GROWTH AND DEVELOPMENT.

BY CHARLES MORRIS.

THE writer has endeavored to show, in a preceding paper,[1] that all the activities of animal life are largely, if not entirely, dependent upon the action of external influences. A fuller consideration of this subject seems desirable. There is no question but that the voluntary motions are instigated in the lowest animals directly by external stimulation. In the higher animals this instigation is partly direct and partly indirect, being largely that of mental influences, which arise from preceding individual or ante-natal impressions. Probably the involuntary motions have the same origin. We know that the digestive activities are set in motion by food pressure, and that the action of the kidney ducts is instigated by pressure, while it is not improbable that the actions of the heart and arteries result from a like influence.

If this rule be as general as it seems, then the animal body has no innate power of motion. All its activity is accompanied and rendered possible by oxidation, which furnishes its force. If oxidation never takes place except through nerve stimulation, as there is reason to believe, and if all nerve stimulation arises primarily or secondarily through the influence of external force contact, then the animal body is simply a mechanism adapted to respond to the touch of outer force, and possessed of no inherent powers of activity. However sensitive it may become through nutrition, yet if utterly removed from external influence it must remain quiescent, since oxidation of its protoplasm could not take place.

The organization of the body of the higher animals is in close accordance with this idea. Every portion of it is brought under the influence of external force. There has been evolved a highly complex nervous system, with sensitive extremities on every portion of the surface tissue, and on all the active internal membranes, while motor fibers penetrate every region of the internal body. Thus almost every cell is connected with the surface by force-conveying fibers. And the surface extremities of the sensory nerves are adapted to receive motor influences of almost every kind that exists in the external world. The skin is sensitive to the direct contact of moving matter and the vibratory con-

[1] AMERICAN NATURALIST, February and March, 1883.

tact of heat. The tongue receives the finer contacts of liquid, and the nasal nerves of gaseous matter. The coarser range of vibratory influences acts upon the nerves through the medium of the ears, and the finer range through the eyes. Thus the body is like a highly delicate instrument, upon which nature plays with a thousand fingers, and which responds to the faintest touch of physical force, though it cannot act of itself any more than the piano can yield music without a pressure upon its keys.

But an important secondary result flows from this primary relation of organisms to outer nature. Contact induces oxidation. Nutrition follows. Growth takes place in the active regions of the body, but not in the passive. In the study of the genesis of the species particular attention must be given to this fact. The parts of the body which come most into contact with external substances, and move most readily in response thereto, are those which grow and vary most rapidly. This is particularly the case in the lowest animals, in which a developed nervous organization is yet wanting. In them contact induces motion in the contiguous surfaces. Local growth follows. Protrusion of sensitive and active tentacles results.

In the higher animals, in which a nervous system has been developed, a different result of external contact appears. The motion induced takes place at some internal point, and it is here that the subsequent growth occurs. Thus the influences which yield local growth in low forms mry be generally distributed throughout higher forms, and the great power which external nature has to mold the surface regions of the one, is reduced to a minimum in the case of the other. We may look upon external contact as first inducing a genesis of pseudopodia, tentacles and other motor appendages; and as next inducing a genesis of nerves, sensory nerve organs and muscles. A surface exposed to repeated touch both grows more sensitive to touch, and the energy received gradually makes its way inward, though protoplasmic channels. Every habitual touch either signifies some peril, or some other condition to which the organism must respond if its highest good is to be attained. The more readily it responds, the more varied its motions, and the more adapted they are to the good of the animal, the more likely is it to survive. Thus, though the nerve channels leading inward from a sensitive surface might take any direction, and induce a great variety of motions, yet those running in the direction and inducing the motion best adapted to the good of the organism, will be eventually selected, and the others crowded out. If, then, the early local response to touch and outgrowth of li mbs or tentacles is followed by an evolution of nerves and muscles, out of the many possible directions of these nerves and positions of these muscles, those which are of advantage to the animal must be selected or the animal will perish.

