PRINCIPLES OF EDUCATION

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CHAPTER II

ADAPTATION, ADJUSTMENT, AND SPECIALIZATION
OF FUNCTIONS

General Considerations.—The previous chapter has prepared the way for a wider conception of education than that generally held by the popular mind. Most definitions of education characterize it as a preparatory stage for something yet to come. This is the truth, but not the whole truth. Spencer was right in regarding education as a preparation for complete living, but Dewey has furnished a desirable supplement by showing that all life processes and activities are a vital part of education. Consequently while we properly regard the formal, artificial educational processes as preparation for adult life, let us not forget that the very maintenance of an existence is a schooling more rigorous and influential than any artificial exercises we may interpose.

Since all of life's experiences are contributory factors, whether we will or no, we must then include in our educational philosophy not only mental, moral, and even physical education, but we must make our consideration cover a field as broad as life itself. Biology, the science of life, is not confined, as many seem to suppose, to worms, insects, beetles, and algae; but includes man as well—not only physical but psychical and moral man. It is perfectly proper to speak of the biological consideration of memory, imagination, instinct, the emotions, love of right, etc. They all have their genetic or developmental aspect. In dealing with these, even in a practical way in the school-room, we ought to know how they differ in children and adults, in different families, in different children, in different races, their laws of growth and development, their instinctive beginnings, and their
hereditary variations. Consequently this and several succeeding chapters will deal with the biological phases of education.

With these preliminary remarks and with the admonition to keep constantly in mind that experience and education, fundamentally considered, are one and the same thing, we shall enter upon the discussion of some concrete facts showing how adjustment of various organs, organisms, and functions to ever-varying conditions has produced modified organs, organisms, and functions, in harmony with the demands of new environments. Illustrations will be drawn from lower animal life and even from the plant world to exemplify the points under consideration. Similar processes though often infinitely more complex, affect man's progress and destiny and constitute the essential features of education.

Adaptation in Unicellular Animals.—Without varied environment and consequent varied experiences, development, progress, education in the best sense could not be. In the first chapter it was shown that anything is educative which acts upon individuals or a species so as to mould them to new ways or to bias their future conduct. The resultant tendencies constitute the education received. With this idea more firmly in mind, let us consider the unicellular animals in their relation to environment, and study in them a most primitive educational experience. These little creatures can exist only under tolerably uniform conditions. A slight increase or decrease of heat means destruction to them. Their aqueous environment is a relatively simple, uniform, and unchanging medium in which to exist. They have little to learn to fit them for this environment. It is probable that they have been little modified through long ages. President Jordan says, "That the character of the body structure of the Protozoa has changed but little since early geologic times is explained by the even, unchanging character of their surroundings. The oceans of former ages have undoubtedly been essentially like the oceans of to-day—not in extent and position, but in their character of place of habitation for ani-
mals. The environment is so simple and uniform that there is little demand for diversity of habits and consequent diversity of body structure. Where life is easy there is no necessity for complex structure or complicated habits of living. "1 But even here we find individual and race adaptations and modifications which permanently influence all subsequent actions. That is, these minute animals are in that sense educated.

Experiments in Adaptation.—Lloyd Morgan records 2 the results of experiments by Dr. Dallinger to determine whether monads could gradually become acclimatized to a temperature higher than 60° Fahr., that which is normal to them. By the end of four months the temperature had been raised to 70° without destroying them. On reaching 73° adverse conditions were observed. A rest of two months was made at this point, and then the gradual increase resumed. In five months 78° was reached. "By a series of advances, with periods of rest between, a temperature of 158° Fahr. was reached. It was estimated that the research extended over half a million generations. Here then, these monads became gradually acclimatized to a temperature more than double that to which their ancestors had been accustomed—a temperature which brought rapid death to their unmodified relatives."

Although allowing for elimination of the unfit, Morgan says: "But in any case, the fact remains that the survivors had, in half a million generations, acquired a power of existing at a temperature to which no individual in its single life could become acclimatized. Here, then, we have the hereditary transmission of a faculty." Here we have an illustration of the permanent modification—education—of a species through experience. These processes of adjustment of the individual to environment constitute the most primitive type of education. This is true of all the lower animals as well as of man.

Effects of Experience.—There is a constant struggle on the part of each animal to master its surroundings and to put itself into harmonious relation with them as it understands them.

