

# SCIENCE

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## BIOLOGY AND PREPAREDNESS<sup>1</sup>

THE association of ideas suggested by the words "biology" and "preparedness" probably marks the beginning of a new epoch in history. The careful consideration of the sequence of events that have led to the formal act of linking together these two words should supply material for an interesting chapter in history, and should furnish an impulse strong enough to re-awaken in the minds of those who have already left hope behind them rational expectations for a slow but steady progress of civilization.

Science, as one of the chief witnesses to this fortunate union, is relieved of any necessity for explaining that while certain by-products may liberate destructive forces, her aims and methods tend beyond peradventure to conserve both life and energy. In view of the critical times in which we are living, this fact by itself is not even half-way satisfying. The human animal needs the stimulus of positive hope and the knowledge of actual accomplishment; and these will be added to our most treasured possessions when once we shall begin, after centuries of indifference, to make preparations for rational living.

During the last two years we have not only changed our general attitude towards life, but have been made most bitterly aware of the disappointments sure to follow dreams of incredible Utopias, or visions of universal peace. We have paid a high price for our failure to emphasize the greater importance of preparing to live ef-

<sup>1</sup> MSS. intended for publication and books, etc., intended for review should be sent to Professor J. McKeen Cattell, Garrison-on-Hudson, N. Y.

<sup>1</sup> Read in symposium on "Biology and National Existence," meeting of the American Naturalists, New York, December 28, 1916.

fectively as compared with the special preparations we have thought essential for dying in proper fashion. Prophet, priest and mystic philosopher have urged men to prepare to die, while science has only recently directed attention to the larger duty of preparing to live more efficiently, happily and successfully. We are just beginning to realize that if *to-morrow we die, to-day* we must live.

The mental attitude necessary to appreciate the full significance of the present associations between the words "biology" and "preparedness" also calls for the formulation of a new philosophy of living—a philosophy that will be of more direct assistance in enabling us to face the present with a greater display of intelligence and courage than has hitherto been expended. This is not the time to make a mistake in the choice of the path we are to follow. If civilization is truly symbolized by the figure of a caravan crossing a desert, we can not permit any false prophet to act as our leader. Far better to endure patiently the dangers and trials of our present situation than to incur any additional risk.

In order to comprehend both the scope and spirit of the Preparedness Campaign the character of the forces that have shaped it must be given due consideration. A few of these are obvious, but many are not generally recognized. As a people the majority of us would not admit until forced by circumstances, the truth of the allegation that a vague though compelling sense of unrest and an ill-defined consciousness of lack of preparation for dealing with the critical situations in life, have created at this moment of world-wide crisis a desire both to reorganize our ways of living and to secure protection from invasion of our territory.

The campaign for preparedness, as we see it, has two distinct objects in view, rep-

resenting double aspects of the same problem: personal and national preparedness. To discuss these two kinds of preparation as unrelated, is both impractical and illogical, because the personal can not be wholly separated from the national aspect. Personally we accept the reality of the presence of disease and face it, because most of us with our backs to the wall must do so. But in case of war, because there is time and opportunity for mystics living with their heads in the clouds to dream of a transformed humanity, some of us still believe that entirely unrelated problems are under discussion.

Preparations for war must be made because the sudden disappearance of its threatening specter could only be brought about by some miraculous metamorphosis in humanity; and the consideration of the probability of this should be left to those who assume the possession of prophetic ability. The extreme superficiality of any thinking that takes for granted the possibility of being able to recommend a method for the great and immediate reduction in the frequency of wars, is revealed in the mere supposition that the roar of guns and clatter of swords are the only sign of war. "When both are silent," said John Bigelow, "war may go on even more fiercely than ever before. Hate, vengeance, jealousy, covetousness, ambition, treachery, cowardice, survive." These conditions no magic touch can remove. When we remember these facts, and consider how few have been the efforts to analyze the genesis of impulses, to ferret out the causes of obsessions, to trace the origin of hatreds, or, to discover methods of controlling emotions without the formation of dangerous repressions, the boast that we can prevent war by the introduction of a change here and there in our social and political systems, has a very hollow sound. Before the outbreak of

the European war Israel Zangwill wrote to the late Mr. Stead:

I take the opportunity of reminding Mr. Stead that more good will be done by facing the brutal facts of life and the European situation than by allowing the wish that war shall cease to be father to the thought that it is ceasing.

