and a fourth, with inferior ovaries and gamopetalous corolla, as *Sambucus*, *Viburnum*, *Houstonia*, *Galium*, *Campanula*, *Vernonia*, *Aster*, *Helianthus*, etc.

In the foregoing work the pupil should get some idea of the structure of the whole plant. He should learn enough technical descriptive terms so that he can give intelligent descriptions of each plant. At every stage of the work the pupil should be required to make careful drawings in his note-book, accompanied by concise descriptions of essential characters."

Suggestions as to the proper selection of books for a small botanical library and the collection of a reference herbarium are given. Field work and the systematic determination of plants are encouraged, this work being regarded as a desirable part of the pupil's training, although it must not be permitted to occupy so large a portion of his time as was formerly the general custom.

It may interest botanists in colleges as well as in high schools to know that before these directions were issued a considerable number of the Nebraska high schools were already giving essentially the work outlined above, and there are many indications that encourage us to hope that it will not be long before this will be true of all.

CHARLES E. BESSEY.

EXTRA-ORGANIC EVOLUTION.

IN explaining the method of evolution Darwin and Wallace have laid great stress upon the struggle between *organisms*, Roux upon the struggle between the *parts of the organism*, and Weismann upon the all-sufficiency of natural selection. Darwin emphasizes *organic selection*, Roux *intra-organic selection*, and Weismann *germinal selection*. All progress is thus apparently organic. Heredity, at least with Weismann, is the continuity of the germ plasm, and progress is due to the survival and accumulation of advantageous congenital variations *within* the organism.

I wish to speak of what I may call *extra-organic* evolution. Progress has marched with colossal strides during the last fifty and even twenty years. Nevertheless, we see no corresponding advances made organically which may be deemed adequate to such progress. As far as our congenital or blastogenic qualities are concerned, we are probably little if any better than our forefathers of fifty or a thousand years ago. The progress actually made is out of all proportion to the advances made in our organisms.

Our sense and motor organs are essentially instruments and tools. So also, for that matter, is the brain. They are sifters, sentinels, receivers, transmitters, etc., all pressed into the service of the organism or some of its parts. The eye is manifestly an optical instrument, though a poor one, when compared with that additional eye or sense organ, the microscope or telescope. It is a well-known fact that it suffers from every defect that can be found in an optical instrument. It was useful in its time, and is so, I presume, to-day. Civilization, however, has taken its gigantic strides guided by extra-organic eyes.

Most, if not all the three hundred or more mechanical movements known to mechanics to-day are found exemplified in the human body. From an evolutionary standpoint it is still more important to note that all the machinery in the world, all the bars, levers, joints, pulleys, pumps, girders, wheels, axles, ball-and-socket movements, etc., etc., are but variations, extensions, adaptations of the accumulated advantageous variations and adaptations of the human organism.

Thus our sense organs are indefinitely multiplied and extended by such extra-organic sense organs as the microscope, telescope, resonator, telephone, telegraph, thermometer, etc. Our motor organs are

multiplied by such agencies as steam and electrical machines, etc., in the same manner. The printing press is an extra-organic memory far more lasting and durable than the plastic but fickle brain. Fire provides man with a second digestive apparatus by means of which hard and stringy roots and other materials for food are rendered digestible and poisonous roots and herbs rendered innocuous. Tools, traps, weapons, etc., are but extensions of bodily contrivances. Clothing, unlike the fur or layer of blubber of the lower animal, becomes a part of the organism at will. One becomes more or less independent of seasons, climates and geographical restrictions. Thousands of extra-organic adaptations are being invented (most of them really accidental variations) every day.

Professor J. Mark Baldwin, writing on this question of social heredity, defines it as 'the process by which the individuals of each generation acquire the matter of tradition and grow into the habits and usages of their kind.'* By social heredity I mean not only this, but also the transmission from the parents to the children of the improved environment, more especially of the extra-organic sense and motor organs. By organic heredity I mean, roughly speaking, the transmission of the congenital characteristics of the parents to the children.

By the latter process alone, all progress depends upon the transmission of variations occurring *within* the organism. Thus progress would be, as it has been, indefinitely slow. Moreover, these advantageous organic variations die with the individual, and must be born again, so to speak, with each new individual. This requires time. On the other hand, by means of social heredity each new member of the race has handed to him at birth, not only the accumulated organic advantageous variations of sense and motor organs (animals and the poor inherit in the same way!), but has handed to him the extra-organic adaptations which have multiplied so indefinitely in the age of civilized man. The vast importance of accumulation of capital is obvious.

