in culture solutions greater antagonism between 0.04 M $MgSO_4$ + 0.18 M KCl than from mixtures containing higher concentrations of $MgSO_4$.

The factors involved in the absorption of salts (or ions) by plants have been discussed by the writer,[18] and a recent paper by Cooper[12] presents some stimulating new ideas on the subject. The causal relations are known to be extremely complex. Nevertheless, although the factors producing differential absorption and influencing utilization of elements within the plant at the different planes of nutrition may not at the present stage of our knowledge be identified, the interpretation advanced to account for the discrepancy between Lagatu and Maume's results and those of the writer is the only one that, at the present stage, accounts for the observed facts. Details of the experiments will be published elsewhere.

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THE ORGANIC WORLD AND THE CAUSAL PRINCIPLE: A CRITICISM[1]

WITH some reservations, the theory of evolution as propounded by Darwin three quarters of a century ago is accepted by most psychologists of the present day. We use accepted advisedly. To the psychologist the view-point and all the accumulated data are gifts. As a group we have done little to advance this illuminating principle nor have we been greatly interested in understanding the far-reaching significance of its many aspects. We have been content to believe but not to strengthen the basis for belief. Ours has largely been a lip service to Darwin and this in spite of treatises of imposing titles purporting to deal with one or another aspect of the evolution of mental life. Having accepted evolution as fundamental to our science we have not oriented our concepts with regard to it. Not uncommonly we observe that an author may profess to a purely mechanistic view-point on one page and on the next offer "inhibition" as the solution of some felt difficulty. The "inhibition" is not evaluated in the light of the "mechanism." Inhibition, in any form in which we have seen it stated, is in opposition to at least one of those general principles which we have come to call the laws of nature.

Perhaps it is the feeling of a lack of critical evaluation of our concepts which leads our students to question whether or not psychology is a science. Possibly it is the same vague feeling on our part which motivates us either to spend valuable time and energy in demonstrating in our text-books and class-rooms that psychology is a science, or to assume the "I don't care" attitude. That this lack has been felt is indicated in a new note that has recently been struck by Warren in his vice-presidential address. Warren clearly sees that a vast amount of revision must be made in our mode of thinking if we are to make full use of the principle of evolution. Primarily his article is an attempt to demonstrate that principles of causation characteristic of organisms may be assumed without damage to the mechanistic conception of life. Two such principles, he concludes, are natural selection and anticipation.

It is in hope of furthering rather than opposing the general point of view that we raise the question: Are these two principles characteristic of biological systems and are they causally related to evolution? There seem some grounds for believing that they are not, but before entering a discussion of causation it will be well to specify what we conceive the term to mean. A cause, we understand, is any event which directly or indirectly delivers energy to another event. A clear distinction must be made between causal factors and limiting factors. Silver nitrate in a transparent container undergoes certain changes when exposed to the sunlight. Causal efficacy will hardly be attributed to the container in so simple a case. Its only influence is to limit the amount of energy delivered to the solution by the sun. It is further evident that so long as we are dealing with one time frame the delivery of energy will take place only in the forward direction, and that the assumption of retroactive causation will make a hodge-podge out of all science. Cause must precede effect.

Of the supplementary causes which Warren conceives to be characteristic of organisms he says, "The first of these supplementary principles is that of natural selection. . . . It does not occur—it has no meaning whatever—except in connection with those peculiar groupings of molecules which we call organisms. . . . It is perhaps unnecessary to-day to emphasize the importance of selective adaptation[2] in promoting organic evolution. Through its means the organization of matter takes on an entirely new trend."

In communication with Warren he informs us that he does not conceive of natural selection as a cause but rather that it is based upon causation, and nowhere in his speech will the term "cause" be found when he refers to these supplementary principles.

[18] Walter Thomas, *Soil Sci.*, 27: 249–270, 1929; *Plant Physiology*, Vol. 5, No. 4, 1930 (forthcoming).

[1] A paper appearing in SCIENCE, February 21, 1930, bearing the same title, was the publication of Howard C. Warren's address as retiring vice-president and chairman of Section I—Psychology, American Association for the Advancement of Science, Des Moines, December, 1929.

