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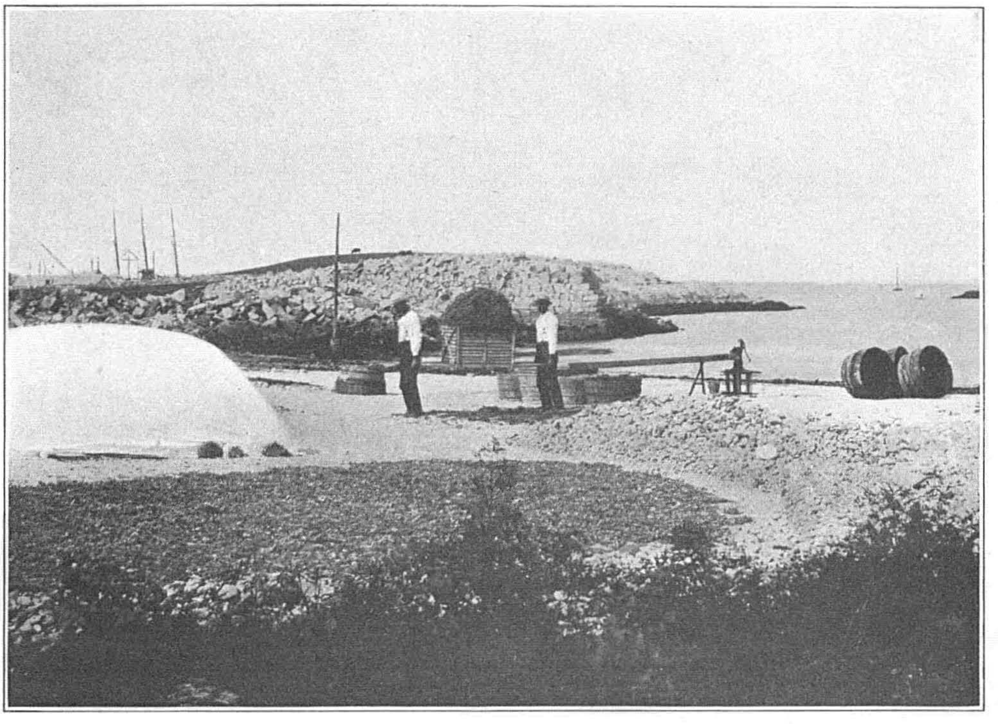

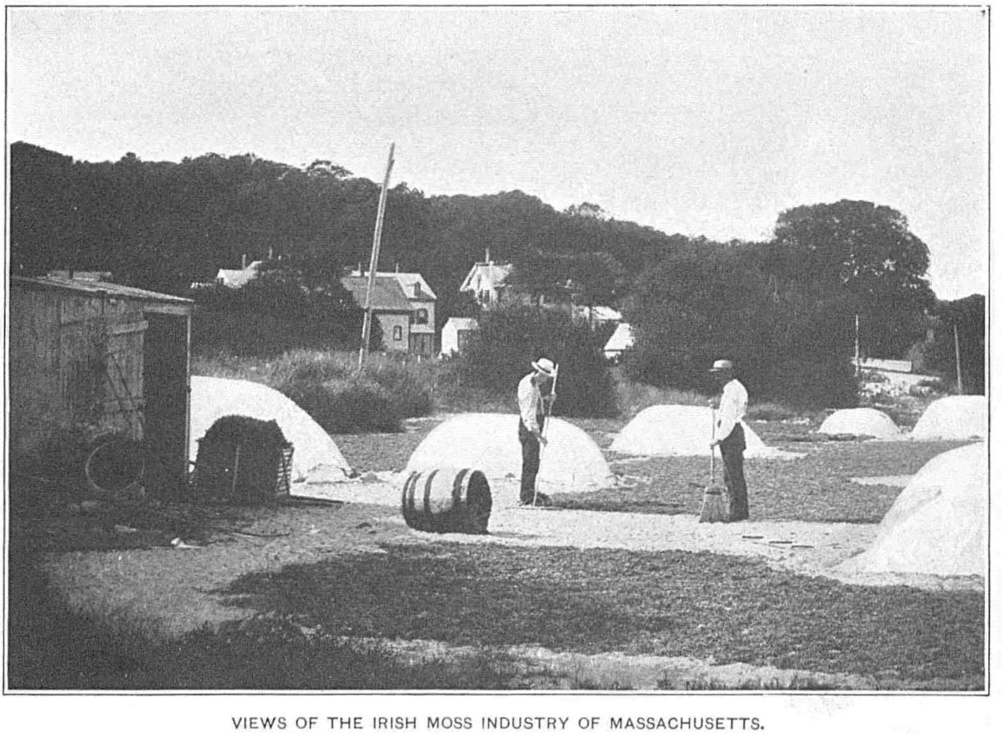

VIEWS OF THE IRISH MOSS INDUSTRY OF MASSACHUSETTS.

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With seaweed resources certainly not inferior to those of Japan or any other country, and probably much superior, the United States may be said practically to ignore these valuable products except at a few points on its extensive coast. Statistics recently gathered give the paltry sum of $35,000 as the value of the marine algæ prepared in the United States in one year. The business is practically restricted to Massachusetts, and is addressed to a single species, the "Irish moss" (*Chondrus crispus*). Considerable quantities of seaweeds are used as fertilizer on farms adjacent to the coast, but this is not a commercial enterprise. In Monterey and Santa Barbara counties, Cal., the Chinese fishermen dry certain algæ for food, medicine, and fertilizer; in 1899 the quantity prepared was 35,824 pounds, valued at $896.