Indeed such a thought as Mr. Zangwill sought to oppose merely reflects the fanatic's contemptuous disregard for the necessity of keeping open the approaches to truth even when we ourselves have not the strength to do more.

The same spirit of weakness and disinclination to face life as it is is shown in the intellectualist's efforts to impress us with his ability to live in the world and not be of it. Those who recognize this particular form of complex can easily detect the signs of disappointed ambitions and dissociated personality rather than a lofty and commendable purpose.

A truly high purpose should culminate in a decision to go as straight as we can, without further temporizing, to the root of most of the troubles to which the flesh is heir, and to substitute for an astonishing amount of ignorance as accurate a store of knowledge as can be gathered together. In a reasonably short time the result of working with this object in view would so impress us with the magnitude of our task as to make us reject promptly all promises of salvation bearing the trade-mark of any "ism."

Concrete information of this kind would not only prevent the occurrence of many unpleasant surprises regarding some of the basic qualities of human nature, but would enable us to remove a good many of the causes that lead at critical moments to explosive reactions of great violence, disturbing alike to the development of a well-balanced personality, the cause of democracy, and the progress of civilization. Moreover, we know that if the forces giving shape to

personality are not focused, dissociation is the result, with the subsequent development of peculiar mental qualities that possess high explosive potentiality. An excellent illustration of this is wishful thinking, which may become a habit; and when this occurs it forms a menace to orderly thought processes, and results in blocking the peaceful settlement of any questions either personal or national.

These are some of the conditions we fail to recognize because we have become so accustomed to measure the value of brain activity merely by the content of consciousness without considering the character of the processes concerned in the operation. The autoethonous thoughts that are the products of a split-up personality often supply an emotional spark to explode the powder, and on this account we should learn to recognize in the apparently harmless dreamer, to whose reveries we often give encouragement, a source of danger to the community not infrequently exceeding that of the victim of systemized delusions.

For similar reasons there are excellent grounds for not placing too much confidence in the intellectual judgments of any person who disregards logical conclusions and shirks the responsibility concerned in the reconciliation of faith and works; such a man tries first to ignore and then to obliterate every memory of defeat, and resorts to subterfuge to conceal the strong personal disinclination to meet definite issues by absorbing himself in some general scheme for the regeneration of humanity. In such cases it is often the half-repressed memories of a personal struggle ending in defeat that drives the loser to turn aside from the real world and its concrete problems to live in an imaginary one which can only be described in abstract or platitudinous phrases.

Although it would be superfluous to point out the important bearing the analysis of

some of our national traits would have in supplying the information essential for directing our energy to the best advantage, a reference may be made to one glaring example of specific ineptitude due to lack of emotional balance. Consider for a moment the extraordinary opportunity existing at this crisis in world affairs for our universities to make adequate provision for supplying the leaders of thought urgently needed if a triumphant democracy is to be assured. Is the contribution of these institutions to the intellectual awakening now in progress to be measured only by an amateurish interest in military preparedness? Have we not reason to expect, perhaps we may even say to demand, that our universities shall not base their chief claims for recognition as institutions of learning merely upon traditional and hereditary rights? Should they not now set the example of facing squarely the vital issues of the present? One proof that the gravity of the present situation has been appreciated might be found in some effort to break with the restrictive influences imposed by trying to satisfy the parochial notions of the alumni and by placing on governing boards and in administrative offices representative citizens competent to realize the value of scholarship and research and the importance of cultivating broad national ideals. The signs of the times are indeed threatening, but what can we expect in the way of great intellectual leadership from an institution that places so little value upon the influence of example as to retain the services of an athletic coach receiving more than double the recompense of any member of its faculty! Judged by their spirit and works, the universities have failed lamentably to rise to meet the present situation. To-day when we are so earnestly seeking the abolition of petty sectional feeling, and turn to our oldest institutions of learning for a substitute, we find only a Harvard,

Yale or Princeton sentiment tending to prevent the development of the idea of service to the general government.

