every advance in pure science is immediately seized upon and applied in the most unexpected directions. Illustrations might be found in any of our large chemical industries—as, for example, that of artificial silk. Or, again, observe how quickly the comparatively recent intangible electron theory has created wireless and its related industries. Even the newly discovered and not yet isolated element hafnium is already being applied in wireless valves. Or we might consider such discoveries as those of radium and insulin. Indeed, during the last twenty years, applications of science in medicine have added ten years to the average expectation of life. Every process we employ, every device and invention of which we take daily advantage in our factories is the result of some former, may be forgotten research.

Some seed corn must be returned if the future is to repeat the successes of the past. Knowledge is power, and it is through scientific knowledge that we gain control over nature.

However, it is not upon utilitarian grounds that we present the claims of science upon the educated community. I would quote the words of President J. E. Barton of our Bristol Rotary (a movement which came to us in England from you):

> The real world is not the world of material prosperity or lack of prosperity. The real world is the world of science and discovery, of art, literature, emotion and passion. These are the things which give color and texture to experience.

J. W. N. Sullivan in his "Aspects of Science" has rightly emphasized that scientific research is thoroughly human; it is at once tentative, imaginative and courageous. In science we find a sense of unlimited possibilities, of adventure and of exultant hope.

In such men as Kelvin and Newton and Willard Gibbs we find the modern prototypes of Aristotle and Archimedes. "Science again affords theories and objects of contemplation which are as delicate, as subtle, as harmonious as the dreams of Plato—and much better founded." Many scientific theories are objects of surpassing beauty. Their innate truth appeals as directly to us as that of a great work of art. It is in this sense that Dr. Norman Campbell has written that "science is the noblest of the arts."

Science is bound to become an integral part of the culture of the future. It is profoundly influencing our conception of the universe and of man's place therein. A liberal education must have some acquaintance with the trend of the new physics, chemistry, biology and psychology, for they are too obviously pertinent to all man's chief preoccupations to be ignored.

Many of the convictions which I have expressed are felt by all scientists, although we do not often care to voice them.

They underlie all our efforts in the training of our students, the primary object of university work.

I have tried to justify the statement with which I commenced that this far-sighted benefaction will have long consequences.

It is with these high hopes that we dedicate the Metcalf Chemical Laboratory of Brown University.

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SOME ASPECTS OF THE RELATION OF SPECIES TO THEIR ENVIRONMENT[1]

THE close relation between an individual plant or animal and its surroundings is strongly emphasized. It is recognized that the conditions under which it lives may affect its size, its form, its habits and its methods of reproduction. But the influence of the environment on the groups of individuals which we call species, while recognized, seems not to be given the weight that it deserves. It seems to me, at least, that the environment may play a greater part than is indicated by many of the current writers. While the germ plasm is no longer generally regarded as being as completely isolated and independent as set forth by Weismann, and while most workers recognize the action of the environment in cutting off certain individuals and so maintaining the characters of the species within certain limits, there seems to be a failure to recognize the extent to which external conditions determine that the species now living shall show the characters that they do show rather than some other characters. If this is true, if the collections of individuals which we call species show the characters by which we recognize these groups, not alone because of the inherent properties of their protoplasms, but also because of the molding action of the environment, does it not follow that we must assign to the environment a large share in determining the forms of the species as we recognize them to-day?

Many plants and animals, when transferred to new conditions, have changed their form and structure in response to their new surroundings. Criticisms of these results have usually brushed them aside with the statement that the descendants of these individuals return to their old form and structure when returned to the old conditions. These criticisms seem to fail to recognize the fact that the species show the form and structure which we describe as characteristic for them only under a particular set of conditions. We can not doubt that, if the conditions on the earth were different from what they are, we should have our plants and animals showing different groups of characters from those which they now show. In other

[1] Address of the retiring president of the Association of Virginia Biologists, Norfolk, Virginia, April 27, 1923.

words, we should have different species, as we recognize species, from those which we now have. Stockard, exposing the eggs of a marine fish, *Fundulus,* to sea water with the addition of certain magnesium salts and to some other substances, obtained developing young showing marked differences from the characters usually shown, notably the development of one-eyed fish. Sometimes this single eye was on the side of the head, and sometimes in the middle of the forehead, giving a cyclopean form. It seems that, in these fish, the two eyes will develop in their usual places if the eggs are exposed to untreated sea water, but that various modifications of eye development and location appear if the sea water contains an unusual amount of certain magnesium salts. If, now, the sea water regularly contained larger amounts of these magnesium salts, should we not have these unusual forms of the eye as the usual characteristics of the species? In that case, by removing some of the magnesium salt we should obtain "abnormal" forms bearing two eyes, one on each side of the head. We can not too strongly emphasize the fact that many of the so-called abnormalities are normal developments under particular conditions. This seems, upon consideration, to be self-evident, but, while admitted by the tongue, is, I believe, frequently ignored by the mind of many a present worker.

The periodicity shown by several different kinds of plants and animals is probably an example of the molding action of the environment on these organisms. The marine alga, *Dictyota,* has been found to produce its sexual cells periodically in all places where it has been studied, but it has also been found to have one type of periodicity in Europe, a second type on the coast of North Carolina, and a third type in Jamaica. Moreover, while showing the same type of periodicity in Wales, England, and Italy, it has a different time of fruiting in each of these regions. On the other hand, at the two widely separated localities where this alga has been found on the Atlantic coast of the United States, it fruits on the same days at both places. While we have not yet been able to analyze the factors concerned here, we can scarcely conceive of this result being obtained in any other way than by the response of the plant to the conditions of its environment.