There is undoubtedly a good opportunity to develop the seaweed industry of every section of the United States coasts, and to establish a profitable trade in the various species and preparations of marine algæ along the new lines indicated in the foregoing paper on the Japanese seaweed industry, as well as by increasing the output of the species already sparingly utilized. To this end the following information and suggestions are offered in regard to some of the useful algæ of the United States.

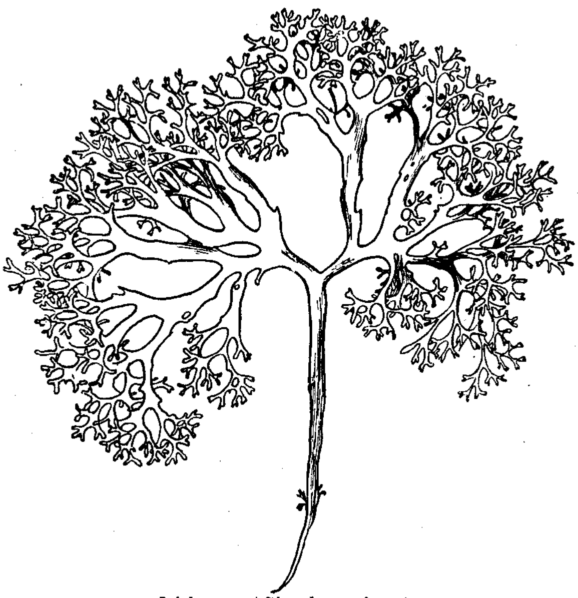
IRISH MOSS, OR CARRAGEEN (*Chondrus crispus*).

This alga is found from North Carolina to Maine, being especially abundant north of Cape Cod, growing on rocks just below low-water mark. The fronds are 3 to 6 inches long and usually purple, but when growing exposed to a bright light are yellowish-green. There are various other algæ considered to be quite as useful as *Chondrus crispus* for the purposes for which the latter is gathered. Among them are several species of *Chondrus* found on the California coast; various species of *Gracilaria*, found from Key West to Cape Cod and also on the Pacific coast; *Eucheuma isiforme*, found in the Key West region; and *Gigartina mamillosa* and numerous other species of *Gigartina*, which closely resemble *Chondrus* and abound on our east and west coasts.

The plant has from time to time been gathered on various parts of the New England coast, but at present is utilized at only a few localities in New Hampshire and Massachusetts, the principal place being Scituate, where it would seem the business has always been more important than at any other place on our coast. It is recorded (Wilcox, 1887) that prior to 1835 the small quantity of Irish moss used in this country was imported from Europe and sold here at one to two dollars a pound, and that in the year named Dr. J. V. C. Smith, at one time mayor of Boston, made it generally known that the "moss" which abounded on the Massachusetts shores was the same as that which was imported at such a high price. From that time to the present Irish moss has been prepared at Scituate, and in 1879 was the leading marine production. By 1853 the price, which in 1835 was $1 a pound, had dropped to 25 cents, and by 1880 to 3 or 3½ cents. About 1880 the average annual yield was 5,000 barrels of dried weed, averaging 90 pounds to the barrel.

The methods of conducting the business have changed but little in many years, and the simple apparatus required remains the same as in the early days of the industry. Mr. T. M. Cogswell, of the Bureau of Fisheries, has furnished the data on which the following account is based.

A small part of the crop is gathered by hand, but most of it is torn from the rocks by means of rakes used from boats. The rakes are made especially for the purpose, and have a 15-foot handle and a head 12 to 15 inches wide, with 24 to 28 teeth 6 inches long and an eighth of an inch apart.



Irish moss (*Chondrus crispus*).

The gathering season extends from May to September. If the rocks are not scraped too clean in the early part of the season, it is said to be possible to get two crops in some of the warm, sheltered coves, where the alga grows much faster than in the more exposed places.

The output in recent years has varied considerably, owing chiefly to the inclination or disinclination to engage in the business. Some years a large number of people seem moved by a desire to gather the weed, while other seasons only a few go into the business. Occasionally heavy storms do damage by tearing the plant from the rocks and scattering it along miles of beach. There is said to be a scarcity at times, owing, it is supposed, to too active gathering the previous season, the rocks being almost completely denuded.

In the preparation and curing of Irish moss fair weather and much sunshine are prime requisites. When first brought ashore, the plants are washed in salt water and then spread upon the sandy beach to dry and bleach. After twenty-four hours in good weather they are raked up and again washed and again spread on the beach to dry. Three washings are usually sufficient for complete cleansing, curing, and bleaching, but as many as seven are sometimes given. After the final washing the plants are left in the sun, the entire process requiring about two weeks of good weather and warm sunshine. The plants gradually fade, and by the time the curing is finished they are white or straw colored. Two more weeks are then required to sort and prepare the product for shipping.

Great care has to be exercised in the curing to prevent the rain from spoiling the crop, and when a storm is impending the moss is hastily raked in piles and covered with canvas. Should it chance to get wet in the last week of its curing, it is practically ruined.

