pothesis regarding the mode or origin of the microsomes is correct, then these small particles would share with the cell itself, and within the cell, with the chromosomes, the centrioles, the plastids and possibly the tonoplasts, the most general law of living matter, that of genetic continuity. It must be emphasized that the above conception is concerned exclusively with the biochemical aspect of the origin and evolution of the granular substance of the cytoplasm. It does not deny the possibility that the cytoplasmic constituents may come, in the course of their evolution and activity, under the influence of the nucleus.

THE UTILIZATION OF AQUATIC FOOD RESOURCES

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THE food and forage situations in Europe during the past three years have stimulated discussions regarding the availability of certain aquatic plants and animals not now generally used as sources of such material. The utilization of large aquatic plants as forage for animals and the use of both marine and fresh-water plankton as sources of human food have been mentioned. Little has been said, however, about the quantity of these materials found in fresh waters, and a brief consideration of this phase of the problem may be worth while.

Large aquatic plants have been used as forage for cattle in Yugoslavia for many years,[1] and it has recently been reported that they are now being used extensively for the same purpose in Sweden owing to the scarcity of fodder in that country. While these plants have a rather high mineral content (10 to 35 per cent. ash), they contain considerable quantities of nutritious materials; protein makes up 12 to 25 per cent. of the dry weight, fat 1 to 3 per cent. and the remainder of the organic matter consists of carbohydrates, of which crude fiber constitutes 16 to 21 per cent. Using the averages of these percentages of organic matter and assigning 4 calories to each gram of protein and of carbohydrate and 9 calories to each gram of fat, their energy value is about 1,450 calories per pound, dry weight. A mean of 18.5 per cent. of the dry plants consists of crude fiber and the greater part of this may be regarded as indigestible; deducting this part of the carbohydrate would leave an energy value of 1,100 calories per pound for the digestible organic matter in the plants.

Rather large crops of these plants are found in some of the Wisconsin lakes; in Mendota, for example, the annual yield has been estimated at 2,100 tons of air-dry material, or about one ton per acre of the shallow area in which they grow.[2] In Green Lake the crop was estimated at 1,600 pounds per acre, air-dry, in the shallow water zone and the total crop at 1,528 tons. In the soft-water lakes of northern Wisconsin, the yields of large aquatics are much smaller, ranging from 10 to 100 pounds per acre in the vegetated zones.

With respect to the use of plankton for human food, Clarke[3] has discussed this problem from a marine standpoint, referring especially to the plankton crustacea, while Hardy[4] and other authors have called attention to the possibility of using fresh water as well as marine plankton for food; both phytoplankton and zooplankton have been mentioned in some of the communications. It has been pointed out that the chief difficulty is to obtain enough plankton material to warrant the labor involved in collecting it. The smaller organisms which make up the great bulk of the plankton are especially difficult to capture. One author has suggested the use of the tons of plankton collected on the filter beds of cities that filter their water supplies, while others have considered various types of nets. The latter capture only the larger organisms, chiefly zooplankton forms, which usually constitute not more than 10 per cent. of the total plankton and frequently as little as 5 per cent.

Data obtained on Wisconsin lakes show that the dry organic matter of the plankton found in them ranges from a minimum of half a gram in the soft-water lakes to a maximum of 9 grams per cubic meter in some of the hard waters. This minimum in Crystal Lake represented a standing crop of 45 kilograms per hectare (41 pounds per acre), while the maximum in Lake Waubesa indicated a standing crop of 966 kilograms per hectare, or 862 pounds per acre; the live weight of this dry organic matter would be ten times as large, since 90 per cent. or more of the weight of the living organisms consists of water. The mean standing crop of plankton in Lake Waubesa over a period of two years was 242 kilograms per hectare, dry weight, or 216 pounds per acre, of which 49 per cent. consisted of protein, 5 per cent. fat and the

[1] Vilim Mršić, SCIENCE, 83: 391, 1936.
[2] H. W. Rickett, *Trans. Wis. Acad. Sci.*, 20: 501, 1921, and 21: 381, 1924.
[3] SCIENCE, 80: 602, 1939.
[4] *Nature*, 147: 695, 808, and 148: 115, 143, 314, 375, 1942.

remainder was made up of various carbohydrates, including 6 per cent. pentosans and 4 per cent. crude fiber.

