

stronger or weaker than another, or a certain salt to be more hydrolyzed than another; what properties of substances make them useful for certain purposes.

The success with which the more intelligent students are able to answer such questions has convinced us of the efficacy of this form of instruction. The students seem also to grasp something of the enthusiasm and interest in the science of chemistry which turns some of them ultimately into capable research workers. We have noted with considerable satisfaction moreover, that even the more purely descriptive type of chemistry is rather readily learned. It is evident that the habit of correlating facts with each other and with theory has made the assimilation of the information comparatively easy.

In order to achieve its object such a course must have the advantage of contact with the more advanced work and the research carried on in the department, and must be taught by men interested in discovery. It has been our policy, therefore, for all members of the departmental staff to take part at more or less frequent intervals not only in the weekly conferences of instructors, but also in the laboratory and quiz sections. This practice has been effective in unifying the purposes of all the departmental courses. The junior assistants are all candidates for the Ph. D. degree, and hence actively engaged in research. The better students are frequently invited to see the work these graduate assistants are carrying on in the research laboratory, which proves a source of considerable inspiration.

Thus beginning with students from the high school, many of whom have not had even high school chemistry (for we admit students if they have had high school physics and trigonometry), we are able to accomplish in a single intensive course what is ordinarily extended over two years; and by continuing the same intensive method in the more advanced courses, to prepare the student for serious research at the beginning of the senior year. The large proportion of students who go on into graduate work and the output of the laboratory in research are evidence of the rich fruit of the

method. We are confident also that those students who have studied elementary chemistry as preparation for some allied science have received a far better training for their later work than a more purely informational course could afford.

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### ARE IODIDES FOODS?

It has been considered by some biologists and chemists that living matter originated in the sea and the elements of living matter correspond to those found in the sea water. We might look, therefore, to the composition of sea water for the elements we should expect to find in living matter. Sea water consists largely of  $H_2O$  and sodium chloride, and besides those the chief ingredients are magnesium, calcium, potassium and carbonates, sulphates and bromides, but there are also present the following elements in traces: ammonia, lithium, rubidium, caesium, strontium, barium, manganese, zinc, iron, cobalt, nickel, lead, copper, silver, gold, radium, fluorine, iodine, nitrate, phosphate, silicate, aluminium, boron and arsenic. In searching for these substances in living tissue they have been found chiefly in marine organisms. However, chemists are finding them to a greater and greater extent in tissues of mammals. Damiens<sup>1</sup> finds bromine in a large number of animals and Gautier<sup>2</sup> finds iodine in quite a number of animals. We are familiar with the fact that fluorine is a regular constituent of bones and teeth and iodine of the thyroid gland. In experiments on the nutrition of animals, I have found it very convenient to feed them evaporated sea water and in this way insure a supply of all the rare elements. Cameron and Carmichael<sup>3</sup> have not observed any deleterious effect in feeding rather large doses of sodium iodide to white rats and rabbits. The use of sodium

<sup>1</sup> Damiens, A., *Comptes Rendus*, 1920, clvii: 930.

Damiens, A., *Bull. Soc. Chem. Biol.*, 1921, iii: 95.

<sup>2</sup> Gautier, A., *Comptes Rendus*, 1920, clxx: 261; 1899, cxxix: 66.

<sup>3</sup> Cameron and Carmichael, J., *Journal of Biological Chemistry*, 1920, xlv: 69.

iodide in preventing goiter in sheep and in preventing the hairless pig malady is quite well known. The use of iodide in the treatment of goiter was first brought out by the work of Dumas, who was born in 1800 and studied pharmacy in Geneva. Dumas and Coindet found that iodine was valuable in the treatment of goiter. The use of sodium iodide in the prevention and cure of goiter was strikingly emphasized in 1917 by Marine and Kimball.<sup>4</sup> This leads to the natural conclusion that the cause of goiter, or at least one of the causes, might be the lack of iodine in our diet. Iodine seems to be very rare in food and soils (Private communication of Oswald Schreiner) or else the former methods of detection have not been sufficient for such traces as do exist (See Kendall and Richardson<sup>5</sup> for later methods). Iodine has been found in a number of rocks such as slates (Gentile<sup>6</sup>), limestones (Lembert<sup>7</sup>), dolomite (Rivier and Fellenberg<sup>8</sup>) and granites (Gautier) in Europe and has been reported in vapor from Vesuvius (Matteucci<sup>9</sup>), but it seems to be leached out so rapidly from soils it is seldom to be detected. Forbes<sup>10</sup> failed to find iodine in about half of the specimens of foods, and Cameron<sup>11</sup> had a similar experience. The question of the relation of goiter to locality has caused much discussion and most persons have come to the conclusion that goiter is due to the presence of some substance rather than the absence, but since much fruitless work has been done in the attempt to find this substance it would be well to investigate more thoroughly the question of the absence of some substance.