The moss is sent to market in barrels holding 100 pounds, and the first of the crop is usually shipped in August. The product has a wide distribution in the United States and Canada, a part of it going to druggists and grocers, but much the larger part to brewers and firms handling brewers' supplies. The wholesale price was 4 to 4½ cents per pound in 1902, and 5 to 5½ cents in 1903.

From information regarding this business recently gathered by the Bureau of Fisheries, it is seen that 136 men were employed in gathering this plant in 1902; the boats, rakes, and shore property used were valued at over $12,000; and the quantity of dried algæ sold was 740,000 pounds, with a market value of $33,300. In 1898 the output was 770,000 pounds, valued at $24,825.

Statistics of the Irish moss industry of New England for 1902.

Locality.	Men.	Boats.		Rakes.		Shore property.	Product.	
		Number.	Value.	Number.	Value.		Pounds.	Value.
Massachusetts:								
Scituate	100	15	$1,873	75	$375	$5,000	500,000	$22,500
North Scituate	5	5	200	5	25	200	30,000	1,350
Cohasset	10	12	480	10	50	600	60,000	2,700
Plymouth Harbor and White Horse Beach	15	14	730	15	75	700	100,000	4,500
New Hampshire:								
Rye Harbor	6	8	240	6	30	1,500	50,000	2,250
Total	136	54	3,523	111	555	8,000	740,000	33,300

Irish moss of excellent quality is now placed on the market in 1-pound and half-pound boxes, selling at retail for 45 cents and 25 cents, respectively; it is intended chiefly for making blanc mange, and is used as follows: Soak half a cup of dry moss in cold water for five minutes, tie in a cheese-cloth bag, place in a double boiler with a quart of milk and cook for half an hour; add half a teaspoonful of salt or less, according to taste, strain, flavor with a teaspoonful of lemon or vanilla extract if desired, and pour into a mold or small cups, which have been wet with cold water; after hardening, eat with sugar and cream. To make a demulcent, for coughs, place moss in cold water and heat gently until the liquid is of a sirupy consistency, then strain and add sugar and lemon juice to suit taste.

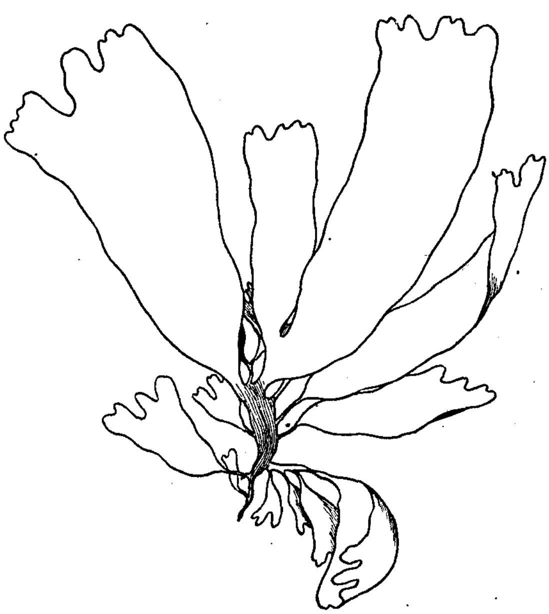
Other uses to which it has been put are the making of jellies and puddings, the clarifying of beers and the sizing of fabrics.

VEGETABLE ISINGLASS FROM GELIDIUM CORNEUM.

The identical species of alga from which the Japanese prepare their "kanten," or vegetable isinglass, grows in abundance on our Pacific coast, and is also found at various places between Florida and Maine. Other species (*G. coulteri*, *G. cartilagineum*) exist on the coast of California and about the Philippine Islands. The high price of this product and the large consumption of it and fish isinglass in the United States warrant the belief that a profitable business could be established.

Isinglass made from *Gelidium* is one form of agar-agar, now so extensively used in making culture media in bacteriological work. Other sources are the Australian and Asiatic plants, *Eucheuma spinosum*, *Gracilaria lichenoides*, *G. tenax*, and other related species, which yield the products known in commerce as agar-agar, agar-agar gum, agal-agal, Bengal isinglass, Bengal isinglass gum, Ceylon moss, Ceylon agar-agar, Chinese moss, etc.

Vegetable isinglass is composed largely of gelose or pararabin, a substance remarkable for its gelatinizing properties, which exceed those of any other known product. It is insoluble in cold water, alcohol, dilute acids, and alkalies; its melting point is 90° F; it has eight times the gelatinizing power of ordinary gelatine and isinglass; and 1 part to 500 parts of boiling water forms a jelly on cooling. Gelose jelly keeps well, but owing to its high melting point is not so well adapted for food preparations as some other jellies.


Dulse (*Rhodymenia palmata*).

DULSE (*Rhodymenia palmata*).

The dulse is found along the shores of all the States from North Carolina to Maine, and is very abundant in New England. It is rough-dried in the sun, and eaten dry as a relish. It is met with in stores in the coastwise towns of the Eastern States, but is usually brought from the Canadian provinces, and has not figured in recent statistical canvasses of the New England fisheries. Other species of this genus grow on the west coast of the United States. Several other algæ known as dulse in Europe, and used in the same way as *Rhodymenia*, are represented by various species on the Pacific coast of America. In Ireland, dulse is eaten with butter and fish, and is also boiled in milk with rye flour (Simmonds, 1883). Some gentlemen in the Scotch Highlands known to Stanford (1884) are quoted as holding that "a dish of dulse boiled in milk is the best of all vegetables." Swan (1893) states that dulse is common on the northwest coast and is an article of diet among the Haida Indians of Queen Charlotte Island and other tribes, although not in general use. Like the green and purple laver used by the same Indians, it is dried and compressed into blocks, and as needed is sliced with a sharp knife, soaked in fresh water, and boiled. Swan partook of an Indian meal of dulse boiled with halibut and found it very palatable.