Just how much of this plankton material could be harvested and still leave a sufficient number of the organisms to perpetuate the crop and supply sufficient food for larger organisms has not been determined. Likewise the rate of turnover in this standing crop of plankton can not be definitely assessed because it includes a large variety of forms, ranging from bacteria and algae to crustacea and insect larvae, which are diverse in size and in rates of reproduction; in addition growth, multiplication and destruction of the constituent organisms takes place throughout the year. Under favorable conditions, bacteria may multiply several times a day, while algae and protozoa are probably limited to once or perhaps twice a day; the life span of the crustacea ranges from about a week to three months or more, depending chiefly on temperature and food conditions, and that of insect larvae may extend to 8 months or more. Assuming a turnover in this heterogeneous crop of plankton once a month during the year, which is a conservative estimate especially during spring, summer and autumn, would give an annual yield of 2,892 kilograms of dry organic matter per hectare, or 2,580 pounds per acre. It seems probable that the actual annual production is more nearly twice the above amount.

From the standpoint of collecting this plankton, it was found that at least 98 per cent. of it could be obtained by passing the water through a large clarifier type of centrifuge at a rate of 1.5 cubic meters in two hours. The average yield from samples of this size in Lake Waubesa was approximately 5 grams of dry organic matter per cubic meter of water. Assuming the same values for protein, fat and carbohydrate as noted for the large aquatics, the energy value of these 5 grams of plankton would be 20 calories. Thus with an energy requirement of 3,000 calories per person per day, it would take the plankton from 150 cubic meters of water to satisfy this energy demand. To obtain the plankton from this amount of water would require the operation of the centrifuge continuously for a period of 200 hours, or a little more than 8 days, to satisfy the energy required for one day. From this result it is evident that the installation of a large battery of these centrifuges in order to reduce the time of obtaining the desired quantity of this material would not be a profitable investment.

Another difficulty may be mentioned in connection with certain forms included in the phytoplankton and protozoa. While both marine and fresh-water crustacea have been pronounced as "not unpleasant" by those who have eaten them, it seems probable that the verdict would not be so favorable if the smaller plankton organisms were included in the menu because a number of them produce odors and tastes[5] that are not only unpleasant but quite disagreeable under certain conditions. Fresh-water plankton crustacea make up such a small percentage (less than 10 per cent.) of the total crop of plankton that they can not be relied on to contribute greatly to the energy requirement of a person, but they might be used to supplement a sub-standard food ration to a certain extent. They have a high food value, since an average of 52 per cent. of their dry weight consists of protein and 13 per cent. fat. One of these crustaceans, namely Daphnia, is cultured extensively in pools and ponds by fish culturists for food for young fish and there is no apparent reason why they can not be grown in quantities large enough to serve as a supplementary food for man, especially during the more favorable growing seasons in spring, summer and autumn. They are readily preserved for future use by the simple process of drying.

The plankton, either directly or indirectly, makes an important contribution to the food supply of fish; in fact, the menu of fish in one way or another is derived principally from the plankton, the bottom flora and the bottom fauna. Fish, however, are very poor converters of the biota of a lake into nutritious food for man in the form of their own bodies; they are much more easily harvested and much more palatable to man. Their inefficiency as converters is shown by the fact that they constitute less than 3 per cent. of the total weight of the biota in some of the smaller lakes.

As indicated above a turnover once a month in the plankton crop of Lake Waubesa would give an annual yield of 2,592 pounds per acre of dry organic matter, or 25,920 pounds per acre of live organic matter. In control seining on this lake carried out by the Conservation Department, the average annual yield of carp from 1934 to 1939, inclusive, was 278 pounds per acre;[6] in addition the estimated catch of game and pan fish by anglers was 17 pounds per acre in 1938 and 1939, thus making the average fish yield 295 pounds per acre for these six years. This annual yield of fish was only 1.1 per cent. of the estimated annual production of live plankton as indicated above; in other words only one pound of fish per acre was produced annually for every 88 pounds of plankton. It must be remembered also that the bottom flora and fauna are not taken into account in this comparison; if they were included the result would be still more unfavorable for the fish. The weights of these two groups of organisms have not been determined so

[5] G. W. Whipple, "The Microscopy of Drinking Water," New York, 1927.