In undertaking to formulate concrete plans for a campaign of preparedness it is advisable to begin with the clear recognition of the collective, binding and directive forces supplied by the present biologic methods of studying human behavior. Upon the adoption of a biologic line of approach, not only apparently unrelated subjects are shown to be intimately dependent, but a still greater change is evident in the new mental attitude developed towards the actual significance of the history of the human race. It has generally been the custom to proceed from the discussion of relatively obscure events in the past to the analysis and interpretation of the behavior of persons now living. The almost exclusive use of this method has left us in profound ignorance of ourselves, and has delayed considerably the presentation of the underlying facts of history in a vital fashion. If we reverse the ordinary procedure and begin with the analysis of the phenomena of behavior by making a first-hand investigation of the processes as they actually take place in individual lives, we shall then be in a better position to advance historical interpretation by making the past live; an accomplishment impossible as long as the approach to the study of human life was along avenues lined by tombs where only records of the dead were visible.

When once the importance of interpreting life in terms of vital reactions is recognized, then we shall find it possible to proceed in a logical and enthusiastic manner to inaugurate a movement that promises to result in greater efficiency and success in living, and in this way an opportunity may be presented of demonstrating that democracy has the power to minister to the biologic needs of men. At present we have become so intoxicated with words that in

order to evade facing a good many pretty stern facts, we are almost ready to accept as efficient any public confession of faith in crude notions about political freedom. We really dread discussing biologic problems.

But what indications are there that we are on the right path of biologic discussion? The efforts to remedy the present neglect of the study of the brain and nervous system are few, because the interest of the general public has not been aroused to the necessity for it. It is a most curious comment upon the lack of interest shown in our universities and institutions devoted to research, that so little attention is paid to making any adequate provisions for increasing our knowledge of these organs—the brain and nervous system—which are commonly esteemed to be the chief stock in trade of institutions of learning. While encouragement is given to those who delight to speculate upon man's place in nature, practically little has been done to assist in the determination of those structural and functional differences of the nervous system that are responsible for our elevation above the plane occupied by our simian ancestors. The time is rapidly passing, as Yerkes has pointed out, when on account of the disappearance of the higher apes it will be possible to trace the various gradations in our ancestral line. Of equal importance to these problems should be the studies made upon the nervous system with the object of correlating the structural and functional changes taking place during the early stages of the life of the individual. With the methods now at our command this particular field of investigation should offer fruitful results to the student. By carrying out these comparative studies a great deal of valuable information could be obtained which would throw light upon the fundamental nature of the adjusting processes and indicate the order followed as the capacity for adaptation was extended.

Think of the extraordinary opportunities existing in New York—the greatest melting-pot the world has ever seen—for the analysis of human behavior! Parents, educators, social workers, physicians, anthropologists, criminologists, eugenists, those endeavoring to find improved methods for increasing industrial efficiency, lawmakers, and all persons interested in the acquisition of knowledge relating to the regulation of human behavior, need to feel the inspiration coming from the realization of working towards a common goal.<sup>2</sup>

It would not be difficult to plan some central organization aiming to coordinate effort and to correlate results in attacking problems that are of the most vital importance for our personal and racial salvation. If we continue merely to dabble the tragic results will be even more appalling than they are to-day. Let us not deceive ourselves any longer nor try to apologize for our failure to understand and direct intelligently human energy by referring as "evidences of organized charity" to the application of remedies to correct the end stages of imperfect adjustment in numberless people.