In the higher animals, then, there is not, as in the lower, a special development of the parts directly exposed to contact. This method of development has been succeeded by a development of special channels of force inflow, and of muscles to which motion is principally confined. An impression received on one part of the body induces growth in another part, in which the affected muscle is situated. Yet it must not be supposed that all development of the touched surface at once ceases. It is not enough for the nerve to end upon the surface. It must have a peculiar termination, specially fitted to receive the contact influence of the external force. These contacts are of several distinct kinds, and each of them may be readily received by one form of nerve termination, but with difficulty by other forms. There is, therefore a natural selection of nerve terminations, the animal best fitted in this respect having the advantage. Hence local growth of the parts of the surface exposed to touch is succeeded by local modification of those parts, to render them delicately sensitive to some special mode of touch. Development in response to force contact is at first local protusion of motor organs, then a gradual evolution of sense organs, nerve fibers and muscles, a conveyance of the contact energy inward from the point of its reception to some internal point, and a localization of motor activity and growth in internal regions of the body.

In the very lowest animals we find nothing to indicate the existence of even the rudiment of a mind. There is no retention of energy. Every excitation powerful enough to make itself felt is responded to by a reflex motion. We cannot fairly credit the Amœba with desire for food and definite motions towards food. More probably it moves only in response to external pressure, its movements becoming definite in direction only when this pressure is similarly definite. If this be the case then the taking of food is a chance result of motions without a fixed purpose. The abundance of Rhizopod food, and the incessant motions of Rhizopods, are the two conditions through which the survival of these primitive life forms is attained.

But every motion has some modifying effect upon the constitution of the body. Response to any contact causes increased sensitiveness in the part affected. As the steel accepts magnetism most readily in the direction in which it has been formerly magnetized, so does the Amœba respond to contact influence most readily in parts that have been most frequently touched, and it repeats most easily the special motions it has previously made. Of the many motions and changes of form which may occur, those best adapted to food-getting will be selected, since the animals making them will survive while their competitors will perish. The various species of rhizopods indicate the various kinds of rhizopodal motion that have best succeeded in food capture. Evolution in this early stage is first the preservation and then the inheritance of such results of chance deviation as have proved successful.

The best adapted movements from danger are as important as the best adapted ones towards food. In the earliest life stages we might imagine that survival of ill-protected forms could result only from retrograde movements, or from excessive reproduction. It would seem as if protection by the formation of defensive armor should be a late result of evolution. Yet, on the contrary, armor is assumed by some of the lowest forms of life, the diatoms and various rhizopods. This result proves that the conditions for the assumption of defensive armor exist abundantly, and arise from some native characteristic of protoplasm. Nor need we go far to discover the cause of this effect. All active protoplasm absorbs and employs water. But the water absorbed contains lime and silica in solution. As the water is chemically employed these substances are precipitated, and are ejected from the body in their insoluble form. Here chance comes into place They may be washed away by the surrounding water. They may continue on the surface, the minute particles aggregating into a solid coating. Proving protective they are retained, and selection and inheritance act to the evolution of armored species. Very early, then, in the animal series evolution takes two directions. In one there is a naked body, trusting to quick motion for safety. In the other there is a coated body, trusting to armor for safety. Another form of armor may begin in the chance clinging of sand to the jelly-like body. All such favored forms are sharply selected from the multitude of variations, and thus assume the definiteness of species. The intermediate, weakly-protected forms are crowded out.

The subsequent evolution of naked and armored forms must necessarily differ. The one becomes generally sensitive, gains varied motor organs, and becomes swift and diverse in its powers of motion. The other is sluggish and lacks sensitiveness. Sensation is confined to the unprotected parts, and it is these which develop into elongated organs of touch and movement. In the one food is obtained by swift approach, safety by swift retreat. In the other, food is usually obtained through currents made by cilia or tentacles in the water, safety by a withdrawal within the armor.

