and paralytic shellfish poisoning

On the positive side, anatoxin-a is used in research on Alzheimer's disease and other degenerative neurological diseases with the hope that a modified version of the toxin might one day be used to slow the degeneration

Hepatotoxins

Hepatotoxins act on the cytoskeleton within liver cells and can be fatal by causing blood to pool in the liver

They also increase tumor development and may be responsible for the high rates of liver cancer in parts of China where blooms occur frequently

Less deadly cyanobacterial toxins cause conditions such as swimmer's itch, characterized by swelling and inflammation of mucus membranes and redness of the skin

Red tides

Dinoflagellates can undergo a population explosion and become so abundant that they color the water red, orange, yellow, brown or any hue in between; several species of dinoflagellates produce powerful toxins that can cause massive fish kills

Fish swimming through a bloom can disrupt or kill the dinoflagellates causing them to release neurotoxins into the water; the toxins damage the gills or suppress heart rate and result in asphyxiation

Shellfish can accumulate the toxins without being affected, and animals or humans consuming such shellfish can be poisoned

Shellfish poisonings have been categorized as paralytic, diarrhetic, and neurotoxic, depending on which dinoflagellate and which toxin is responsible

Pfiesteria

Pfiesteria piscicida and related dinoflagellates have been implicated as the organisms responsible for major fish kills and fish diseases

These are heterotrophic organisms that normally feed on bacteria and algae

Under certain environmental circumstances, they produce a toxin that stuns fish and causes them to develop open bleeding sores and eventually die; the dinoflagellates feed on the epidermal cells, blood, and other fluids that leak from the sores

Different from other dinoflagellates, *Pfiesteria* releases toxins to immobilize fish, which it then feeds on; dinoflagellates responsible for Red Tides release their toxins only when the cells die and break apart

Other toxic algae

Another dinoflagellate phenomenon is ciguatera poisoning, the leading cause of non-bacterial food poisoning in the U.S., Canada, and Europe

Many species of tropical fish accumulate ciguatoxin in their fatty tissues, and people eating tainted fish experience nausea, vomiting, and diarrhea; they can also develop strange neurological symptoms such as reverse sensations (e.g., hot objects feel cold)

Diatoms can form toxic blooms; some produce domoic acid, a toxin that is accumulated by shellfish and causes gastrointestinal and neurological symptoms and fatalities in humans

Nontoxic diatom blooms can also kill fish by lodging in the gill tissues and triggering the release of massive amounts of mucus that cause suffocation

Main Points from A Closer Look 22.1 – Drugs from the Sea

In the search for drugs from the sea, two promising areas are the development of anticancer and antiviral drugs from algae

For example, dinoflagellates of the genus *Amphidinium* produce amphidinolide-B, which has shown potent activity against a mouse leukemia line and a human carcinoma cell line

Also, compounds extracted from algae (e.g., red and brown algae) have shown activity against a range of viruses, including herpes simplex viruses and human immune deficiency virus (HIV)

Main Points of A Closer Look 22.1 – Killer Alga–Story of a Deadly Invader

A major ecological problem today is the loss of species diversity due to invasions by exotic species

Such species have natural predators in their normal range, but in a foreign area without a natural predator present they can sometimes overrun and out-compete native species

An example is the alga *Caulerpa taxifolia*, which is native to tropical seas

A mutant variety was developed in Germany and, because of its beauty and hardiness, became widely distributed in public and private aquaria

The Oceanographic Institute of Monaco dumped some *Caulerpa* and other aquarium refuse into the Mediterranean Sea, and this mutant *Caulerpa* was able to survive and thrive in the cold waters

Caulerpa produces toxic compounds, mainly caulerpenyne; in its native range, two species of sea slugs are immune to the poisons and feed exclusively on the alga

In the Mediterranean Sea, however, there are no natural predators that can handle the toxin; therefore, the *Caulerpa* grows quickly over the sea bottom, rapidly blanketing all other sea life, such as marine angiosperms, native algae, corals, and sea fans

The *Caulerpa* cuts off vital essentials such as sunlight for photosynthesis and currents that carry nutrients to filter-feeding organisms; the area becomes a *Caulerpa* lawn and species diversity is lost (see box fig. 22.2)

This lecture outline was prepared mainly from *Plants and Society*, by Levetin and McMahon, 2003 (3rd edition), and may contain phrases or entire sentences taken verbatim from that source.