[2] Natural selection and selective adaptation are used synonymously by Warren.

However, it must be pointed out that the above extracts indicate that causal efficacy is being attributed to natural selection. Only a cause can promote and only a cause can organize matter.

Natural selection is a term used to indicate that the survival of a system is limited by environmental conditions. Those organizations of matter which do not find themselves within the limitations imposed by the environment do not survive. Unfortunately we have come to speak of natural selection as acting in this or that way. It does not act in any way. It is not a force. It does not deliver energy to organisms. It limits in one way or another the delivery of energy to organisms and nothing more. Natural selection, then, since it is purely an abstraction and is quite devoid of energy, may not in any way be conceived to be causally related to evolution. It can not promote evolution and it can not organize matter. It is to be pointed out that Darwin did not make this error. He saw only too clearly that natural selection could but limit the forms that would continue to evolve.

It may be remarked in passing that it is even possible that we have overemphasized the importance of natural selection in limiting the survival of forms. We observe that a large number of widely divergent forms survive within the limitations of any given environment. If, as Claude Bernard and Beaunis have held, evolution is a characteristic of organisms, it follows that offspring will arise which are slightly different from, and perhaps slightly more complex than, the parent. Evolution, although characteristic of organisms, will not cause these changes. Rather evolution is the final result obtained from the summation or integration of the series of changes. The range of these differences will be wide, but since the organism may be considered as a Gibbs system the number of possible changes, or the degrees of freedom, will be expressed by the phase rule. Further, death, the return to equilibrium, also being characteristic of multicellular organisms, it follows that new forms will appear and the old forms disappear in an environment equally beneficent to all. Without doubt there have been cataclysmic changes at certain periods during the course of organic evolution, but it must be recognized that evolution goes on in the absence of such. Natural selection acts in no way to produce new forms. It can only limit the survival of whatever new forms may appear. The old question of the origin of variations remains unanswered by natural selection now just as in Darwin's time.

That natural selection "has no meaning whatever" except in connection with organisms is not apparent to us. Karl Pearson in his "Grammar of Science" has a chapter on natural selection in the inorganic world. This question seems to us to be merely one aspect of the phase rule. Water survives in its solid form at the earth's poles. Fresh-water lakes survive only in regions of moderate temperature. Certain rocks are selected for sands and certain sands selected for rocks. Natural selection is as old as evolution and evolution as old as the universe. Biological organisms are not new systems as Warren has stated. Organic and inorganic are both Gibbs systems. The difference between the two, as Baldwin has pointed out, is that the series of changes in living organisms is always irreversible.

Except for one, Warren foresees the arguments against his second supplementary principle, as is evident from the following extract:

> Recently a tornado was reported in the Caribbean Sea moving in the direction of Florida. Preparations were made at once to prevent the loss of life and minimize the damage to property. Ships altered their course. Buildings were shored up. Dwellers in the everglades were transferred to more elevated ground. All these activities were in response to what stimuli? In a measure they were reactions to present verbal stimuli—telegrams, storm signals, newspaper bulletins, radio messages, individual warnings by word of mouth. I have no doubt but that if a superscientist were to trace the cause-and-effect relations of this series of responses in the case of any person involved, he would find that the fundamental causal principle[3] accounted fully for the person's activity. But this causal explanation does not exhaust the meaning of the behavior. The activity of some thousands of individuals in this instance has reference to a certain future situation as well as to the present. As a matter of fact, in cases like this the immediate antecedents (the verbal stimuli) may be regarded as merely incidental—the responses were primarily to stimuli which were yet to come.