In all animals above the very lowest it is of importance that the surface should grow in some degree indurated. If the naked protoplasm were exposed freely to every contact there would be constant motion in response, and the energies of the body be uselessly and dangerously exhausted. The animals best adapted are those which have limited and partly protected parts of the surface alone exposed to the influence of the finer modes of force contact, while the protoplasm of the remainder of the surface is sensitive only to the more vigorous impacts.

Surface induration may take one of two forms. It may increase until the skin becomes a hard armor, to which the animal trusts more than to motion, it becoming heavy in weight, slow in movement and dull in sensation. Or it may end at a slight degree of induration, the animal being light in weight, quick in movement and sharply sensitive. Thus the two phases of evolution which appear in the lowest animals, reappear in the higher with similar results.

All protoplasm is sensitive to touch of all kinds, when exposed to it, but each separate kind of touch tends to develop conditions of appropriate sensitiveness. Excessive light causes a general development of dark pigment, probably as protective against heat effects through its active radiation. This aids absorption of the light rays, and is the condition preliminary to the evolution of the eye. Sound also tends to develop a receptive organ. The preliminary condition of this organ is the deposition of solid particles, which seem to collect the vibrations. In fact all the special senses make use originally of conditions which arise in the body as necessary or occasional results of its action, and which are subsequently developed by the incessant play of external force, into definite sense organs.

In the secondary development of nerves the incessant inflow of motor impressions renders some check important, since, as the sensitiveness of the body increases, a muscular response to every sense impression would totally exhaust the vital energies. This check takes place wherever the nerve fibers are reduced in size, the energy dissipating from that point, as electric energy dissipates in the form of heat when its conductor is too much reduced in size. This checked energy becomes growth force at the points of its dissipation; and nerve cells, aggregating into ganglia, appear at these points. In the higher animals a special region for the checking of sensory force is developed, the congeries of nerve cells there produced constituting the brain. The growth of the brain increases as sensitiveness increases and as the muscular response to impression is hindered, while the energies which outflow into the brain are stored up in some unknown manner, whose results we call the mind.

Thus external impression appears to yield several successive kinds of organic results. It first instigates growth at the immediate point of contact, and surface protrusions appear, in which reside the chief motor and sensory power. Secondly, the external energy forces its way inward, by conductive channels, and is discharged at internal points. Growth of muscular organs takes place at these points of discharge, and of sensory organs at the points of reception. Thirdly, the inflowing energy is checked at certain points on the nerve fibers, and instigates the growth of nerve cells at those points. Fourthly, the energy discharged in the principal ganglion causes the development of some special organism for its reception and organization. The energy thus organized we call the mind, its substantial basis the soul, but are ignorant of the nature of either. Such seem to be the successive results of external force impact. The other organs are similarly derived. The functions of digestion and excretion produce their growth results through pressure impressions upon a secondary system of nerves and muscles; the development of the vascular organs is a necessary accompaniment of that of the muscles and ganglia; and the growth of the connective tissues may be instigated by muscular pull, gravitative pressure and other general force influences discharged into the body.

Thus there is some reason to believe that all animal growth and transformation is instigated, directly or indirectly, by the influence of external motor force, which penetrates the body, induces oxidation (which could not otherwise take place) and produces some phase of animal action, succeeded by an increased blood flow to the point of activity and a subsequent special nutrition. The indirect results of this principle—those of mental instigation—arise from previous individual or from ante-natal contacts, whose influence is stored up in the organism as a directive energy. The ante-natal contact influences tend to the development of the type; the individual to variations from the type, which grow decided when new forms of contact, arising from changed external conditions, act upon the body.