LAVER (*Porphyra laciniata*).

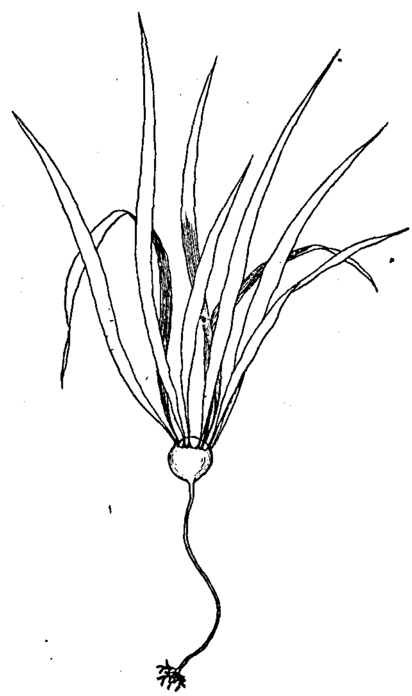
This alga is found in abundance along the entire coast, but is not collected except sparingly by Chinese, who obtain most of their supply from Asia. It was recorded in 1876 by Farlow that laver was imported from China by the Chinese living in this country, even by those as far east as Massachusetts, although the plant is common on the Massachusetts shores. The considerable demand for *Porphyra* among oriental people in the United States should be supplied from local sources, the algæ being prepared after the Japanese method or by simple washing and drying.

In Ireland, where it is called "sloke," laver is boiled and served with butter, pepper, and vinegar as a dressing for cold meat.

GIANT KELP; GREAT BLADDER-WEED (*Nereocystis lütkeana*).

This most remarkable plant, which attains an enormous length, grows on the Pacific coast from Monterey Bay northward. Swan (1893) writes as follows regarding it in the Puget Sound region:

The *Nereocystis* of the northwest coast is said, when fully grown, to have a stem measuring 300 feet in length, which bears at its summit an air bulb, from which a tuft of upward of 50 long, streamer-like leaves extend, each of which is from 30 to 40 feet in length. The stem, which anchors this floating mass, though no thicker than a common window cord, is of great strength and flexibility, and has for ages been used by the natives as fishing lines, being first cut of the required length, which is where the stem begins to expand into the hollow tube, and varies from 10 to 15 fathoms, then soaked in fresh water in a running brook until it is nearly bleached, then stretched, rubbed to the required size, and dried in the smoke in the lodge. When dried it is very brittle, but when wet it is exceedingly strong, and equal to the best flax or cotton fishing lines of the white fishermen. These pieces, varying from 10 to 15 fathoms each, are knotted together to the required length of 80 fathoms, required in the deep-water fishing around the entrance to Fuca Strait, or 200 fathoms at Queen Charlotte Islands, British Columbia, where the natives take the black cod at that profound depth.



Giant kelp (*Nereocystis lütkeana*).

Until within a few years the coast Indians used the upper or hollow portion of these great kelp stems as receptacles for holding dog-fish oil, which, together with the paunches of seals and sea-lions and whale gut, properly prepared, were the utensils found in every house for holding the family supplies of whale, seal, or salmon oil which are used as articles of food, or for dog-fish oil, which is used for trading purposes only. Now, however, the Indians are using coal-oil cans, barrels, and other utensils easily procured from the white traders, and the use of kelp for holding oil is nearly abandoned.

Among my collections for the National Museum in 1885 I received a number of specimens of this kelp which had been used for dog-fish oil. I split one open and found that the oil had hardened the inside of the kelp tube to the consistency of leather. This specimen I washed with soap and water, then wiped it to remove the moisture, and then rubbed and manipulated it after the manner used by natives in dressing deer skins, and when perfectly dry by this process of continual rubbing, it was soft and flexible, presenting an appearance of wash leather, but if allowed to dry without manipulation it would be hard and brittle. A party of coast Indians were camped on the beach at Port Townsend, and, at my request, they showed me their method of preparing kelp for holding oil. The great stems of the *Nereocystis* are covered with a thin coating of silex, which is carefully pealed off as one might peel the skin from an apple; only the hollow or upper part of the stem is used. When the skin is removed the tube is placed above the fire and smoke in the lodge, and, as it dries, the salt it contains exudes on the surface; this is carefully removed by rubbing, which also serves to soften the kelp and render it pliable. It is then again placed over the fire, and the process continued until the salt is removed; then the tube is blown up like a bladder and allowed to dry until it will retain its shape, and it is then filled with dog-fish oil and is ready for market.

The rude and simple experiments I made with this giant kelp convinced me that it is capable of being converted into articles of commercial value, but as I had not the means of conducting experiments, or of procuring the machinery requisite to the manufacture of the kelp products on a scale of commercial importance, I have allowed the matter to rest until some one of enterprise and capital may be found ready to continue these investigations.

