surface and within reach of my dip-net, though a good many were brought up by use of the oars. This habit of retreating from the surface when weather conditions are unfavorable explains the apparent absence of the medusae on some of my previous visits to the creek. It has become evident that cloudy weather is unfavorable to finding it. The best conditions, judging by the character of the three seasons when it has now been found, are settled, clear days, when the water is low, free from silt and there is little current in the creek.

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### THE PEANUT PLANT

Since the peanut plant (*Arachis hypogea* L.) has become of such economic importance as to demand a description in every text-book on field crops, attention should be called to a mistake that was made by the early writers so that in the future the blossoms of this important plant might be correctly described.

*Arachis hypogea* is one of the Leguminosae and has sessile papilionaceous blossoms. The calyx consists of a tube about an inch in length crowned by the five sepal tips. On the throat of calyx tube are situated the five bright yellow petals. The calyx tube was mistaken for a peduncle and so described by the early authors, and the whole structure was termed a "sterile" blossom. After the blossom withers and falls off, the ovary, by the rapid growth of the internode between it and the receptacle, is lifted from between the bracteoles in the leaf axil and responding to geotropic influence turns toward the earth and the seeds are further developed and ripened only after it has been pushed below the surface of the ground. The early writers looked upon and described this gynophore with its ovary as a "cleistogamous" blossom.

Poiteau in 1805 first correctly described the blossom of the peanut. Robert Brown in 1816 confirmed Poiteau's description. In 1839 Bentham wrote of *Arachis hypogea* as a plant with dimorphic flowers, one with calyx and corolla which is always sterile, the fertile flowers having "neither calyx, corolla nor stamens . . ." and when Neisler in 1865 reconfirmed Poiteau's description, Bentham in the same year defended his paper of 1839. Corbett as a contributor to the "Cyclopedia of American Agriculture" (1907) describes the plant as having dimorphic flowers and *illustrates* the "fertile" and "sterile" blossoms.

Notwithstanding the works of Poiteau, Brown and Neisler, the majority of our modern publications, including scientific papers, agricultural bulletins and text-books on farm crops, in referring to the peanut plant seem to quote from the earlier writers and speak of it as having fertile and sterile blossoms, whereas it has complete blossoms and is self-fertilized.

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## SCIENTIFIC BOOKS

*Neurological Foundations of Animal Behavior.* By C. J. Herrick, H. Holt & Co., New York, January, 1924, xii + 324 pp.

*Physiological Foundations of Behavior.* By C. M. Child, H. Holt & Co., New York, January, 1924, xii + 330 pp.

The "Neurological Foundations of Behavior," by C. J. Herrick, and the "Physiological Foundations of Behavior," by C. M. Child, were written, in close collaboration and were issued from the press at the same time. They represent, so to speak, twin volumes; they appear, as twins commonly do, in the same garb, and they are of nearly the same size. But in addition to these superficial features of likeness, there are many other points of resemblance due to common hereditary factors. The writers appear to be in essential agreement in regard to their fundamental concepts. The notion of metabolic gradients which Child has elaborated in several volumes and a multitude of papers is adopted also by Herrick, and it forms the keynote of both volumes. The gradient idea, according to the authors, gives not only an interpretation of organic form, but it affords the basis for a science of behavior.

Both authors regard form and behavior as intimately and essentially correlated. It is the structure and physiological properties of the nervous system that form the neurological foundations of behavior, and Herrick's volume is devoted largely to describing the various types of nervous organization in different groups of animals, and in showing the significance of these types in relation to the kinds of behavior which the animals exhibit. After Herrick's first two chapters, which are mainly introductory, there is a description, in chapters 3 and 4, of the different types of receptors. Then follows in chapters 5 to 16 a survey of the types of nervous systems with their correlated kinds of activity from the protozoa to the higher vertebrates. For the reader who wishes to obtain a comprehensive idea of the architecture and evolution of the nervous system, these chapters will prove most useful. Throughout the volume, structure is interpreted from the standpoint of function. To show how the mechanism works is the constant aim.