1 Animal Life, p. 23. 2 Animal Life and Intelligence, p. 147.
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Each experience produces a modification of form, structure, or function, either physical or psychical, and the modification becomes a permanent possession, producing predispositions which tend to bias all future action. This means that the animal profits by experience. The process of learning by experience is education. Thus we see that all organisms receive education. It may not be according to our ideals, but there is education nevertheless. Not only man, but the lowly earthworm and the amoeba receive it. Not only does the individual gain an education, but through heredity the species is made a sharer and a contributor.

In the effort toward adjustment there is always an accentuation of some function or organ. For example, in the effort to capture a certain kind of food certain organs or sets of muscles are brought into new use, or, as in the case of man, when mere muscular power no longer suffices he uses his wits to effect a capture. In the former case the muscles that underwent extra exercise became specially developed; in the latter the mental powers performed the extra work and were developed accordingly. Thus specialization has taken place because it has been advantageous. In fact, we may say, to paraphrase Spencer's cosmological formula, that the whole course of life development, that is, education, has been a process of change from that which is relatively simple, homogeneous, undifferentiated, unspecialized, to that which is complex, heterogeneous, and specialized. This is as true of society as of animal structure.

"With the increase in degree of the division of labor among various parts of the body, there is an increase in definiteness and extent of differentiation of structure. Each part or organ of the body becomes more modified and better fitted to perform its own special function. A peculiar structural condition of any part of the body, or of the whole body of any animal, is not to be looked on as a freak of nature, or as a wonder or marvel. Such a structure has a significance which may be sought for. The unusual structural condition is associated with some special
habit or manner of performance of a function. Function and structure are always associated in nature, and should always be associated in our study of nature.”

Necessity for exercise in a particular direction has either produced variations or accentuated them. These modifications have been preserved through heredity. This is the history of evolution, of progress, of education. While each individual tends to vary in some direction or other, heredity tends to conserve with great jealousy everything gained. In this there is not complete success, for we find in some cases a loss of function and structure.

Illustrations of Nature’s Adaptations.—Among both plants and animals it is easy to cite a sufficient number of cases to demonstrate fully that the processes of adjustment to environing conditions are continually taking place. Not only are new species evolved in this way, but organisms selected from a given generation and placed under changed conditions become very materially different from the specimens that remain under usual conditions. For example, if either plants or animals are removed from a terrestrial life to aquatic conditions, or from fresh to salt water, and succeed in adapting themselves to the new conditions, they undergo changes of external aspect, internal structure, and other modifications. A few illustrations are subjoined to make the point clear. De Moor says the leaves of the water Ranunculus with laciniate leaves are of normal structure, when grown on dry land. The epidermis is furnished with stomata and the constituent cells contain no chlorophyll. But when grown in water the leaves are much longer, have no stomata, and the epidermic cells are full of chlorophyll. Again, upon the authority of Goebel, De Moor says that cacti show remarkable adaptation to varying conditions. The Phyllocactus when grown in the light has a smooth stem, but when grown in the dark it becomes prismatic and thorny. The cactus and all the odd desert flora are doubtless the result of ages of struggle with peculiar climatic conditions. The cacti and each one of the other peculiar

1 Jordan, Animals, p. 77.
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guardians of the lonely waste had an ancestry quite unlike the present inhabitants. The edible mussel has one kind of shell if grown in shallow water, another if grown in deep water, and yet another if it lives in salt water. Shells vary in color according to the latitude and the depth of the water. We know that domestication produces changes in every species. It is seldom that a wild species when kept captive will breed. Darwin says: 1

"Nothing is more easy than to tame an animal, and few things more difficult than to get it to breed freely under confinement."

This is often true of plants as well as animals. The ancestor of the horse was a clumsy, five-toed animal that lived in swamps. But through a process of adjustment to new conditions necessitating flight as a means of preservation it lost first the great toe, then the fifth, and next the second and third, and now only one toe ever develops to functional maturity. The others assert themselves in embryonic stages, but so feebly as to give way entirely to the single toe, the only one which could now be of any use. The cloven hoofs with the "dew-claws" tell the tale of a process that did not continue to the same extent; but the record of adaptation is there, plain to him who understands evolutionary processes. We need but to ask a "show of hands" to secure ample corroboration of the story of adaptation to environment. We can get the whole series from the fins of the fish, the hand of the frog, the wing of a bat, the arboreal hand with the peculiar thumb of the ape, clear to the beautiful hand of man with its infinite potentialities.

