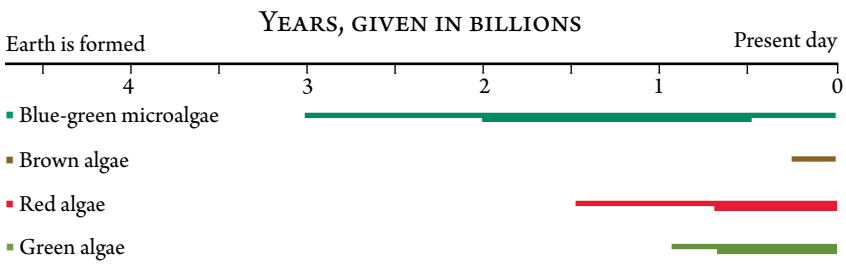
Evolutionary history and the life cycle of seaweeds

Technical and scientific details

Evolution

As discussed near the beginning of this book, the impact of algae on the global ecosystem is enormous. It is estimated that they are currently responsible for about 90% of the oxygen that is released into the atmosphere. Furthermore, their contribution to the physical conditions on Earth were vitally important in setting the stage for the evolution of higher organisms.

The first signs of life on our planet date back to a time when it was still very young. Earth was formed about 4.5 billion years ago and it is thought that the earliest organisms had already appeared more than 3.8 billion years ago. During this period, the conditions on Earth were very different from those of today. A particular indication of the physical state of the planet was the nearly total absence of oxygen in the atmosphere, less than one part in ten billion. Life consisted of simple, unicellular organisms, the so-called prokaryotes, which most closely resemble present-day bacteria. The prokaryotes encompass two separate domains (or superkingdoms): the Bacteria and the Archaea.



▸ The evolution of microalgae and macroalgae on Earth. The thick lines indicate times during which there was a rapid increase in the occurrence of these species. Macroalgae became prevalent about 500 to 800 million years ago.

About 2.5 to 1.5 billion years ago, there was a noticeable change in the Earth's atmosphere, as the amount of oxygen in it started to increase. This was brought about by the appearance of new forms of life that could use sunlight to convert carbon dioxide into oxygen and carbohydrates, a process we know as photosynthesis. There is probably no other development in the whole of the Earth's existence that has altered its surface and climatic conditions as dramatically as did photosynthesis. The oxygen-producing blue-green microalgae, which go back about 3 billion years, are considered to have been instrumental in effecting this change.

Chemically speaking, oxygen is a very reactive substance. Those organisms that could not adapt to its presence either died, buried themselves in

Energy content, fats, proteins, carbohydrates, and fiber

The nutritional content of seaweeds

	Energy content kJ/100g	Fats g/100g	Proteins g/100g	Carbo-hydrates g/100g	Fiber g/100g
Winged kelp (*Alaria esculenta*)	1,100	3.6	18	40	39
Konbu (*Saccharina japonica*)	1,100	1.1	7	55	3
Hijiki (*Sargassum fusiforme*)	1,000	0.8	10	47	17
Wakame (*Undaria pinnatifida*)	1,150	4.5	13	51	4
Bladder wrack (*Fucus vesiculosus*)	1,200	3.6	6	55	4
Knotted wrack (*Ascophyllum nodosum*)	1,000	1	10	52	6
Arame (*Eisenia bicyclis*)	1,100	1.3	12	52	7
Dulse (*Palmaria palmata*)	1,100	1.7	22	45	33
Laver, *nori* (*Porphyra* spp.)	1,350	2	34	45	7
Carrageen (*Chondrus crispus*)	1,050	1–3	15	60	6
Sea lettuce (*Ulva* spp.)	900	0.6	24	40	5
Green string lettuce (*Ulva* spp.)		0.5	21	50	7
Spirulina	1,250	7	65	14	6
Recommended daily intake	8,400+ kJ	65+ g	50+ g	300+ g	25+ g

mg = milligram = 0.001 gram; kJ = kilojoule = 0.24 kcal

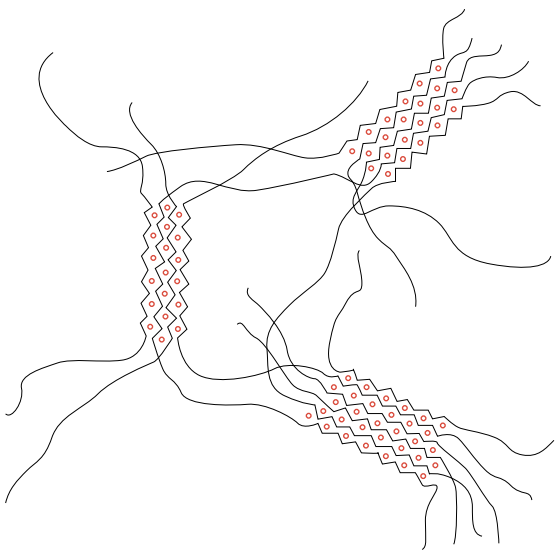
Sources: Arasaki, S. & T. Arasaki. *Low Calorie, High Nutrition Vegetables From the Sea*. Japan Publications, Inc., Tokyo, 1983, pp. 32–52. Erhart, S. & L. Cerier. *Sea Vegetable Celebration.* Book Publishing Company, Summertown, Tennessee, 2001, pp. 154–155; www.nutritiondata.com; www.nal.usda.gov; Dawczynski, C., R. Schubert & G. Jahreis. Amino acids, fatty acids, and dietary fiber in edible seaweed products. *Food Chemistry* 103, 891–899, 2006.

species and the part of the organism from which it is extracted. Chain length also varies, with the shortest typically composed of 500 monosaccharide groups.