[6] D. G. Frey, Ph.D. Thesis. 1940.

that no definite ratio can be given for the total biota; the bottom flora and fauna, however, are major sources of food for the fish, especially the larger sizes, while plankton is the chief source during the first two years of life. With such a large surplus of plankton, it seems probable that 50 per cent. of it could be harvested for human food, if desirable and practicable, without decreasing the rate of fish production.

In spite of the fact that the annual production of fish appears unusually low in comparison with the other biological resources of Lake Waubesa, it compares very favorably with the beef production of pasture land, for example, excellent pasture is required to produce 200 to 300 pounds of beef per acre per year. It may be pointed out also that the fish yields in 1938 and 1939 were more than 500 pounds per acre in this lake, with a maximum of 550 pounds per acre in 1939. The latter yield is approximately twice as large as the maximum beef production of first-class pasture land.

OBITUARY

WILLIAM ALBERT SETCHELL

WILLIAM ALBERT SETCHELL, professor emeritus of botany of the University of California, died in Berkeley on April 5, 1943. Had he lived ten days longer he would have reached his seventy-ninth birthday. Professor Setchell was born in Norwich, Connecticut, on April 15, 1864. He graduated from Yale University with the degree of A.B. in 1887. He then entered Harvard University for graduate study and received the degrees of A.M. and Ph.D. at that institution in 1888 and 1890, respectively. He was appointed instructor in biology at Yale in 1891 and remained in that position until 1895, when he was called to a full professorship and headship of the department of botany of the University of California; this he held until his retirement in 1934, after which he became professor emeritus.

In 1920 Dr. Setchell was married to Mrs. Clara Ball Caldwell, who died on September 4, 1934.

Professor Setchell enjoyed membership in several professional societies, but in addition he was honored by election to several organizations of special distinction. He was a fellow of the American Association for the Advancement of Science, of the American Academy of Arts and Sciences, the California Academy of Sciences and the Torrey Botanical Club. He was a member of the National Academy of Sciences, the American Philosophical Society and the Washington Academy of Sciences in this country, and of several distinguished societies abroad. Among these latter were Société Biogéographie, Société Linnéenne de Lyon, Botanical Society of Japan, the Linnaean Society of London and the Kunglig Vetenskaps och Vitterhets Samhället i Göteborg.

In the field of science to which he devoted his life Setchell made a distinguished record. Thoroughly competent though he was in botanical taxonomy in general, his distinction lay in his monumental contributions to algology and especially to marine algology. From the cooperative researches which he carried on through most of his life with the late Professor Nathaniel Lyon Gardner, there resulted in published form several large volumes on the marine algae which are among the most thoroughgoing and impressive in the world. Moreover, he was never a narrow student of taxonomy. He was as much interested in the causes of the geographic distribution of algae as in their orderly classification, and his contributions to our knowledge of the rôle of temperature in the distribution of algae have received world-wide notice. Setchell was one of the early students of plant genetics in this country and inaugurated the fundamental genetical studies on Nicotiana which have since been carried on with distinction by Professors Goodspeed and Clausen.

His versatility in his field of science was paralleled by his general versatility. With the classical background of his college training he combined a flair for writing and speaking in graceful and humorous vein, thus making him a companion sought after by circles of laymen as well as of scientists. His appreciation and critical appraisal of the best in literature and music went far beyond that of most laymen. Through his possession of so many and varied qualities of mind and spirit he gained numerous friends in Europe and in other continents which he visited on several occasions. These friends regarded him with affection as well as respect. Likewise, in this country his friends were legion and he was especially gifted in appealing to young men from every biological field who always surrounded him in numbers. Many a young man in biological work in this country received inspiration and material aid from him, as well as wise counsel and lasting friendship.

Those of us who knew Professor Setchell intimately not only admired his hearty personality, fine learning and expertness with the marine algae, but in addition regarded him as an example of the best in American scholarship and manhood. He was a great algologist, a sturdy American and a loyal and devoted friend. All who knew him will mourn his loss to us.

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