Adaptation through Artificial Selection.—English races of dogs, according to Darwin, 2 degenerate in a few generations and entirely lose their peculiarities of form and mental characters which formerly marked them off from all other breeds. Eimer showed, 3 as early as 1872, through his study of the variability of the wall-lizard, that changes took place so rapidly that it "might be with equal justice described as species or variety, so much does it differ from the original form. . . . An instance is afforded in

1 Origin of Species, p. 8.
3 Organic Evolution, p. 3.
this animal of undoubted natural race-production, which has evidently occurred in a relatively short period of time."

It has been demonstrated that plants transplanted from plains to mountainous districts soon become accustomed to develop in a shorter period of time and at a lower temperature. The same thing is shown in taking grains grown in southern latitudes to more northern ones. They rapidly adapt themselves to the new conditions, maturing in a considerably shorter period of time. Corn (maize) has been carried farther and farther north, and now large crops are raised in latitudes where it was formerly deemed absolutely impossible to cultivate it. That the changes are real and permanent is shown by the fact that if taken to the former habitat they have to become readjusted to that locality. Similar changes are being effected in the production of fruits. The great differences between domesticated plants and animals and their wild ancestors are so striking as to be discernible by all. These changes have all been effected in remarkably short periods of time. Among animals the psychic modifications are no less marked than the structural. Scientific agriculture, horticulture, and animal breeding are all demonstrating beyond doubt that new varieties and species can be produced at will and in incredibly short periods of time. The development of these new varieties and species is due to use and disuse. Characters which give advantageous adaptations are increasingly exercised and consequently developed; those which are disadvantageous fall into disuse and therefore tend to atrophy or degenerate. My reply to an anticipated objection that natural selection is the cause of all variations will be in the words of Harris in summarizing the work of De Vries that natural selection may explain the survival of the fittest, but it cannot explain the arrival of the fittest.

New Species through Adaptations.—De Vries maintains that the production of new species is nothing unusual. He also contends that the process of development of new species is not so slow as to elude observation. More startling still, he maintains that sudden mutations resulting in new species are the natural
and usual processes. His whole book, *Species and Varieties: Their Origin by Mutation*, is a professed attempt "to prove that sudden mutation is the normal way in which nature produces new species and varieties. These mutations are more readily accessible to observation and experiment than the slow and gradual changes surmised by Wallace and his followers, which are entirely beyond our present and future experience" (p. 30). In another place he observes that "in horticulture, new varieties, both retrograde and ever sporting, are known to occur almost yearly."

**Variation and Specialization in Nature.**—Species and individuals develop in special ways according to their own particular needs. In making the examination, let us keep in mind the pedagogical question whether uniformity among individual men is a prime consideration, or whether a great deal of variety is not a law of evolution and progress.

Oftentimes different animals on the same general scale both physically and mentally, exhibit very different characteristics in some direction or other. Their success in life has been due to the possession of their peculiar development. Variations in function and structure in nature came about through the necessity for adaptation to conditions. Food-getting, self-protection, rivalry, defence of young, and accommodation to surroundings include most of the causes for adaptation in nature. A few illustrations will be given to show how special modifications are continually taking place. The native English sheep have developed a long wool to protect them in a cool, damp climate. The giraffe's curious long neck is a result of continued high-reaching for food in a country where this was to be found mainly in trees. The different varieties of birds each have bills and claws especially adapted to their methods of food-getting. A stork with duck's legs and a hawk's bill would have a sorry time getting food under natural conditions, as would an eagle with stork's legs and crane's bill. Insect-eating animals have peculiar structures enabling them to secure food. The ant-eater is a good example. Insects' mandibles are wonderful instruments
illustrating the adaptation of means to ends. The curious forms and structures of fishes are interesting illustrations of the same relation. Some can fly, others have swords, and there are those with spines that vanquish enemies; some have eyes on the side of the head, others on top, and still others are blind. The great variety of habits manifested by different animals have all been accumulated through long practice of certain activities necessitated by surroundings. Bats and owls are nocturnal, and bears and most insects hibernate through the winter. Some animals are solitary, others social. The opossum has learned to simulate death, and the partridge practises deception in feigning a broken wing in order to lead enemies away from her brood. Through adaptation degeneration frequently occurs. This is true of cave animals. Certain insects that inhabit islands have lost their wings because flying insects are in danger of being carried out to sea. Protective coloration and mimicry afford striking examples of the laws of adaptation. “In general,” says Jordan,1 “all the peculiarities of animal structure find their explanation in some need of adaptation.”2