In psychology we are accustomed to say that a response is determined by the condition of an organism and the stimuli acting on it. Warren's example provides no exception to this general statement, we believe. Energy is stored up by metabolism and other processes in the anterior end of the central nervous axis of the Florida inhabitants in the form of learning. This in part determines the condition of the organism, the remainder being determined by the present stimuli. That the present response is neither "primarily" nor even remotely caused by "stimuli which were yet to come" is apparent when we recall that frequently under the above conditions, after all the responses have been made, the event "tornado in Florida" does not materialize. We should then have a response without a stimulus. Responses do not transcend their stimuli. There can be no "referring to" some future stimuli. The Florida

[3] The law of conservation of energy.

tornado is in no way a cause of the Florida activity. Energy is not retroactive. Event A, happening to-day, can not be influenced by event B, happening to-morrow. A and B may influence C, and in Warren's example the shoring up of the houses is an important cause of a later event which is "intact houses" after the tornado. Warren, we believe, has interpreted the effects of past experience, learning, as being the effect of some event which may or may not occur at some future time.

Warren has not demonstrated any new causes or principles in evolution. His examples are not energy manifestations, though he appears to use them as such. Any search for causal factors must be directed towards the possible sources from which organisms may derive energy. As has been pointed out by one of us,[4] there seems only one source available for all organisms, and this, the energy of the sunlight, is the motive force behind the appearance and evolution of organisms on the face of the earth. The series of living organisms is a series upon which work has been done, and in the source of this work we are to seek for the cause of evolution.

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THE PALEOBOTANICAL EXCURSION OF THE FIFTH INTERNATIONAL BOTANICAL CONGRESS

IMMEDIATELY following the close of the Fifth International Botanical Congress at Cambridge, England, on August 23, 1930, a tour was undertaken for the purpose of visiting some of the fossil plant localities in England and Wales. The tour was organized by Dr. H. H. Thomas, of Cambridge, and was conducted by Mr. W. N. Edwards, of the British Museum.

The party left Cambridge by motor bus on the afternoon of August 23 for Cayton Bay, near Scarborough, on the Yorkshire coast. Here, under the direction of Dr. Thomas, the Upper Jurassic beds containing the oldest known angiosperms, the Caytoniales, were visited and an opportunity was given to collect material.

The party then proceeded to Leeds where, under the direction of Dr. Hudson, several localities were visited for upper Carboniferous plants. Leaving Leeds the route followed was across the Pennine Moors to Manchester, where two days were spent. Besides visiting the coal mines in the vicinity of Manchester the party was entertained at tea by the botany department of the university and an opportunity was given to examine the magnificent fossil collection in the geological museum.

The party was then accompanied by Dr. John Walton, of Manchester, to north Wales. The first objective was the Teilia quarry near the village of Gwaenysgor for lower Carboniferous plants. Afterwards the Archeosigillaria beds at Denbigh were visited.

The south Wales coal field was the next objective. The route followed was along the scenic highway to Llangollen, then through Shrewsbury and Brecon to Swansea, which is one of the two centers of the coal industry in south Wales. On arriving at Swansea the party was entertained at tea by the mayor and at luncheon the next day by Captain H. Rees, of the Cefn Coed Colliery at Crynant. During the two days following the arrival at Swansea the party was conducted by Dr. A. E. Trueman, of the University College at Swansea, and Miss Emily Dix, of London. Numerous coal mines in the middle and transition Coal Measures were visited and rather extensive collections were made. On the evening of the last day the party was entertained at dinner by the Swansea District of the Monmouthshire and South Wales Coal Owners' Association and the South Wales Institute of Engineers.

The trip was concluded by visiting the mines in the vicinity of Bristol, Gloucester and Bath for upper Carboniferous plants under the direction of Dr. Crookall, of the British Geological Survey. The party then proceeded to London.

The participants of the tour were the following: Dr. T. G. Halle and Baron von Post (Stockholm); Dr. O. A. Høeg (Trondhjem); Professor A. Renier and Mme. Ledoux (Brussels); Professor and Mme. Jongmans (Heerlen); Professor W. Gothan (Berlin); Professor and Frau Hirmer (München); Dr. Sze (China); Professor Rudolph (Prague); Mr. W. N. Edwards and Miss E. Dix (London); Dr. G. R. Wieland (Yale), and Dr. C. A. Arnold (Michigan). Professor B. Sahni (Lucknow) and Dr. J. Pia (Vienna) accompanied the party for the first couple of days.

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THE first attempt at a marine biological station in China was begun this summer at Amoy in southeast-

[4] F. H. Pike, *Ecology*, 10: 167–176, 1929.