If we consider the life of an individual animal, it may seem as if the idea here advanced is not sustained. For the inherent physical and mental aptitudes of the body control its development far more than external influences. But what is the life of an individual? The aptitudes mentioned were derived from parents, who in turn derived aptitudes from their parents, and the parental line might be followed back, if we adopt the evolution hypothesis, through an excessively long series of animals until it reaches its source in the primitive speck of homogeneous protoplasm. The complete life history of an animal really includes the organic histories of all these precedent forms, though it be millions of years in the making; and the germ of every advanced animal is the record of an interminable era. But nowhere along the line will we find all the organic aptitudes which are displayed in the final form. These physical and mental characteristics were gradually gained. The original rhizopod did not have them. Whence, then, did the man obtain them? The original rhizopod was not without its inherent characteristics. It possessed chemical differentiations to which the difference of sex may be ascribed, and differences in the relations of its internal and external regions to which the separation of the motor and nutritive func-

[1] For illustrations of this fact see chapter on "the law of use and effort" in paper on "The Method of Creation of Organic Forms," by Professor E. D. Cope, Proceedings of American Philosophical Society, Dec. 15th, 1871.

tions may be ascribed. These characteristics of the lowest forms have had a constant influence upon the subsequent development, and vigorously control the evolution of structure in the highest animals. But all other organic characteristics must be due to the play of the fingers of outer nature upon the whole long line of progress. Nature has constantly surrounded and pressed upon the body with her varied energies, inducing responsive motions, growths and variations, and influencing every step of evolution. The most highly evolved body has been thus formed and molded, and possesses hereditary characteristics derived from its whole long line of ancestors. The same may be said of its mental strain. The mind receives and develops under the force of impressions received from without. There is no proof that it has any self-power of development. It began in a possibility, which has been wrought by outer nature into the existing actuality.

Each animal, then, has inherent conditions gained during ages of development by its ancestors. As an individual it is but slightly molded by exterior influences, its internal tendencies being too vigorous to be easily bent aside. But these tendencies arose from the action of exterior influences on its long line of parentage. Hence its whole development is virtually a struggle between external forces—those which play upon the animal during its short individual life, contending against those which have played upon and become inherent in it during its long ancestral life. It is as one impression contending against a million, and we can readily understand the stubborn resistance of the inherent organic conditions to external warping influences.

The influence of external contact upon life and development is strikingly seen in certain peculiar phenomena of the animal world. Vigorous as are the inherited tendencies, yet they are in some cases checked by the action of external conditions belonging to a lower grade of development. The Amphibia, which pass their first life stage as gilled water animals, do not attain their final grade of development if confined to the water. The tadpole that is forcibly kept in the water does not develop into a frog. Although inherently tending to attain this grade of development, it seems to need the contact of air with its surface to induce the necessary changes of organization. While exposed only to water contact nutrition proceeds without modification. The Axolotl, a gilled salamander, continues so if it remains in the water, but becomes the lunged Amblystoma if it leaves the water. Reproduction takes place in the former stage, though it is partly larval. Various other instances of this character might be adduced. There are peculiar fishes, the Leptocephali, which, by deprivation of normal contact influence, seem to remain embryonic throughout life. They are small, pellucid, ribless, cartilaginous creatures, destitute of generative organs, which are found floating far out in the ocean. Gunther considers them to be the offspring of various marine fish, which represent an arrest of development in an embryonic stage. They have been exposed to abnormal conditions, and failed to receive the contact influence necessary to call into play the innate energies of development. It may be, then, that growth can proceed at any stage of life, but that for each new phase of development the animal must be exposed to new conditions of nature. It has in itself the inherited tendencies to successive phases of development until the highest is attained, but these remain dormant until set in play by the requisite kind of external contact.

If this be the case, every animal is, to a very marked degree, controlled by the influences of the outer world, growth, activity, variation, and the inherent development being all dependant upon the instigation of external energy. If we knew the various conditions to which the ancestral line of any animal had been exposed, and could reproduce those exact conditions with which to surround its offspring, its development might be arrested at various ancestral stages, and its line of evolution made out. The instances given of retarded development in Amphibia, are cases in point.