**Human Adaptations.**—(a) Anthropological. We need scarcely more than mention the myriads of human adaptations that have occurred, some of them through the necessities imposed by chance conditions, others, as in the higher social and ethical life, designedly wrought in the attempt to realize higher ideals which we have formed. The historians have long since noted and emphasized the far-reaching importance of climate and geographic surroundings upon the development of peoples. The mountains and coast-lines of Greece, the seven hills of Rome, the arctic winter and intolerable nights of Greenland, the torrid sun and sweltering heat of Africa, and the fertile fields of America have formed the texts for many a chapter designed to show the effect of environment in shaping destinies. Reverse the sur-

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1 *Animals*, p. 147.
2 Those who wish to follow out the varied data should consult works like those of Darwin, Huxley, Cope, Brooks, and Romanes. The section on Recapitulation recounts more particularly the evidence of man's line of development which has been established through the sciences of embryology and paleontology.
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roundings of the Eskimo and the New Englander, the Briton and the Abyssinian, and what inversions of character might have ensued. Indeed we may say that the chance environment surrounding one's birthplace to a large extent determines whether one is to be a dreamer or a doer, an idler or a producer, a savage or a progressive citizen. In fact, a few weeks only of a particular environment at a critical time frequently decides whether one will become an upright citizen or a perverted sinner.

As will be shown more fully in the discussion of heredity, only slight modifications of physical and mental characters can be produced in a single generation. Heredity is a great conservative force. In sociology natural selection plays only a secondary rôle, while artificial selection is the dominant factor. The real problem of higher human education is to discover a desirable ideal life for each individual and then to shape his environment so as to contribute best to development in harmony with that ideal. This should not be a matter of chance, but a work demanding the brightest intelligence and highest wisdom.

Human Adaptations.—(b) Biological. The first weeks of life of all human beings and their entire ante-natal existence offer a close parallelism to the adaptations accomplished by lower organisms. The conditions of existence must be tolerably uniform or extinction is the penalty. That the babe is at first powerless to acquire any great range of activities or much dexterity is well known. Microcephalous and other idiotic children always remain in bondage to a circumscribed range of life and are powerless to initiate new things or to acquire them if instructed. It will readily be granted that it is a long stride between education of this sort and post-graduate university education, but the difference is one of degree. The processes are similar.

In childhood, and in fact throughout life, the main adaptations, as is true of the protozoans, are concerned with the every-day problems of existence. As in the case of the micro-organisms, the human being learns to avoid or inhibit that which is harmful or disadvantageous, to repeat that which is pleasurable or bene-
ficial. Thus many activities become stereotyped and largely a matter of routine. Not only does an individual follow grooves which have been established by experience—by education—but the same is true of the race. Instinct, as will be explained more fully later, is simply a race habit, or the standardized results of race education. The individual and the race virtually become "repeaters." This is not the whole of education. To progress much there must be independence of thought, initiative, inhibition, resistance, deliberation, voluntary variation from stereotyped action. But all of these higher depend upon the lower, and, as will be shown, are even more efficient when the lower are best developed. In fact, it must not be forgotten that conservation is equally as important in life as are variations. It is even as important for progress. The frog which climbs out of the well ever so fast makes no progress if he slips back with equal rapidity and regularity.

The School-master Should Imitate Nature.—It is a part of nature's great plan to fix immediately every advantageous acquisition. The successful school-master must again consider her ways and be wise. All learning must be put into some vital relation to the every-day thoughts and actions of life, otherwise the child is ever acquiring but never conserving. Nature builds absolutely sure foundations by fixing "for keeps" everything acquired that is worth while. In our hot-house educational methods our tendency is forever to sample new things and never grow a single process into the texture of muscles, brains, and minds. At the close of such an education the individual is as limp as a squash vine—possesses no real fibre physically, mentally, or morally. This is especially true of much present-day moral and intellectual education. Intellectual and moral truths are learned, not to be put into effective relations, but to be given a mere kaleidoscopic exhibition on examination day. Obsolete arithmetic problems are learned for the examinations, not for their every-day value; children babble a catalogue of the bones, but fail to learn and practise a single, real, hygienic principle like deep breathing or temperate eating. They tattle proverbs, mum-
ble words of morality, sing hymns—even say prayers—in a perfunctory way with no thought of the application to their own lives. Such teaching cannot produce the results we claim for education. Formal educative acquisitions should become integrated with every thought, every feeling, and every proposed action of our every-day existence in exactly the same manner as the racial educational experiences have become integrated. Otherwise they disappear like the dew before the morning sun, and there persist only the oft-repeated, manifoldly related impressions and processes that are gained through the school of experience. Every impulse is a resultant of thousands of experiences repeated in manifold variations.