* * * * * * *

During a residence of many years in the vicinity of Cape Flattery, at the entrance of Fuca Strait, I have had ample time and opportunity to observe the great masses of the giant kelp and other marine plants which are torn up by the roots every fall by the storms and piled by the waves along the beach at Neah Bay. I have frequently noticed, when a mass of this kelp has been thrown into a pool of fresh water, that in a few days it is covered with this slippery substance, which Stanford (1884) has named algin, and I think that the *Nereocystis* is rich with this valuable ingredient. The supply of the raw material is practically unlimited, and if attention shall be directed to the valuable uses to which this plant and other algæ may be put, I feel confident that a new and important industry will be developed.

FOOD PREPARATIONS FROM THE KELPS.

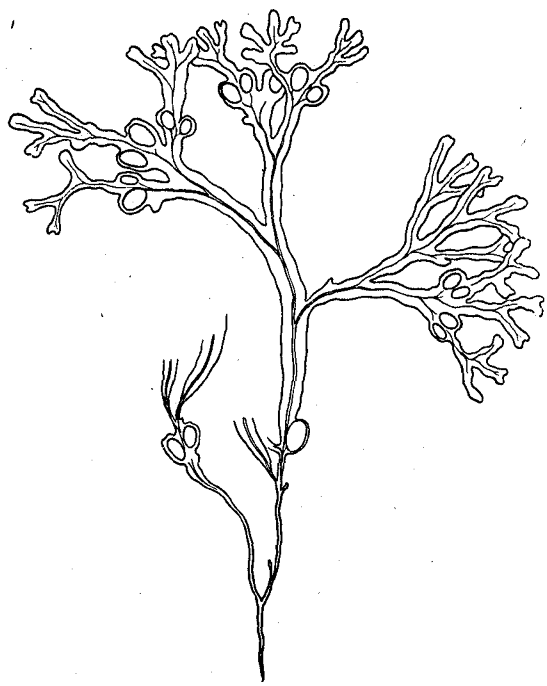
Numerous species of *Laminaria* exist on the northern parts of both coasts of the United States. The only use to which the plants are now put is for fertilizer. There is no question but that some of the Japanese "kombu" preparations would meet with ready sale, not only among Chinese and Japanese in the United States and its island possessions, but also among natives. The forms of "kombu" which are likely to prove most acceptable to the American palate are the powders, films, and dried sticks. It occurred to the writer that the crisp sticks might be broken into small pieces and serve as a breakfast dish, like oatmeal or other cereal. An Osaka manufacturer accordingly prepared some in the form of small rectangular flakes, which, when moistened with milk or hot water, formed a very wholesome and agreeable dish.

KELP AND OTHER SEAWEEDS CONTAINING IODINE.

Algæ representing species identical with or similar to those used in Scotland, France, and Japan in the manufacture of iodine abound on the northern coasts of the United States, but are never used for this purpose. In view of the large consumption of iodine in the United States and the facility with which it may be prepared, in crude form, at many places on the New England and North Pacific coasts, it is quite remarkable that no one has undertaken the manufacture of this product. Supplementary to the outline of the Japanese method of preparing iodine, it is therefore deemed advisable to give some account of the iodine industry in Scotland.

Nearly all marine algæ contain iodine, but a few have such a comparatively large quantity that they are utilized almost exclusively. In the early days of iodine and soda manufacturing on the Scotch coasts, only "rockweeds" or "wrack," technically known as cut-weed kelp, were used; they represented three species—namely, *Fucus vesiculosus*, *F. serratus*, and *Ascophyllum nodosum*. Stanford (1884) gives an interesting historical account of this industry:

This crude substance (kelp), which for many years made the Highland estates so valuable, was at first made as the principal source of carbonate of soda. At the beginning of the century it realized £20 to £22 per ton, and the Hebrides alone produced 20,000 tons per annum. The importation of barilla then began, and for the twenty-two years ending 1822, the average price was £10 10s. The duty was then taken off barilla, and the price of kelp fell to £8 10s.; and in 1823, on the removal of the salt duty, it fell to £3, and in 1831 to £2. It was used up to 1845 in the soap and glass factories of Glasgow, for the soda. Large chemical works were then existing in the island of Barra for the manufacture of soap from kelp, and a very large sum of money was lost there. In the meantime, soda was being largely made by the Le Blanc process, and superseded kelp, which was always a most expensive source, yielding only about 4 per cent, often less than 1 per cent. It must have cost the soap-makers what would be equal to £100 per ton for soda ash, the present price of which is £6.


Rock weed (*Fucus vesiculosus*).

The manufacture of iodine and potash salts then began to assume some importance, but the kelp required was not the same, that which contained the most soda containing the least iodine and potash. Chloride of potassium, the principal salt, was at one time worth £25 per ton. The discovery of the Stassfurt mineral speedily reduced this price to about a third, and the further discovery of bromine in this mineral also reduced the price of that element from 38s. per pound to 1s. 3d., its present price. The amount of bromine in kelp is small, about a tenth of the iodine, and not now worth extracting. Large quantities are now produced in Germany and America. More recently, the manufacture of iodine from the caliche in Peru has attained large proportions, and has so far reduced the price of that article as to make its manufacture from kelp unremunerative.

* * * The plants were cut at low tide, floated ashore, dried and burnt. * * * This kelp, burnt into a dense fused slag, contained the most carbonate of soda, and was that variety which employed so many poor crofters and cotters, and enriched so many Highland lairds. It is now worthless, and the *Fuci*, which hang from the rocks at low water in luxurious festoons, are now entirely unutilized.