An animal species constantly surrounded by one unvarying set of conditions will not change. Any tendency to change will be restrained by lack of adaptation. Yet natural conditions vary not only in kind, but also in degree. Two animals occupying the same locality may be exposed to very different natural conditions. One is played upon by comparatively few of nature's influences, the other by very many, and the complexity of their adaptations to nature are in accordance therewith. Thus evolution may be of two kinds. One is a change in constitution to meet a change in climatic or other conditions. This produces no change in rank of development. A second kind of change may be either a progression or a retrogression. The animal becomes adapted to simpler or to more complex conditions of nature, and the question as to whether a creature is higher or lower in rank depends entirely upon the degree of complexity in its adaptations.

Embryonic development closely follows the ancestral line. If there has been a retrogression, the point from which the fall commenced is always attained by the larva, as in the case of the barnacles and in other instances. But the successive changes of condition are not all clearly displayed. Some stages of development are retarded, others hurried through. It is probably a question of the influence of external conditions. Of the conditions of nature to which the various ancestral forms of the animal were adapted, many have vanished. Some yet exist. Thus in some stages of larval life the animal would find no support from nature. In others it is adapted to existing nature. The former stages are hurried or slurred over in development, the latter are passed through slowly. Of the many thousands of ancestral forms which the embryo might exhibit, the great mass succeed and overlap each other so rapidly as to be indistinguishable, while some persist as marked conditions of larval life.

And if the animal is forcibly retained under conditions favorable to one of its larval phases of development, its individual life may long continue in that phase, as in the cases above cited. The lives of intestinal parasites present marked instances of this kind. One phase of life is pursued for an indefinite period in one host. Yet as soon as another host is entered, and the animal exposed to new contact influences, and surrounded by new conditions, growth is succeeded by development, and a new life phase assumed. One instance of this is that of the Trichinia, which lays its eggs only in the intestine of its second host.

It would seem as if the conditions surrounding the larva strongly favored growth in that life stage, and hindered the innate tendencies to develop. For the latter to come fully into play, the animal must enter into the conditions necessary to its next life stage, or at least be withdrawn from active external influence, so as to permit the play of organic chemistry within its tissues, and the consequent unfoldment of new conditions of the tissues.

The facts of insect transformation present the most striking instances of the life process above considered. In the higher animals, indeed, the conditions of embryonal life preclude the long retention of larval stages. The embryo here is fully developed within the body of the parent, or within the egg with its proper conditions of warmth and nutriment. There is no hindrance to a rapid development. But in many of the lower tribes the young is born and abandoned to the influences of outer nature while still in an early stage of embryonal growth. In its further process of development it must be exposed in some stages to advantageous, in others to disadvantageous conditions. Natural selection will act to lengthen the period of the former, and shorten that of the latter. The animal will develop irregularly, now remaining long in one phase, now hurrying rapidly through several successive phases. And the retention of any one phase of life is not simply an effect of natural selection, but also of the principle above enunciated, that the action of favoring external contacts tends to restrain the operation of the innate tendencies to development, and to promote simple nutrition and growth without change of organs.

In insect larvæ very active nutrition takes place. The tissues increase rapidly in size, but their further development is, for the time, arrested. Other important effects result. The animal whose life is arrested at the larval stage being exposed to all the molding influences of nature, gains specific variations similar to those which occur in mature animals. As the conditions to which the larva was originally adapted change, it changes in accordance. It gains special habits and organs necessary to its success in this stage of life, yet forming no part of its native plan of development. These are adventitious organs, and are thrown off by the animal in its pupal development as useless additions to the body. But the most marked and singular instance of this principle of growth occurs in another branch of the animal kingdom, the Echinodermata. There is nothing more remarkable in the history of animal transformations than that displayed in the development of the various members of the Echinoderm races. Yet these strange transformations are undoubtedly results of the principle of development here enunciated. Only the core of the true larva is indicated in the form of the swimming larva. It has gained many adventitious organs, probably as results of a long process of adaptation to conditions surrounding its larval life, but which are utterly outside its original life plan. Only the deep-lying organs are in the true line of development. When development is resumed only these internal organs are retained as part of the mature animal, and the secondary larval organs are thrown off, or absorbed as nutriment by the new body. To so great an extent has this secondary development proceeded, that in some cases the discarded organs retain their power of swimming and devouring food, though with no means of digesting it. The energy of further development resides only in the core of the strange creature which has surrounded itself with a temporary shell of swimming, food catching and masticating organs. The tissues of the mature form are molded out of those of the larva, and its useless series of temporary organs discarded.