The fact of the effect of the environment on species is, I believe, unquestionable, but the manner of its effect is open to indefinite discussion. We may conceive of this as acting solely by directing and molding the development of the individuals, suppressing certain capacities and bringing others to expression. It is undoubtedly true that every individual has more inherent potentialities than are ever brought to expression. On the other hand, an individual can never develop structures or habits for which it has no inherent capacities. If the fish used in the experiments of Stockard had not had the capacity to respond to the presence of increased amounts of magnesium salts they would not have shown any such responses to these salts. The question immediately arises, then, Can conditions of the environment alter the inherent potentialities of individuals and finally of the race? Can acquired characters be inherited? I am aware that it is unorthodox to present-day biology to even raise this question, but I do not believe that the final answer to it has been given. The term "acquired characters" seems to be used in two senses—one, in the stricter sense, referring only to those cases where the inherent capacities of the organisms have been changed; the other including the cases where the effects of the molding action of the environment are inherited by subsequent generations without the direct influence of these factors of the environment. In the one case there will have been an alteration by the changed environment of the inherent potentialities of the organisms, in the other case the inherent potentialities already present will simply be brought to expression. Conklin, in his treatment of heredity nad environment, limits the discussion of the inheritance of acquired characters to the inheritance of particular characters such as hypertrophied heart or loss of sight and uses the term "induction," for the continuance in later generations of other characters which have been produced in the parents in response to changes in the external conditions. He states:

> Probably such changes are not instances of true inheritance; they do not signify a change in the hereditary constitution but an influence on the germ cells of a nutritive or chemical sort comparable with what takes place when fat stains are fed to animals; the eggs of such animals are stained, and the young which develop from such eggs are also stained, though the germinal constitution remains unchanged. The very fact that the changed condition is reversible and that it disappears within a short time is evidence that it is not really inherited.

Such discussion seems to me to show too limited an interpretation of the results. It seems comparable with the discussion of the failure of mutilations to produce effects on subsequent generations. It is obvious that mere changes in the form of individuals exposed to new conditions do not indicate acquired characters. The conditions may have affected only the material of the body and not have reached and affected the germ cells. But when the offspring of such plants or animals, produced after the return of their parents to the original environment, continue to show these changes for one or more generations, are not these to be properly regarded as examples of the inheritance of acquired characters? Such effects can be transmitted only through the germ plasm, and their

appearance in later generations shows that the germ plasm has been affected and altered. The fact that the descendants of such individuals return to the original state upon their return to the original conditions would seem to indicate only that they have again shown their capacity to respond to a changed environment. We can not call either the original or the altered form normal, for each is "normal" to the particular set of conditions under which it develops. Moreover each form is capable of yielding descendants showing the parental characters only if the successive generations are maintained within the environmental range which produces that particular set of characters. In this sense we may regard the characters ordinarily shown by a species as being acquired, since these are maintained only under the conditions under which the species ordinarily lives and must, therefore, be regarded as developed in response to these conditions and impressed by these conditions on the germ plasm. A full description of a species should include not only the characters which we ordinarily recognize, but a statement of the conditions under which these develop, together with all other characters which the species may show under other conditions. Surely, the potential characters are as much a part of the species as the expressed characters. It is only the chance of the environment that makes one set of characters expressed and keeps another set suppressed and potential. We have not yet such a description of any species, but only when we have this can we believe that we really know the species.

As to the means by which the environment accomplishes its results we still know almost nothing. Results of great importance to this question will, I believe, be obtained in the future from careful experiments carried on for many years. I believe, for example, that the effect of use and disuse is still to be determined by a series of properly conducted experiments. For this the caves abounding in some parts of Virginia seem to offer an excellent opportunity to determine the manner in which many cave animals have become blind. Such work should be done under the auspices of some organization which could continue the studies with the necessary care for several decades or possibly centuries, but could be expected to yield results of fundamental importance and lasting value. Whether the environment can or can not produce new characters within a species, altering its inherent capacities, is still open to question. But, however this may be, we can not doubt that our species are what they are partly because of the molding action of the environment; and a true interpretation of the evidence shows, I believe, that, in many cases, the external conditions affect the germ plasm as well as the body material and consequently have their effects shown in a smaller or larger number of succeeding generations.

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GRANTS IN SUPPORT OF RESEARCH

THE opinion seemingly is prevalent that research is inadequately supported in the United States of America and that small grants are especially difficult to secure. Undoubtedly it is true that larger resources could be used to advantage in the promotion of scientific inquiry. Nevertheless, it should be recognized that very large sums are now available for research and that numerous sources of small emergency grants exist.

This note is written chiefly because the opinion of many investigators appears to be at variance with the experience of committees on grants. The former tend to consider it either impossible to secure assistance or scarcely worth the effort. The latter, on the contrary, are frequently surprised by the scarcity of meritorious requests and the necessity of inviting or even urging investigators to present their needs. Not infrequently committees responsible for special funds are unable to make awards because of this dearth of applications.

The experience of the writer as one-time director of the Research Information Service of the National Research Council and as a member of the Committee on Grants of the American Association for the Advancement of Science convinces him that investigators too often are not familiar with even the more important sources of funds, and strangely careless about informing themselves and presenting applications which permit intelligent committee action. There seems also to be a reluctance on the part of some investigators to ask aid because of the possibility of refusal. This attitude is unfortunate alike for committee responsibility in the distribution of funds and for the progress of research. It is obviously and highly desirable that every investigator whose original work demands additional funds for its proper conduct make known his needs fully and convincingly to the officers of appropriate sources.

Although not all investigators may reasonably be expected to be familiar with the multitudinous sources and forms of support of research in this country, any intelligent and determined individual should be able to assemble pertinent information on need. The Research Information Service of the National Research Council two years ago issued a bulletin on "Funds available in 1920 in the United States of America for the encouragement of scientific research." This publication has been distributed widely and is still avail-