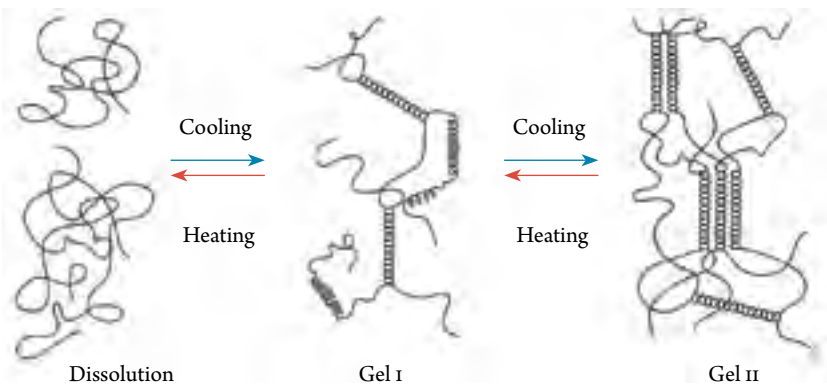
Technical and scientific details

The usefulness of alginates, particularly in the form of sodium alginate, rests on their water solubility. In an aqueous solution, sodium alginate is found in the ionic state as a so-called electrolyte.

Alginates form gels in the presence of Ca^{++} (or other divalent ions such as Mg^{++} and Ba^{++}), a process that occurs at much lower temperatures than is possible with pectins. Gelation with Ca^{++} provides for a stronger gel, whereas Mg^{++} leads to a weak gel, both with different rheological properties and hence different applications. The affinity for Ca^{++}, which is abundant in milk, also means that combinations of alginate and milk are particularly useful.



▸ Alginates can form gels in water when the long polysaccharide chains are bound together by Ca^{++} ions (shown in red).



▸ Some agars and carrageenans in an aqueous solution form double helices when it is cooled. These can bind to each other in a variety of ways to form networks (gels). Carrageenans are differentiated from each other by their ability and tendency to form different types of gels and molecular aggregates.

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haploid generation, the large blades of which are harvested to produce *nori*.

Courtois, Bernard French chemist (1777–1838) who, in the course of producing saltpetre from seaweed ash, discovered the element iodine.

Crawford, Michael A. British neurochemist and brain researcher.

Cryptogamia archaic botanical classification of those plants that lack stems and true flowers, for example, algae, mosses, lichens, fungi, and ferns.

Cunnane, Stephen Canadian researcher studying human evolution.

dashi soup stock made from an extract of bonito fish flakes (*katsuobushi*) and *konbu*. *Ichiban dashi* and *niban dashi* refer to the first and second extracts, respectively.

deoxyribonucleic acid (DNA) polynucleotide consisting of a chain of nucleic acids; basis for the genetic information encoded in genetic material and the genome. In the genome, DNA forms a double helix in which two DNA chains spiral around each other.

desmosterol higher-level sterol found especially in red algae; related to cholesterol in animals.

DHA see docosahexaenoic acid.

diatoms unicellular microalgae, encased in a silicate shell with two valves; one of the most common types of phytoplankton (plant plankton).

dietary fiber macromolecules that cannot be broken down by the body's enzymes. The distinction is made between fibers that are water soluble and those that are not. Seaweeds contain both types: for example, the polysaccharides agar, alginate, and carrageenan are soluble, while cellulose and xylan are not. Dietary fiber can constitute up to 75% of the dry components of seaweeds.

diffusion random movement (Brownian motion) of molecules or small particles.

dillisk Gaelic name for dulse (*Palmaria palmata*).

dimethyl sulphide (DMS) organic compound containing sulphur, CH_3SCH_3, formed by oxidation or organic decomposition of dimethylsulfoniopropionate (DMSP) in green and red algae. DMS has a characteristic pungent odor given off, for example, by heated milk, cabbage, cooked mussels, and rotting seaweed. The formation of DMS in the oceans is deemed to be an important factor in the climate change that is thought to be taking place on Earth. When DMS is released in the atmosphere, it is oxidized to create compounds that, in the form of aerosols, can cause condensation of the atmospheric moisture content, thereby promoting cloud formation and having an effect on the weather.

dimethylsulfoniopropionate (DMSP) organic compound containing sulphur, $(CH_3)_2S^+CH_2CH_2COO^-$, found in red and green (but not brown) algae, where it serves to maintain the proper osmotic balance between the organism and the surrounding salt water. DMSP, which has neither odor nor taste, possibly also acts as an antioxidant within the cells of the seaweeds. When decomposing by oxidation or bacterial action, especially in the presence of the genus *Roseobacter*, DMSP in dead algae and seaweeds gives off the foul smelling gas, dimethyl sulphide (DMS). Fish and shellfish that feed on seaweeds and algae accumulate DMSP in their cells.

diploid word used to describe cells that have the normal complement of chromosomes, that is, a double set.

DMS see dimethyl sulphide.

DMSP see dimethylsulfoniopropionate.

DNA see deoxyribonucleic acid.

docosahexaenoic acid (DHA) superunsaturated, long-chain fatty acid with 22 carbon atoms and six double bonds; member of the omega-3 family. Found in only very small quantities in seaweeds, but in great abundance in microalgae, for example, Spirulina.

domoic acid poisonous amino acid, which acts as a neurotoxin, found in some microalgae. It can accumulate in shellfish that feed on microalgae and is the principal cause of shellfish poisoning.

Drew-Baker, Kathleen Mary British alga researcher (1901–57), whose discoveries regarding the life cycle of the red alga *Porphyra* were the scientific foundations for the large-scale cultivation of *Porphyra* for *nori* production.

Druehl, Louis D. Canadian seaweed researcher.

eicosanoid hormone or signalling molecule formed from omega-3 or omega-6 fatty acids, which play an important role in the regulation of such functions as blood flow and the immune defenses.

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