DISCUSSION

MISCONCEPTIONS RELATIVE TO THE MINERAL COMPOSITION OF PLANTS

THE recent papers[1] on a comparison of the percentage composition of the dandelion with certain other edible plants are indicative of the prevalence of the idea that the mineral composition of each species is a fixed characteristic of that species. This concept is a legacy from the teachings of Liebig known as Liebig's "law of the minimum,"[2] from which the deduction was made that the principal mineral nutrient elements are absorbed only in certain definite and fixed proportions characteristic of the species.

The influence of this concept resulted in the neglect by the majority of those investigators, who, as a means of diagnosis, made analyses of an entire plant (or plants) periodically during the vegetative season or at maturity, to support the analyses by reference to the conditions—soil, cultural and meteorological—under which the plants were grown; and who were thereby led to conclude that the results obtained were established *ad universum et ad aeternum,* whereas, in fact, analyses had been made only of a particular plant (or plants) grown in a particular soil in a particular year. In this way the extreme sensitivity, the flexibility (plasticity) and "le mode d'alimentation" of a plant, readily recognized by the method of foliar diagnosis,[3] were not clearly discerned.

The fact that has been hitherto and is still at present lost sight of is that comparison of the quantitative relations between the elements during the growth of a particular species subjected to different growth conditions—cultural and meteorological—can not be made without a key of interpretation and that consequently comparisons between the composition of different species with respect to any of the dominant or accessory mineral elements also can not be made without a key of interpretation. The problem for the future is to work this out.

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THE ACID-BASE EQUILIBRIUM IN SEA WATER

SINCE the fundamental vital reactions of metabolism and photosynthesis proceed through the oxidation and reduction of carbon, it is important to describe the condition of the oxidized forms of carbon in the environment. In sea water carbon dioxide dissociates as an acid, with results which are directly of biological importance; and, indirectly, they are of no less significance in relation to the solubility and precipitation of calcium carbonate.

There have been numerous attempts to formulate the carbon dioxide system in sea water in terms of the dissociation products of carbonic acid. These have differed in one important way in essential procedure. In one case sea water has been regarded as a solution containing only the weak acid, carbonic.[1] In the other case, sea water has been considered as containing other weak acids than carbonic which are non-volatile.[2]

Proceeding upon the assumption that the only weak acid present is carbonic, titration with strong acid to the proper end point will indicate the quantity of combined carbon dioxide present, and the results so obtained may be utilized to indicate bicarbonate ion concentration for the calculation of the first apparent dissociation constant. If, on the other hand, another weak acid is present, titration will give results for the combined carbon dioxide content of the solution which are too large. The error of the carbon dioxide content so calculated will depend upon the amount of strong acid necessary to deionize the weak acids other than carbonic.

Since the titration alkalinity of the sea water is small (2.5 milli-equivalents per liter), it is not easy to be certain from the titration curve whether or not other weak acids are present. More recently it has been determined that boron is present in sea water to the extent of about 0.4 millimols per liter.[3] Phosphoric and silicic acids appear to be present in too small an amount for significance, but it is difficult to exclude them entirely.

The extensive work of Saunders (1926) and Buch *et al.* (1932) derives the value of k_1 for carbonic acid in sea water from determination of the total CO_2 by titration. The results obtained by titration should give values for bicarbonate, and consequently k_1, which are too large in proportion to the amount of acid required for deionization of weak acids other than carbonic. At the same time it is recognized that the effect of the half molar salt concentration will be to reduce the bicarbonate ion activity, and a correction is applied to reduce the value of k_1. The sum of the positive error due to other weak acids and the negative activity correction perhaps bring the final result for k_1' to its true value, but the result is fortunate rather than correct. That the results are

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[1] E. Bennett, SCIENCE, 80: 142, 1934; G. E. Youngburg, *ibid.*, 80: 337, 1934.

[2] Walter Thomas, SCIENCE, 70: 382–384, 1929.

[3] Walter Thomas, *Soil Science*, 33: 1–20, 1932; and the references to the papers by H. Lagatu and L. Maume cited therein.

[1] Saunders, 1926; Buch *et al.*, 1932; Greenberg, Moberg and Allen, 1932.

[2] Henderson and Cohn, 1916; Irving, 1925.

[3] Moberg and Harding, 1933; Buch, 1933.

consistent with theory on such assumptions is only a demonstration of consistent analytical operations.