For many readers, perhaps the most interesting of the series of chapters mentioned are those dealing with the "Evolution of the forebrain and functional factors in forebrain development." The forebrain is the seat of intelligence in vertebrate animals, and a peculiar interest attaches to the study of its evolution. "Within the forebrain of higher vertebrates, and especially the cerebral cortex," says Herrick, "there are correlation and association centers of very different type, centers which are not dominated by any single sensorimotor system but are reached by fiber tracts from several lower sensory centers. Here the more difficult problems of conduct are solved; these are deliberative reactions, the occasion for which arises only when the innate instinctive and reflex modes of response prove inadequate to make the required adjustment."

How is this higher type of correlation brought about? What is the structural mechanism that underlies it? What is the basis of the modifiability of behavior, and especially how is behavior coordinated so as to secure the welfare of the organism? These are some of the questions which Herrick discusses in the following chapters. With Herrick, as with Child, the conception of dominance plays an important part in the interpretation of coordinated behavior. The nervous system is a dominating system, and the higher centers, at least for certain kinds of activity, dominate the lower ones.

> The higher brain centers, including the cerebral cortex of man and many of the subcortical correlation centers, do not replace the lower reflex centers, but on the other hand the only way into these higher centers is through the lower [see Herrick, 1913, and 1922, chap. 21]. Physiologically, this implies that the lower reflexes and instinctive reactions, which employ the direct passageways through the central nervous system, will always do the work when their stereotyped mechanisms are adequate to resolve any given stimulus complex into the appropriate and satisfying reaction. These lower centers are always first activated, but if they fail to solve the problem of conduct satisfactorily the flow of nervous energy will be dammed up in them and finding no appropriate outlet directly into the motor organs it will then be diverted upward into the higher correlation centers. Once these higher centers are activated, their own intrinsic processes liberate a large amount of latent metabolic energy of the very special type already described, resulting in a local summation or intensification of the excitation process.

When difficult problems have to be dealt with the lower centers pass the problem up to the higher ones, activating the latter with an intensified energy and making them thereby "the organs of highest physiological dominance of the entire body."

In the last chapter on "Progressive factors in evolution," Professor Herrick, who exhibits throughout the volume a keen appreciation of the broader aspects of his theme, permits himself the luxury of philosophizing a bit on a number of topics which lie near the borderland of neurology. Among these topics is a discussion of critical stages in progressive evolution, the uniformity and essential similarity of vital processes from Amœba to man, habit formation in education, creative intelligence, behavior in relation to consciousness, and finally the future of human evolution. On these as well as on many other suggestive discussions, limits of space forbid further comment.

The volume of Dr. Child consists of an elaboration of the gradient concept with especial reference to behavior. In all organisms there are, according to Child, gradations in the intensity of metabolic processes which determine the fundamental outlines of axial symmetry and structural differentiation. The existence of these gradients has been demonstrated in a great variety of organisms and by several different methods. Gradations of metabolic rate are indicated by differences in the rapidity of oxidation and the elimination of carbon-dioxide, differential susceptibility to poisons, and changes in electrical potential. Centers of high metabolism tend to dominate or control centers of low metabolism, excitation being conducted from the one to the other and thus forming the mechanism of the control which is exercised by the dominant center. In the regeneration of a hydroid from a piece of the stem the oral end of the piece usually exhibits the highest metabolism and therefore develops into the head. The head dominates and determines the way in which the part lying just below it develops, and the latter dominates the next region, etc., until the stem is shaped into a new hydroid with duly subordinated parts.

There is no doubt that these metabolic gradients exist. They are shown by the stems of hydroids, the bodies of planarian and annelid worms, the long axis of vertebrate embryos and the growing stems of plants. In one way or another, they probably occur in all organisms. According to Child, they constitute if not the chief, at least fundamentally important directive agencies in development and regeneration. There can be no doubt that they commonly accompany differentiation. Are they to be regarded as the cause of differentiation or its effect, or are both perhaps the result of some common underlying cause? Child believes that these gradients are actual causes of differentiation. In support of his view he cites many cases in which gradients may be reversed or new gradients established by environmental agencies which change the rates of metabolism in different parts of the organism. Even the major axes of plants and animals may be determined by external factors if the latter begin to operate sufficiently early.