<sup>4</sup> Marine, D., and Kimball, O. P., *Jour. of Lab. and Clinical Med.*, 1917, iii: 40.

<sup>5</sup> Kendall, E. C., and Richardson, F. S., *Journal of Biological Chemistry*, 1921, xliii: 161.

<sup>6</sup> Gentile, 1849, *Jahresber. d. Chemie*, 251.

<sup>7</sup> Lembert, 1851, *Jahresber. d. Chemie*, 319; *Jl. Pharm.* (3), xiv, 240.

<sup>8</sup> Rivier and Fellenberg, 1853, *Jahresber. d. Chemie*, 924.

<sup>9</sup> Matteucci, 1899, *Comptes Rendus*, cxxix, 65.

<sup>10</sup> Forbes, E. B., *Bull. Ohio Agri. Station*, No. 299, page 487.

<sup>11</sup> Cameron, A. T., *Journal of Biological Chemistry*, xviii: 335.

Goiter occurs largely in mountainous regions or regions far from the sea. Iodine is so rapidly leached out of the soil that the supply of it may depend upon salt spray blown from the sea. During storms the waves are broken into a spray and the water evaporated and the salt carried for long distances through the air. This salt is washed down out of the air by rains and contaminates the rain water. In the accompanying figure 1 taken from Emmons<sup>12</sup>

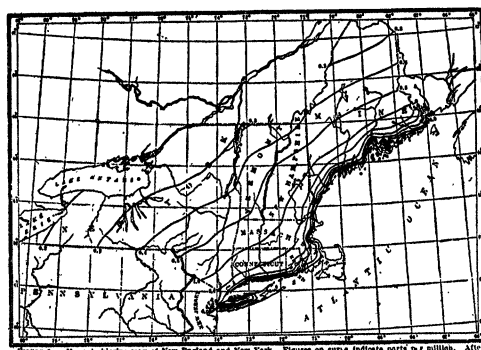


FIG. 1

is shown a map of the eastern states, indicating the relative amount of sea salt in the rain water. Determinations were made by the weight of a certain constituent (the chlorine ion) by the ordinary silver nitrate titration, but sea water is of very uniform composition in regard to everything except  $H_2O$ . That is to say, when the salts are diluted or concentrated, they are all changed in the same ratio, and the dry salt would be of uniform composition, so that the chlorine titration would indicate the relative amount of iodine. Evaporated sea water contains 50 parts per million of iodine, whereas the chlorine forms 55 per cent. of the evaporated sea water. The lines on the map indicate parts per million of chlorine in the rain water and the iodine would be about one ten-thousandth of this amount, or, in other words, a part per million of chlorine would be about a part per ten billion of iodine. We can say, therefore, that the amount of iodine in the rain water rapidly decreases as we go from the coast, and is least

<sup>12</sup> Emmons, W. H., 1913, *U. S. Geol. Survey Bull.*, 529.

in the Great Lakes region. Figure 2 (taken from Davenport and Love<sup>13</sup>) shows a map of

### GOITER, SIMPLE

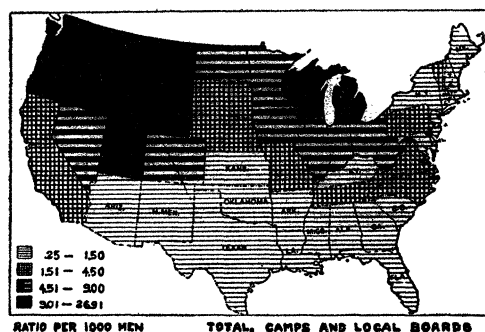


FIG. 2

the goiter as reported by the Draft Board and we have more or less the same distribution in the opposite direction and see more goiter towards the lake region and less toward the coast. Owing to the fact that no chlorine maps have been made for the rest of the country, it is not possible to extend this comparison. It is reported, however, from various sources (and is my personal observation in Minnesota) that the whole Great Lakes region is quite goiterous, and this is necessarily a region in which very little sea salt falls upon the land since the air blowing over it has already been washed free from sea salt by previous rains. Besides this goiterous region, various mountainous regions in the country have been reported to be goiterous and this is also true of Europe. These mountainous regions may be relatively near or far in relation to the sea. We often speak, however, of the clear mountain air free from dust, and it seems very probable that sea salt, being very heavy, would tend to remain in the lower strata of air rather than rise to mountain heights. Volcanic dust when thrown to great heights may remain in the upper air for a considerable time, but this is true only of the very finer particles of dust. The larger particles settle very rapidly. In fact, so rapidly as to sometimes bury towns. We may suppose the same things are true of the sea salt in the air.

<sup>13</sup> Davenport, C. B., and Love, A. G., 1920. *Scientific Monthly*.