The error is unfortunately introduced in the assumptions necessary for derivation of the first constant in the system. It enters the calculation of k_2' for carbonic acid and k' for boric acid as determined by Buch (1933).

There are so many uncertainties in the application of the law of mass action to the dissociation of weak acids that it is better to remember that the whole system is only empirical and that it is only significant as far as the analytical procedure is directly appropriate. The statement that

$$\text{Total } CO_2 = \frac{\alpha P}{760}\left(1 + \frac{k_1}{[H^+]} + \frac{k_1 k_2}{[H^+]^2}\right)$$

affords the chance for direct determination, since at pH 7.0 the last term is negligible and all others but k_1 can be determined analytically. As determined in that way the value of k_1 and its derivatives k_1' and k_2' would have empirical significance corresponding to the accuracy of analytical procedure.

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HOST RESPONSES TO HAUSTORIAL INVASION OF CUSCUTA SPECIES[1]

WORKING on the host responses to haustorial invasion of *Cuscuta* the writer noted, in 1931, that galls were frequently formed by the host plants. Extended observations in the field during the past three years, and controlled experiments in the greenhouse, show that infestation of a given host plant commonly leads to marked hypertrophy of adjacent tissues, resulting in gall formation. Large, primary galls are characteristically formed at the point of initial attack, similar swellings at points of secondary infestation, and other types of hypertrophy at various points of haustorial entry on the same plant.

In all, 334 galls have been collected by the writer, 107 from field stations in Iowa and West Virginia, while 227 were formed following experimental greenhouse infestations. Four species of *Cuscuta* have been observed to induce gall formation, namely, *C. Gronovii* Willd., *C. glomerata* Choisy., *C. rostrata* Shuttlw., and *C. Polygonorum* Englm. The following seventeen genera (containing 21 host-species) have been listed as gall-forming hosts to one or more of the above-named dodders, *viz.*, *Hibiscus, Salix, Solidago, Stachys, Cucurbita, Glycine, Fagopyrum, Helianthus, Cucumis, Chelone, Medicago, Trifolium, Cephalanthus, Impatiens, Myriophyllum, Nicotiana* and *Bidens*.

Young galls consist mainly of hypertrophied cortical tissues; later stages involve an increase in volume of both cortex and xylem, the latter often enlarging greatly and frequently making the galls quite woody. The surface of the older galls is commonly cracked, roughened or fissured and frequently supports a superficial fungus growth. However, no traces of fungi or bacteria have been found in the inner tissues of any gall examined by the writer.

In previous studies of *Cuscuta* primary attention has been given taxonomic and agricultural phases with, of course, a few critical studies on the structure and penetration of the haustoria. Galls apparently have escaped previous notice because of their usual occurrence low, on the host stem, within a few inches of the ground. However, Peirce[2] reported an example in which the petiole of *Solanum jasmoides* showed a general enlargement due to haustorial entry. In the same article he stated that host plants of *Cuscuta* did not form new structures or exhibit new growth as a consequence of haustorial penetration.

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BOHEMIUM—AN OBITUARY

THE sensational announcement[1] by Odolen Koblic that he had found in pitchblende a new element, atomic number 93, atomic weight circa 240, created a considerable stir in the ranks of chemists and physicists. However, "bohemium" lived only about one month, and the undersigned was in some measure responsible for its speedy demise. My teacher, Seubert, had studied under Lothar Meyer, who shared with Mendeléeff the honor of formulating the periodic system of the elements. Brought up in this school I was, of course, greatly interested in the report that the family of our chemical building stones had been once more increased and that the newcomer represented an extension of the periodic arrangement.

Frankly, I was skeptical, and I made a special trip to Joachimstal, C. S. R., visited Koblic in his laboratory and persuaded him to give me some samples of "bohemium"-bearing material. These were taken to the Physikalischtechnischen Reichsanstalt in Berlin and turned over for investigation to that gifted couple, Walter and Ida Noddack, the discoverers of rhenium and masurium.

The x-ray spectrographic study gave absolutely negative findings. Neither the Noddacks nor their expert collaborators could detect the slightest indication of the presence of a new element in the "bohemium" concentrate. The optical spectroscopic tests revealed nothing in favor of Element 93. Chemical tests showed that the specimens consisted chiefly of tungsten, vanadium, etc. Later work showed that

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[1] Preliminary report.

[2] G. J. Peirce, *Ann. Bot.*, 8: 53–118, 1894.

[1] *Chemiker Zeitung*, July 18, 1934, page 581.