From the following table given by Stanford, showing the quantity of iodine in various seaweeds, the preponderating value of *Laminaria* for iodine manufacturing will be apparent:

Iodine in sun-dried seaweeds.

Species.	Per cent.	Pounds per ton.	Species.	Per cent.	Pounds per ton.
Laminaria digitata, "tangle;" stem	0.4535	10.158	Fucus serratus, "black wrack"	0.0856	1.807
frond	.2946	6.599	vesiculosus, "bladder wrack"	.0297	.665
stenophylla; stem	.4028	9.021	Halidrys siliquosa, "sea oak"	.2131	4.773
frond	.4777	10.702	Hymanthalia lorea, "sea laces"	.0892	1.998
saccharina, "sugar wrack"	.2794	6.258	Rhodymenia palmata, "dulse"	.7120	1.594
bulbosa	.1966	4.403	Chordaria flagelliformis	.2810	6.294
Ascophyllum nodosum, "knobbed wrack"	.0572	1.281	Chorda filum, "sea twine"	.1200	2.688
			Chondrus crispus, "Irish moss"	Trace.	....
			Gelidium corneum	Nil.	....

Three methods of extracting iodine have been followed in Scotland, known as the kelp process, the char process, and the wet process. The following accounts of them are abridged from Stanford's report (l. c.), and from Stanford's article in Thorpe (1899):

Kelp process.—This, the primitive method, is similar to that pursued for the extraction of soda from rockweeds. It is unsatisfactory and wasteful, owing to the fact that a large part of the iodine is lost by evaporation and a large part of the remaining substances are not utilized. One hundred tons of wet seaweed usually make 5 tons of dried kelp, and, as only half of this is soluble, 2½ tons are the actual product of the labor of cutting, carrying, drying, and burning 100 tons of raw weed. The fused mass of carbon and ash resulting from the burning of the dried weeds is lixiviated with water, and the solution is evaporated to remove the chlorides, sulphates, and carbonates; the concentrated mother liquid is then treated with sulphuric acid, the resulting sulphur and sulphates are removed, and the remaining acid liquor is treated in a lead-lined retort with manganese dioxide, which, with the free sulphuric acid, liberates iodine; the iodine passes off in vapor and is condensed in a series of earthenware receivers adapted to the retorts. The chemical reaction in this case is as follows:

$$2KI + MnO_2 + 2H_2SO_4 = K_2SO_4 + MnSO_4 + 2H_2O + 2I.$$

Char process.—This has for its object the prevention of loss of valuable material by volatilization and decomposition, and consists in heating dry seaweed in iron retorts or brick ovens. The tangle swells in the retorts and is converted into a very porous charcoal, from which the salts are readily washed. This charcoal is reported to be an efficient decolorizer and deodorizer. The superiority of the char process over the kelp process will be seen from the following comparison of the results of treating four tons by each process:

Item.	Kelp process.	Char process.	Item.	Kelp process	Char process.
Crude product .... pounds..	1,500	3,000	Loss of salts .... pounds..	220	....
Per cent of dried weed	18.7	37.5	Loss of iodine .... do....	15.98	....
Salts recovered .... pounds..	657	877	Loss of salts per ton of tangle..do....	54	....
Iodine produced .... do....	13.27	29.25	Loss of iodine per ton of tangle..do....	3.99	....

Wet process.—Air-dried tangle is boiled with a solution of sodium carbonate, and the mass is filtered. The precipitate is composed largely of cellulose, while the filtrate contains, besides the salts, a peculiar gummy substance, algin. When the filtrate is treated with sulphuric acid, algin is precipitated. The solution, after the removal of algin, is neutralized with calcium carbonate, evaporated, the easily crystallized salts are removed, and the mother liquor is treated for iodine in the usual manner.

This process is the most economical, in that it increases the yield of salts and iodine and reduces the cost by the production of algin and cellulose. The comparative value of the three processes may be readily appreciated from the following table, the figures being on a basis of 100 tons of dry tangle:

Items.	Kelp process.	Char process.	Wet process.
Dry weed utilized (per cent)	18	36	70
Crude product (tons)	18	36	a 33
Salts extracted (tons)	9	15	20
Iodine extracted (pounds)	270	600	600
Residuals (tons):			
Kelp waste (valueless)	18	....	....
Charcoal	....	36	....
Tar; ammonia	....	(x)	....
Algin	....	....	20
Cellulose	....	....	15
Dextrin, etc	....	....	(x)

a Water extract.

Writing of the Scotch iodine industry, Stanford (l. c.) noted that the "drift kelp", the only kind now used in making iodine, consists of two species of *Laminaria*, which are always submerged and are torn up by the violent gales so common on the west coast. In Ireland the plants are sometimes cut under water with long-handled hooks. These plants are much damaged by rain or fresh water and are often, after drying, almost valueless, but if properly cured they contain ten times as much iodine as the rock weeds.

OTHER USES OF THE KELPS.