The very finest particles may be carried to greater heights than the larger ones, provided they can escape the rain long enough to reach that height in the first place. The volcanic dust is thrown rapidly to the great height. The sea salt is thrown into the air at the sea level and its reaching a great height is very fortuitous. Therefore, we may suppose that the occurrence of goiter in mountainous regions fits in with the deficiency hypothesis. The absence of iodine from the rain water and soil in a region would necessitate its absence from the plants growing in the region and the animals subsisting entirely upon the plants and rain water. Man, however, may receive considerable food from some distance. Food rich in iodine, such as fish, oysters, squid, sea-hares, sea urchin ovaries and sea weed, is consumed to a much greater extent along the sea coast than in inland regions. Sea weed is not a general article of diet and is only eaten habitually by the Japanese and certain other peoples living close to the sea. Sea food, owing to its perishable nature, is largely consumed close to the sea. Therefore, even with considerable means of food distribution, the relation of goiter to distance from the sea might still be maintained. Water might hold the same relations. Water flows toward the sea and therefore does not bring iodine from regions richer in it. Water courses rise either in mountainous regions or in inland lakes which are goiterous regions. Certain mineral springs may be exceptions but the consumption of such mineral water is rather limited.

The principal other factor in the diet is salt. Salt was first obtained by the evaporation of sea water. The process used reduces the amount of iodine, but the extent of reduction may depend upon the amount of refining that the salt undergoes. The sea water is evaporated in shallow ponds until the calcium carbonate precipitates. It is then further evaporated in other ponds until the sodium chloride crystallizes out. The mother liquor from the sodium chloride crystals, known by geologists as the bittern, contains most of the iodine along with magnesium chloride and other salts. This crude sodium chloride, which may have some iodine clinging to it, was formerly con-

sumed in this condition but nowadays is often further purified by washing and recrystallization so that the iodine, which is in very low concentration in the sea water, is reduced to infinitesimal quantities. Salt was not purified to as great an extent in the early days as it is now. When it comes to rock salt Nature has already purified it to some extent. Van't Hoff showed the mechanism of stratification of the rock salt deposits. The sodium chloride layers are already more or less purified. This salt when it is mined in the dry state or when it is obtained from salt springs, which consist of water which has come in contact with these salt deposits, is still further purified for table use. Hayhurst<sup>14</sup> investigated some of the salt works in Ohio where the salt is obtained from deep wells. Bromine and a trace of iodine are separated out of the salt and the bromine sold as a by-product.

I have been unable to obtain any evaporated sea water, that is to say, salts obtained from the sea water without fractional precipitation or purification, from any commercial salt manufacturers on the coast. Through the kindness of Metz & Company, Dr. Sherndahl evaporated 100 gallons of sea water for me to use in experimental feeding. This, together with sea water which I have had opportunity to evaporate, has been dried by baking it in an oven. When the last traces of water are eliminated in this way, hydrochloric acid fumes are also given off. The cause of this, as pointed out by Sorensen, is a reaction between magnesium and the other salts whereby oxides of the alkaline earth metals are formed with the elimination of hydrochloric acid. If the baking is continued long enough no calcium or magnesium chloride remains and therefore the salt remains dry. If the sea water has been evaporated in an iron kettle some iron oxide is added to it, which improves it from a nutritive standpoint. The necessity of baking may be eliminated by adding 6 grams of  $H_3PO_4$  to the liter and this salt may aid in the treatment of rickets. In my animal experiments this evaporated sea water has been used for generations of animals as the salt ration, with gratifying results. It is very low in phosphoric acid

unless  $H_3PO_4$  has been added, and if casein is used as the protein there is not sufficient phosphoric acid in the casein for the nutritional requirements. The question as to whether there is sufficient calcium or not for the total calcium ration has not been definitely settled. If wheat flour is used for the carbohydrate portion of the ration there is sufficient additional calcium in the wheat flour to bring the calcium up to the requirements.

The question arises whether it would not be advisable for us to feed our children an impure salt. If iodine is the only mineral constituent that might be deficient it could be easily added to the salt. We have not proved, however, that the other mineral constituents of sea water are not necessary in the diet. Therefore, it would seem much simpler to use evaporated sea water as the salt ration if it could be obtained, and it only remains to create a demand for it. The present process of commercial evaporation of sea water could be simplified if an impure salt was desired. That is to say, only one pond would be necessary for the evaporation of the sea water. Sea water could be evaporated in this pond as far as practical by the sun. The total contents of this pond, including both solids and liquids, could then be removed and evaporated by heat and thoroughly mixed, and baked at a high enough temperature to produce a dry salt. In case the crystals of salt were large, owing to the slow evaporation at first, they could be ground. In baking, however, there is a tendency for these crystals to break up. The inclusion of a little earth with the salt would not impair its nutritive qualities and the product would be sterilized by the high temperature used in baking. It has been shown that salt obtained by the usual methods from the salt evaporating plants on the French coast is reeking with bacteria. The production of a sterile product might be an advantage. The dietary salt of several adults, children and infants has been limited to the above described from Metz for many months with gratifying results, in a goiterous region.

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<sup>14</sup> Hayhurst, E. R., *SCIENCE*, 1921, liv: 131.