suffers from much the same kind of inadequacy as the theory that social organization is the result of a hierarchy of dominant functionaries who derive their authority from a common ruler. It really matters little whether the dominant influences are conceived to be persons or ideas.

There are many features of Child's and Herrick's volumes which can not be considered in a brief review. Both books are substantial contributions from workers who have spent years of research and reflection in the fields which are covered. The biologist, whatever may be his specialty, may gain from them many new facts and stimulating ideas.

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SPECIAL ARTICLES

ENZYMES OF THERMAL ALGAE

THE algae of the hot springs in Yellowstone National Park offer good opportunity for a study of the distribution of enzymes in relation to the temperatures at which the organisms live. There is a complete series of thermal springs ranging in temperature from the boiling point (about 91° C) down to ordinary temperatures. Algae are found growing at a great many different temperatures within this range. One species of Phormidium was found growing at 89° C in Beryl Spring.

The action of some enzymes has been shown to be destroyed at temperatures much below the normal temperature range of some of these thermal algae. It seems of interest to determine at what range of temperature the thermolabile enzymes are present in the algae, and how the algae are able to conduct their metabolic processes at temperatures above the maximum for the activity of several important enzymes.

Phormidium laminosum was found growing in pure culture in Hymen Terrace spring at 73° C. to 65° C. Its range did not extend below 65° C. Possibly other factors than the temperature were concerned in this distribution, since the carbon dioxide and hydrogen sulfide used by this organism are quickly liberated from the water after it escapes. Possibly the temperatures below this range do not allow metabolic processes to proceed normally in the absence of certain enzymes.

Determinations on the catalase, oxidase, oxydoreductase and peroxidase action of this Phormidium were made immediately at the spring. For oxydoreductase activity the reduction of methylene blue in the presence of acetone was used. Strong reduction was shown by the preparation, some of which was probably due to the reducing substances present in the water which can not be eliminated. For oxidase activity, the oxidation of tetra methyl para phenylene diamine showed a slight activity. On the addition of hydrogen peroxide to this reagent a very active peroxidase action was shown. Catalase was determined by means of the Van Slyke apparatus commonly used for the determination of amino acids, the oxygen being liberated in the reaction vessel and measured in the burette. The material was collected from pure culture and the determinations were completed within a few minutes. No catalase activity was shown by the Phormidium filaments either suspended in water or after grinding for a long time in a mortar with fine quartz sand and calcium carbonate. The failure to decompose hydrogen peroxide was not due to any defect in the experiment or to poisonous substances in the spring water, since leaves of Iva xanthifolia treated in exactly the same manner with spring water showed high catalase activity at room temperature. It must be concluded, then, that this Phormidium possesses no catalase and little oxidase activity but shows a strong peroxidase and probably oxydo-reductase action.

Catalase previously has been found to be of universal distribution in living organisms. Czapek in his "Biochemie der Pflanzen" gives a bibliography of its distribution in various groups of plants and animals. Oscar Loew concluded that catalase was universally distributed, occurring in every organism and necessary in every living cell. This is the first instance of its absence from an organism having been demonstrated. G. B. Reed reported catalase activity in ripe and half ripe pineapples but found no activity in very green pineapples. No mention was made of controlling the acidity, so it seems probable that the catalase present in the green fruits was destroyed in the preparation. This enzyme, therefore, can not be required for the life activities of all organisms as has been suggested. The maximum temperature for the activity of catalase is low. Catalase derived from leaves of Iva xanthifolia was destroyed at the temperature of the spring water of Hymen Terrace (73° C.) by exposure for less than one minute. Oxydo-reductase is known to have a rather high optimum (57° C.) for its activity, and peroxidase activity is shown at the boiling temperature since it is thermostable, in fact, to such a degree that there is doubt that it should be included in the class of enzymes.