In this way man's organism is indefinitely extended. He reads Aristotle, and his organism reaches back two thousand years. He reads the latest cable from Australia and Japan, and he listens at the antipodes. With an electric button he accomplishes herculean tasks. There are giants in these days.

The extra-organic part of his organism becomes in many cases as valuable to man as his organic part. Ofttimes for it he will sacrifice his life, as the soldiers throw their lives away on the battlefield to save the gun.

This is obvious and well-known. Such large requirements meeting the individual on the threshold of his life demand a large measure of plasticity. Adaptability to one's new environment is always the mark of high intellectual development. Such adaptability is rendered possible by the nature and growth of the brain. Of the 800 to 1,000 million nerve cells present in the human cortex, all are formed before birth. But all are not developed. Cell elements are present but immature, mere granules, nuclei which do not form a functional part of the tissue. Under certain conditions, however, they are capable of further development. With further growth and exercise nerve fibres appear and form functional systems.

It seems, therefore, that in addition to the cells and fibres connected at birth (and sometimes later), as in instincts, there is a mass of latent or potential nerve cells and fibres which *await connection*. These form probably the physical basis of our acquired (mental) characteristics.

Thus there is rendered possible the speedy

*Science, April 23, 1897. See also Lloyd Mort and Instinct, pp. 340-343.

acquisition of knowledge of the past and new arrangements and adaptations to meet the requirements of a more exacting environment. The latent cells become functional, and new associational paths are formed which become, or may become, by the law of habit, just as fixed and, ontogenetically considered, as reflex, and organic as the most definite inherited reflex action and instinct.

Some such theory as the above seems to be necessary to explain the wonderful advance of modern civilization. It is certainly not explained by any one or all of the three processes mentioned above, namely, those of organic, intra-organic and germinal selection. It may however be considered as a continuation of the same fundamental process. If the organism were forced to evolve within itself, by the slow process of organic selection, all the adaptations necessary for such a civilization as we have to-day, it is obvious that after millions of years it would finally produce a world-colossus, or impossible gigantic monstrosity.

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BINOCULAR FACTORS IN MONOCULAR VISION.

ALL experiments in monocular vision have to be made with one eye closed or covered. Some writers have maintained that binocular factors are by no means eliminated under these circumstances, but that the movements of the closed eye yield just the same sensation data as would result if the eye were opened. The following observations may aid in the solution of this problem.

If an observer closes one eye and looks steadily at an object situated in the median plane and at about the same elevation as his eyes, and then suddenly opens the eye that was closed, he will note an appearance of unrest in the object. Careful observation will show that the object seems to shift horizontally in the direction of the eye that was not closed. The shifting in apparent position becomes very noticeable when the eyes are alternately closed. The object will seem to move backward and forward in a horizontal line, always moving toward the eye that has just been closed. If the object is somewhat above the elevation of the eye there will be a vertical movement downward in addition to the horizontal. This apparent change in position may be observed best when looking at distant objects; the stars and moon show it very clearly. It is evident from these facts that the closed eye is not converged toward the same point as the open eye. At the moment of opening the eye there are double images, and these double images are crossed as is shown by the direction in which the object seems to shift. In fact, it is frequently possible to see the double images, and to note that the one which appears when the eye is open is on the opposite side from that eye, that is, crossed. The crossed images indicate that the closed eye is converged beyond the object. When looking at the stars or moon, however, in order to have crossed double images the eyes must be diverged, and the distance which appears between the images makes it evident that the divergence is considerably beyond the position of parallelism.

Helmholtz* and Le Conte† have both observed that when the muscles of the eyes are relaxed in drowsiness there is a tendency for double images, which indicates divergence of the axes, to appear. Le Conte has expressly noted that the degree of divergence is so great that the axes must be considerably beyond the parallel position. Evidently the facts observed when one eye is closed are related to those which appear in drowsiness. The closed eye tends to

* Physiol. Optik 2te Aufl., p. 633.

†Amer. Jour. of Sc. and Arts (3), ix., p. 160.