The collateral substances produced during the extraction of iodine by the wet process deserve consideration on account of their prospective value in the arts. These substances are algin, cellulose, dextrin, and mannite, in addition to the various salts elsewhere referred to. The following account of algin and its compounds is adapted from Stanford (1884), by whom this substance was discovered:

If the long fronds of the *Laminaria* [*digitata*] be observed after exposure to rain, a tumid appearance will be noticed, and sacs of fluid are formed from the endosmosis of the water through the membrane, dissolving a peculiar glutinous principle. If the sacs be cut, a neutral, glairy, colorless fluid escapes. It may often be seen partially evaporated on the frond as a colorless jelly. This substance, which is then insoluble in water, is the remarkable body to which has been given the name of Algin. The natural liquid itself is miscible with water, but coagulated by alcohol and by mineral acids. It contains calcium, magnesium, and sodium, in combination with a new acid, which is called alginic acid. When this natural liquid is evaporated to dryness it becomes insoluble in water, but it is very soluble in alkalies. This new substance is so abundant in the plant that on maceration for twenty-four hours in sodium carbonate in the cold, the plant is completely disintegrated. The mass thus obtained has great viscosity, and is difficult to deal with on that account. It consists of the cellulose of the plant mixed with sodium alginate. The cells are so small that they pass through many filters, but by cautiously heating it, the mass can be filtered through a rough linen filter bag, the cellulose being left behind, and after the algin is removed, this is easily pressed.

The solution contains dextrin and other extractive matter, and it is then precipitated by hydrochloric or sulphuric acid; the alginic acid precipitates in light gray albuminous flocks, and is easily washed and pressed in an ordinary wooden screw press. It forms a compact cake, resembling new cheese, and has only to be stored in an ordinary cool drying room, where it can be kept any length of time. If desired, by adding a little bleach during the precipitation, it can be obtained perfectly white. The algin can be sent out in this state; it is only necessary to dissolve it in sodium carbonate in the cold for use. If, however, it be sent out as sodium alginate, it must be dissolved to saturation in sodium carbonate, the carbonic acid is disengaged, and sodium alginate is formed. If potassium or ammonium carbonate be used, the alginates of potassium or ammonium are formed, which are similar to the soda-salt. The bicarbonates of these alkalies may also be used; but the caustic alkalies are not such good solvents.

The sodium alginate forms a thick solution at 2 per cent; it can not be made above 5 per cent, and will not pour at that strength. Its viscosity is extraordinary. It was compared with well-boiled wheat starch, and with gum arabic in an ordinary viscometer tube; the strengths employed were as follows; it was found impossible to make the algin run at all over the strength employed:

Gum arabic solution, 25 per cent, took 75 seconds=1 in 3.
Wheat starch solution, 1.5 per cent, took 25 seconds=1 in 8.
Algin solution, 1.25 per cent, took 140 seconds=1 in 112.

So that algin has 14 times the viscosity of starch, and 37 times that of gum arabic.

The solution may be alkaline, or neutral, or acid, according to the degree of saturation; if alkaline, it may be made distinctly acid by the addition of hydrochloric acid, but any excess at once coagulates it; a 2 per cent solution becomes semisolid on this addition.

The evaporation is effected in a similar manner to that of gelatin, in thin layers on trays or slate shelves, in a drying room with a current of air, or on revolving cylinders heated internally by steam; high temperatures must be avoided. The solution keeps well. Thus obtained, the sodium alginate presents the form of thin, almost colorless, sheets, resembling gelatin, but very flexible. It has several remarkable properties which distinguish it from all other known substances.

It is distinguished from albumen, which it most resembles, by not coagulating on heating, and from gelose by not gelatinizing on cooling, by containing nitrogen and by dissolving in weak alkaline solution, and being insoluble in boiling water; from gelatin, by giving no reaction with tannin; from starch, by giving no color with iodine; from dextrin, gum arabic, tragacanth, and pectin, by its insolubility in dilute alcohol and dilute mineral acids.

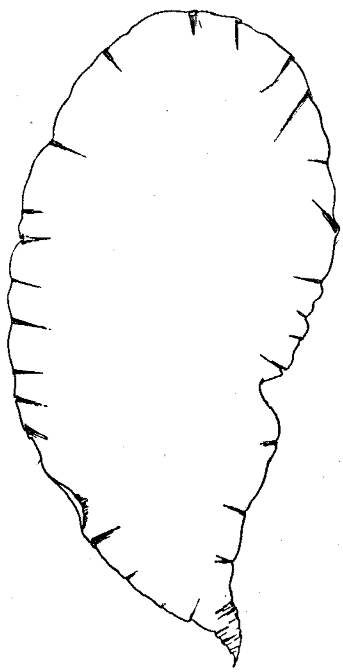
It is remarkable that it precipitates the salts of the alkaline earths, with the exception of magnesium, and also most of the metals, but it gives no precipitate with mercury bichloride nor potassium silicate.