In addition to a coordinating center of activities there is urgent need in New York for a great university psychiatric clinic dedicated to the investigation of the countless forms of imperfect adjustment generally described as mental disease. To those of us who are familiar with the methods used by the modern alienists to analyze the personality and to trace the genesis of these disorders, it is obvious that their knowledge is absolutely essential for the reorganization of our entire educational system. By the promptness with which

<sup>2</sup> Sums expended annually by the City of New York in directing human energy:

Education .....	\$47,000,000
Protection of life and property .....	59,000,000
Charities .....	12,000,000

these objects shall be obtained we may easily estimate both our national intelligence and our peace-loving qualities.

Must it be the grim necessity of war only that shall awaken us to a nation-wide mobilization of all human forces for a single great purpose? Have we the mental capacity to be led by reason rather than driven by necessity "to sacrifice comforts, indulgences, and elegancies" for the purpose of acquiring the knowledge of self without which a practical preparation for living is impossible?

STEWART PATON

PRINCETON, N. J.

#### THE ECOLOGICAL SIGNIFICANCE OF SOIL AERATION

DURING the past two years the writers have conducted, independently, laboratory investigations into the relation of plant roots to the composition of the soil atmosphere and especially to deficiency of oxygen or excess of carbon dioxide in this atmosphere. These investigations are still in progress and will be reported later. It seems, however, that certain features of the results already obtained have important ecological significance, and this phase of the matter is presented in the present preliminary paper.

One series of experiments was conducted by one of us (Cannon) in the Desert Laboratory of the Carnegie Institution of Washington at Tucson, Arizona, and in the Coastal Laboratory of the same institution at Carmel, California. Seedlings of *Prosopis velutina*, and cuttings of *Opuntia versicolor* were grown in glass tubes filled with sand and connected with a gas reservoir in such a manner that any desired gas or mixture of gases could be caused to replace the ordinary atmosphere of the tubes at will. Each tube was sealed with wax and usually a water seal was used in addition. By the use of appropriate thermostats the tubes were kept at any desired temperature. In all cases the shoots were exposed to the atmospheric conditions of the laboratory. The growth of individual roots was observed di-

rectly by means of a horizontal microscope. The experiments included tests with pure carbon dioxide and various mixtures of this gas with atmospheric air or with oxygen.

As a leading result it was learned that the roots of *Prosopis* and of *Opuntia* have unlike responses to carbon dioxide. Exposure to pure carbon dioxide causes cessation of growth in the roots of both species. However, the recovery on the admission of air is uniformly more rapid with *Prosopis* than with *Opuntia*. The two species respond differently, also, to percentages of carbon dioxide which are high but below 100 per cent. Thus mixtures of 50-75 per cent. carbon dioxide with 25-50 per cent. oxygen, do not stop root growth of *Prosopis*, but do stop that of *Opuntia*. Apparently excessive amounts of carbon dioxide in the soil atmosphere would act as a limiting factor for the latter plant, even if the oxygen content of the soil atmosphere was normal or above normal. Neither excess of carbon dioxide nor diminished supply of oxygen inhibits the growth of *Prosopis* roots, for growth did not wholly cease when an atmosphere containing less than 2 per cent. of oxygen was employed. However, entire deprivation of oxygen appears to inhibit growth since the roots did not grow in pure carbon dioxide. Thus while the effects of the undiluted carbon dioxide on root growth of the two species is apparently the same, namely, the cessation of growth, the responses leading to this effect may be quite different.

The conclusion that the root response to a variable ratio of oxygen to carbon dioxide in the soil atmosphere is a specific response, is supported further by the results of direct aeration experiments on several species of plants, among which were *Opuntia*, *Prosopis*, *Fouquieria splendens*, and garden varieties of cucumber and watermelon. An increased air supply to the roots of *Opuntia* and *Fouquieria*, if not excessive, favors root branching and probably accelerates the rate of root growth. In the case of *Prosopis*, increased aeration of the soil appeared not to affect the growth rate of the roots. The results with cucumber and watermelon were not consistent, although in the latter case the shoot growth appeared to be