The fact that an organism can live at the temperature at which water boils at high altitudes demands that by some means it shall be able to carry on the hydrolytic cleavages or other chemical activities required for its metabolism. As the altitude increases there would be found a level at which water would maintain a constant temperature by boiling at a tem-

perature at which some members of the genus Phormidium live normally. This altitude would not be much higher than the present plateau of Yellowstone Park. The fact that amino acids and a great many substances found in living organisms can be synthesized without the intervention of organisms by the ultra-violet radiations existing at such altitudes is suggestive of the probable place of origin of life forms. If such complex substances should be formed under present conditions, they would be quickly used by the omnipresent organisms capable of using them. Before the appearance of any living organism there would be possible the accumulation of such substances in quantity, a condition which is not realized under existing conditions. The action of hydrolytic enzymes in thermal algae might be substituted by the purely physical condition of high temperature on account of the increase in the rate of chemical reactions with increase in temperature according to the Van't Hoff coefficient. If high temperature can substitute the action of hydrolytic or other enzymes in these thermal algae, this may give a clue regarding the environmental conditions obtaining at the time of the origin of living things, since at high temperatures no such enzymes might be required. It is difficult to conceive of an organism originating with a full complement of enzymes, photosynthetic pigments, etc. Absence of certain important enzymes from an organism may well indicate a primitive type of physiological processes in which the organism makes use of physical conditions of the environment to substitute the action of complex biological catalysts. Since these thermal algae are able to carry on their life processes without catalase, which is found in all other organisms, and since they possess certain thermostable catalysts, with the additional use of high temperature to speed up other chemical reactions which are commonly catalyzed in other organisms by special enzymes, they seem particularly adapted to growth at high temperatures. Certain of the enzymes may have become necessary only in the evolution of forms adapted to lower temperature. The chemosynthetic forms of the iron and sulfur bacteria have been considered for several reasons to closely approach the type of physiological processes demanded for a primitive organism. They are able to fix atmospheric nitrogen, and they synthesize their carbon compounds without the intervention of photocatalytic pigments using the oxidation of inorganic material such as H_2S as the source of energy for synthesis.

The algae of these springs offer opportunity for the solution of some physiological questions of fundamental importance. Owing to the lack of facilities for laboratory work in Yellowstone Park at the time, determinations of other enzymes was delayed until they might be made upon material preserved with toluol and with 85 per cent. ethyl alcohol. Report upon the occurrence of other enzymes in these algae will be made by Miss Olga Lakela, who has completed the work.

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THE PRODUCTION OF HYDROGEN SULFIDE BY YEAST

THE production of hydrogen sulfide by living yeast cells in the presence of sulfur or certain sulfur derivatives is well known in the literature. The work of de Rey-Pailhade[1] showed that yeast extracts were also able to produce hydrogen sulfide in the presence of sulfur. He attributed the formation of hydrogen sulfide to the presence of a substance in the yeast which he termed "philothion." The recent work of Hopkins,[2] however, appears to indicate that de Rey-Pailhade's "philothion" is similar to a dipeptide of glutamic acid and cystein which Hopkins isolated from yeast and animal cells. This compound after oxidation is easily reduced and also forms hydrogen sulfide when shaken with sulfur.

The presence of an active reducing enzyme in yeast has been demonstrated by Hahn[3] and others, so that very probably the reducing properties of yeast are largely due to enzyme activity of this nature.

The production of hydrogen sulfide by yeast, apart from its purely biochemical interest, is of considerable practical importance. Examples of hydrogen sulfide production are well known in the fermentation industries. Wine and beer stored in casks which have been fumigated with sulfur will often develop hydrogen sulfide, and such effects have been explained by the reducing activity of yeast in the presence of free sulfur, sulfites, and loosely bound sulfur compounds of a protein nature.

In flour and baking, however, the production of hydrogen sulfide by yeast in dough seems to have received little or no attention, and the writer has been unable to find any information or reference to this phenomenon in the literature thus far examined.

Recently the production of hydrogen sulfide by yeast in this connection was brought to the writer's attention. The flour was a northern spring patent, of normal appearance, odor and taste. It was capable of producing a fairly good bread, but on fermentation gave off the odor of hydrogen sulfide. An

[1] Rey-Pailhade, J. de *Compt. rend., 106,* 1683, *107,* 43, 1888, and subsequently.

[2] Hopkins, F. G., *Bio-chem. J., 15,* 286–315, 1921.

[3] Hahn, M., Münchener med. Wochenschrift, S. 595, 1902.