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Demonstration of Hereditary and Environmental Effects in Corn Seedlings

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Corn seedlings segregating for green and albino in the ratio of three to one are raised in many biology laboratories for the purpose of demonstrating Mendel's first law of heredity. Two additional biological principles of general application among plants and animals are easily demonstrated with this same material. In the first place it may be shown that heredity and environment are both indispensable in the development of the organism and therefore that neither one of these factors can be considered more important than the other. Secondly, the demonstration can be used to illustrate the fact that a hereditary effect may resemble closely an environmental effect. The history of a given case must be known if the observer is to ascribe correctly the role of each of these factors.

In maize, albinism is due to a recessive mutation which prevents the formation of chlorophyll. After the albino seedlings have exhausted the food stored in the seed they wither and die of starvation because of their inability to synthesize carbohydrates. Segregating ears are produced by self-pollination of heterozygous normal green plants. Seeds from such ears are obtainable from the laboratory supply houses. Those used in the demonstration here illustrated were purchased from The Ohio Biological Supply Co., Columbus, Ohio. The environmental factor chosen for study is light.

In a tray filled with good black earth the seeds are planted in rows. As soon as the seedlings begin to break the surface a light-tight cover (Fig. 1) is placed over the rows occupying one-half of the tray. The cover illustrated is an open box made of heavy galvanized iron. The tray is constructed of the same material.

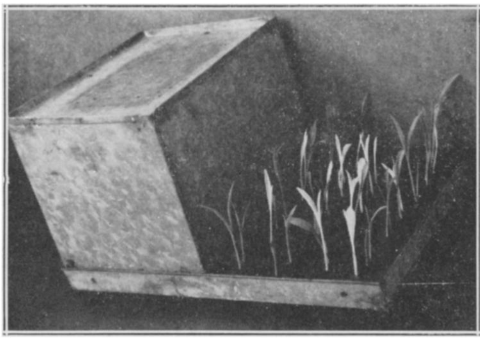

FIG. 1. Albino corn seedlings growing among normal green plants. A similar population is growing under the box in the absence of light.

All environmental factors save the one which is to be varied should of course be held constant. Although the present set-up does not fully meet this ideal, it is probable, considering the known facts about plant growth, that the chief effective factor in the observed differences is the presence or absence of light. In order to permit circulation of air into and out of the cover the central region of the top is perforated; and in order to prevent light reaching the plants through the holes a second steel top is fastened inside the box about one inch below the outer top. This inner top is about one inch smaller in both dimensions than the box, thus allowing circulation of air without the admission of light to the plants. As a further precaution all inside surfaces are painted black for the absorption of light rays entering through the holes in the top. The cover was made to order in a tin shop at a cost of $2.50. A corrugated paper carton without perforations gave results similar to those obtained with the metal cover. The permanent cover has been found convenient, however, since the demonstration has become a standard procedure followed one semester after another. Among the advantages of the metal cover are these: the sharp edges cut into the soil and exclude the light from below while the metal itself is affected very little by the water applied to the plants; the box may be made in any size desired, and when once constructed it is always available.

If the soil is thoroughly soaked before the cover is placed in position no water need be added to the plants under the cover. After planting, approximately two weeks are required for the seedlings to reach the height shown in the photographs, the exact time depending on the temperature.

The apparatus as described probably furnishes a reasonably good control of all factors in the environment except humidity. Under the box the humidity is naturally much higher than it is outside. Likewise, the concentration of oxygen and of carbon dioxide is probably somewhat different for the two groups of plants: this point has not been tested. At times there may be some difference in temperature, especially if the cover is exposed to the direct rays of the sun. With a metal cover it is best to keep the tray out of the sun.

Subject to the foregoing qualifications, the striking differences between the plants growing in the opposite halves of the tray (Fig. 2) may be attributed to the light factor. It is obvious that

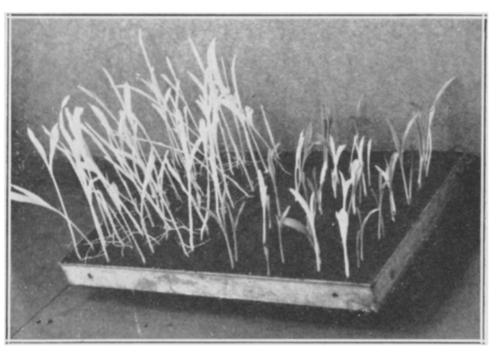

FIG. 2. Corn seedlings, all of the same age. The tall plants at the left were grown in the dark.

among the plants raised in the light the primary difference between the albino plants and the green ones is due to heredity. In the dark, normal plants are unable to manufacture chlorophyll; and at a distance of a few feet they look like albinos, although on closer inspection they may be distinguished from the mutants by their pale yellowish color. In a black and white photograph this difference is not apparent. Absence of light clearly produces an effect on the color of normal plants very similar to that produced by the albino gene.

Incidentally, another interesting environmental effect may be noted: the corn grown in the dark is much taller than the corn raised in the light. Absence of light stimulates elongation of the stem, and as a result some of the roots are pushed above ground.

SUMMARY

In the demonstration herein described it is evident that under the normal environment heredity is much more important than environment in producing the observed differences in color among the corn seedlings. On the other hand, with plants raised in the dark, hereditary differences are of slight importance as compared to the great modifications produced by the environment. Strictly speaking, characteristics are not inherited: genes are inherited, and the genes merely determine potentialities of development in particular directions. The realization of the potentialities in a developing organism depends upon the environment. A modification of the environment may produce profound changes in the end result.

The Influence of Biology on Theories of Human Behavior[1]

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There is a strong human tendency to over-simplify social phenomena: to find a panacea for the ills that beset us. Probably those whose special knowledge lies in the biological sciences are not greater sinners in this respect that other men. But there is a peculiarly subtle form of danger facing the biologist not shared by specialists in other disciplines; biological organisms are alive; they have self-determination; they are under certain controls in their development which we call heredity and environment. Man is a biological organism and the analogy of his behavior with that of pre-human species is treacherously easy to make. Nor are such analogies always misleading. Perhaps the most brilliant biological hypothesis ever made—the doctrine of evolution—has been found useful in explaining social as well as biological phenomena. But to a larger extent than any of us are likely to realize we find it easy to transfer, uncritically, as did the experimenters on the alcoholization of guinea pigs, the findings in prehuman phenomena to human situations; or to assume that if we know what biological change takes place we can predict behavior.

[1] Presented before the National Association of Biology Teachers, Dallas, Texas, December 29, 1941.