Child has little sympathy with preformational theories of development. The production and maintenance of organic form is a dynamic process. Development is not a process of building in which materials first get arranged somehow and begin to function afterward. It is a process of physiological functioning, or we may say behavior, at all stages. The progress of experimental morphology has given the death blow to the older theories of both nuclear and cytoplasmic organization as a basis for development. Often there is, it is true, a visible organization of the substances of the egg, but it is also true that it has no very fundamental significance for ontogeny. It is the product of development and not its antecedent. Child is probably right in his contention that the theory of formative stuffs, which Loeb has taken over from Sachs, has little real explanatory value. He is probably also right in rejecting the various theories which would explain form production as akin to crystallization. Development he regards as a process of physiological regulation in which the differentiation of organic form is the outcome of organic adjustment. The thing that makes for order, in his view, is the relation of dominance and subordination involved in the establishment of gradients.

It has always been a troublesome problem for the epigenesist to supply a real explanation of the order and harmony manifested during development, and it is a noteworthy circumstance that the great protagonist of this doctrine, C. F. Wolff, felt himself compelled to postulate a *vis essentialis* as a guiding principle to keep things in order. Gradients are supposed to function as unifying agencies which introduce a certain system of correlation on account of the relations of dominance and subordination which they involve. Hence they form an alluring notion to an epigenesist who is seeking for a dynamic interpretation of the orderly wholeness of the organism in the various stages of its history.

Apparently a gradient is a very simple thing, at least at first. It is merely a decreasing series of metabolic changes which differ primarily in purely quantitative aspects. But quantitative changes, as Child plausibly argues, may cause qualitative differences, and the latter may in turn occasion further differentiations, the precise way in which the process of complication is carried out being conditioned by the initial constitution of the protoplasm which is transmitted by heredity. A simple gradient may be passed on through the polarity of the egg, but this axis is not important. It may be determined by environment. But once the gradient is set up, it does not matter much where or how, the rest of development follows.

We must refer the reader to the original volume if he would gain an idea of Child's application of the gradient concept to the problems of physiological integration, regeneration, budding, the functioning of the nervous system and the coordination of behavior. The notion of gradients has been the dominating concept in most of Child's numerous researches for several years. How far it will take us towards a causal explanation of the phenomena of organic regulation remains to be seen. The dominance and subordination brought about by pace-making centers is essentially a one-sided relation. It represents an autocratic type of control. It is analogous to the control of an army in which the general issues orders to the superior officers who transmit them to officers of lower rank, from whom they finally come down to the common soldiers. Is this the kind of government that goes on in an organism, or are the relations throughout those of a thoroughgoing reciprocality? Is the organism governed from a dominant center like a monarchy, or like a democracy with plenty of initiative and referendum? These are important questions in regard to Child's general viewpoint. If development and regeneration involve a thoroughgoing mutual adjustment of developing parts, the establishment of gradients can apparently do little more than provide for the localization of formative processes (to use a favorite expression of Driesch) without supplying the fundamental principle underlying the production of organic form.

In the last two chapters Child extends the gradient concept to the organization of society. "Leadership, dominance, the pacemaker play the same rôle in social as in physiological intergration." The center of high metabolism has its analogue in the social leader, or it may be in the "dominance of ideas." The similarities which exist between society and the organism largely grow out of the fundamental likenesses of their component units. And societies are essentially democratic whatever may be their form of political government. Even in the most arbitrary of despotisms rulers do not rule their subjects nearly so much as the subjects rule their rulers. Societies are everywhere founded on a give and take relationship; they are always mutual benefit organizations. If the analogy betwen social and physiological integration is to be taken seriously, as I believe it must, it would lead us to infer that the unity of the physiological organism is the result not so much of a one-sided relation of dominance and control as a thorough, mutual determination. I can not feel that Child's incursion into social science has strengthened his case. Rather, it has served to reveal more clearly a fundamental shortcoming of his theory of organic wholeness. It is not denied that the gradient relation may be one of fundamental importance in the establishment of organic axes and the localization of morphogenetic processes. But the gradient theory 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-