Alginic acid is insoluble in cold water, very slightly in boiling. It is insoluble in alcohol, ether, and glycerin. The proportion of soda ash used is one-tenth of the weight of the weed, and the cake of alginic acid obtained is usually about the same weight as the weed. The quantity of dry alginic acid is given below:

Algæ.	Water.	Alginic acid.	Cellulose.	Algæ.	Water.	Alginic acid.	Cellulose.
Laminaria digitata:				Laminaria stenophylla:			
Stem	37.04	21.00	28.20	Frond	40.02	24.06	15.06
Frond	44.00	17.35	11.00	Laminaria bulbosa	43.28	17.95	11.15
Laminaria stenophylla:				Fucus vesiculosus	40.10	12.22	12.22
Stem	34.50	25.70	11.27				

It is not necessary to extract the salts first with water; it comes to the same thing to act on the seaweed at once with soda ash, and to recover the salts by evaporation of the solution, after the alginic acid has been precipitated. In this case chloride of calcium, or of aluminum, may be employed, the alginate of calcium or aluminum being precipitated. With either salt the alginate is thrown down instead of rising to the surface of the liquid, and the cakes are more compact and easily pressed. In addition to the cheapness with which it can be procured in almost any quantity, as a by-product in alkali works, now all thrown away, the calcium chloride has the advantage of throwing down the sulphates in the salts, and decomposing them into chlorides of potassium and sodium, which are easily separated, and do not require the tedious and expensive processes necessary in the lixiviation of kelp. The same remark applies to aluminum chloride, which can be cheaply obtained by dissolving bauxite in hydrochloric acid. Either salt can be decomposed by hydrochloric acid, and the calcium and aluminum chlorides recovered; or the salts can be decomposed by sodium carbonate. The calcium alginate, when dry, is very like bone, as the dry alginic acid is like horn. The aluminum alginate is soluble in caustic soda, forming a neutral solution, and giving, on evaporation, a substance like algin, but harder and making a stiffer finish; it is also soluble in ammonia, the salt becoming an insoluble varnish on evaporation. The alginates of copper (blue), nickel (green), cobalt (red), chromium (green), and zinc are all soluble in ammonia, and form beautiful colored insoluble films on evaporation. So also do the alginates of platinum, uranium (yellow), and cadmium. The latter is exceedingly soluble in ammonia. The alginate of chromium is also soluble in cold water, and it is deposited on boiling the solution, becoming then insoluble.

With bichrome, algin acts as gelatin, the mixture becoming insoluble under the influence of light. The silver alginate darkens very rapidly under exposure to light, and suggests applications in photography. Algin forms a singular compound with shellac, both being soluble in ammonia; it is a tough sheet, which can be rendered quite insoluble by passing it through an acid bath.


Sea lettuce (*Ulva latissima*).

Algin and its salts appear to have a wide range of usefulness. Some of these are indicated by Stanford (l. c.). Thus, as a sizing for fabrics, algin supplies the great desiderata of a soluble gum with marked elastic and flexible properties, and of a soluble substitute for albumen which can easily be rendered insoluble and used as a mordant. As a stiffening and filling agent, algin has an advantage over starch, in that it fills the cloth better, is tougher and more elastic, is transparent when dry, and is not acted on by acids. It imparts to fabrics a thick, elastic, clothy feeling, without the stiffness caused by starch. An additional advantage, possessed by no other gum, is that algin becomes insoluble in the presence of dilute acids; and, furthermore, no other gum has anything like the viscosity of algin, hence it is the most economical for making solutions for sizing. The alginate of aluminum in caustic soda makes a stiff dressing; in the crude unbleached state it is a cheap dressing for dark goods, and in the colorless state for finer fabrics. A glossy, insoluble surface results from the use of ammoniated alginate of aluminum.

Sodium alginate has been used for fixing mordants, and is a substitute for the various salts now used in precipitating mordants previous to the dyeing of cottons and yarns. For resolving and preventing the incrustation of boilers, sodium alginate has been pronounced by experts to be one of the best preparations, precipitating the lime salts in a state in which they can readily be blown off.

The charcoal formed during the manufacture of iodine by the wet process, when combined with algin, has been largely used for covering boilers, under the name of carbon cement. Three per cent of algin is sufficient to make the charcoal cohere, and a cool, light, and efficient covering is formed.

As an article of food, algin has been suggested for thickening soups and puddings, and as a substitute for gum arabic in making lozenges and jujubes. It contains about the same percentage of nitrogen as Dutch cheese, and has a faint, pleasant flavor best expressed by "marine." In pharmacy it has a place in the emulsifying of oils, as an excipient in pills, and for refining spirits.

The cellulose obtained from the *Laminariæ*, as before described, bleaches easily and under pressure becomes very hard, so that it can be easily turned and polished. A good tough paper can also be made from it.

"Badderlocks" (*Alaria esculenta*).

Dulse (*Schizymenia edulis*).

Farlow (1876) records that the rough-dried stems of *Laminaria saccarhina*, *L. longicruris*, *L. flexicaulis*, and other large species of *Laminaria*, under the name of "artificial staghorn", were used for making handles to knives, paper cutters, and other ornamental purpuses; and that at one time an attempt was made to establish a manufactory of buttons out of dried *Laminaria* stems at Marblehead; but the attempt was given up, as the buttons did not bear washing.

OTHER FOOD ALGÆ.

The number of other algæ susceptible of being prepared as palatable and wholesome foods is very large. Many of the genera utilized for this purpose in Japan exist in our waters and should be given a thorough trial.

The sea lettuce, or green laver (*Ulva latissima*), which is abundant on all our coasts, is eaten in Scotland like purple laver, and is also consumed by Indian tribes of the northwest coast.

The "badderlocks," "murlins," or "henware" (*Alaria esculenta*) common on the shores of New England and California, is eaten in Scotland. *Dilsea edulis*, which occurs on the Oregon coast as well as in Europe and Japan, is a food product in Europe, being eaten like dulse, and known by that name in Great Britain.

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