It would appear, then, that if any animal during its embryonal development enters, at any stage of this process, conditions favorable to the persistence of that stage, its further development is temporarily checked. The energy of outer influences resists the action of internal energies. Nutrition opposes development. The vigor of the organism is devoted to growth, and its energies of change are restrained. Many animals pass on to maturity without a halt. Others make several halts in the path of development, in each of which nutrition checks unfoldment. For development to be resumed, nutrition must be checked. The insect larva must cease to eat ere it can resume its life progress. It also seeks some shelter to secure it from danger during this process, this being probably an instinct arising from natural selection.

And now proceeds a series of organic changes, arising perhaps from the exercise of chemical affinities inherent in the tissues, by which the molecules of these tissues are rearranged and new forms of tissue produced, the nutriment stored in the form of tissue during the larval period serving as material for the new-forming tissues.

It is quite possible that in the embryonal development of all animals there are periods of active nutrition in which growth replaces unfoldment, and periods of quiescence and cessation of nutrition in which the chemistry of evolution resumes its activity, acting on the products of nutrition and molding them into new forms. In some cases these changes rapidly succeed each other. In others the period of larval restraint grows abnormally long. In such a case as that of the Aphis, the larva is so well provided with food that its further development is completely checked.

It reproduces by gemmation and continues larval through many generations. Only in autumn, when the conditions of nature grow unfavorable to its larval nutrition, do the long-checked energies of development assert themselves, and the final progress to maturity take place.

Marked instances of the same kind as those here considered appear in other fields of life, and notably in the Hydrozoa. Here as in insects we have species which progress directly to the mature or Medusa stage, while in others there are long periods of restraint in the larval stage, and of differentiation and reproduction of the larval form. In some cases the advancement to the Medusa stage is checked to such an extent that the free-swimming state is not entered, and occasionally only an aborted representative of the Medusa, or mature Hydrozoan, appears.

In all cases one thing is evident; the development of reproductive organs seldom occurs in the larval form,[1] and is always the last stage in the attainment of maturity. Though the larva represents a former mature animal possessing reproductive organs, it now fails to gain them, and such reproduction as it displays is always by gemmation. It is a nutritive not a reproductive organism. The production of the reproductive organs is the final phase of individual life. It is the signal that the animal has attained the apex of its individual life, and is about to continue its existence in the person of its offspring. Did these organs appear in the larva they would indicate a retrogression, since sexual offspring would be produced, and the final life stage fail to appear. Thus larval retardation effects a lengthening of the individual life, and in some insects constitutes the whole of the nutritive stage. In these cases no nutriment is taken in the imago state, and only sexual reproduction attended to.

The marked production of adventitious organs in Echinoderm larvæ leads to another thought. The modern theory is, that all animals in their progression from the germ to maturity pass through form phases indicating every ancestral type. But it would be useless to seek for detailed indications of the ancestral forms in the embryo, since probably only the core of these forms is reproduced. The general, deep-lying, essential features of structure are displayed, but not the special superficial organs. Only when, as in insect and echinoderm larva, development is retarded, do

[1] One case in which it does occur is that of the Amblystoma, above given.

these specific organs appear, to be secondarily modified through the influence of changed conditions of nature.

The question might here be reasonably asked, why, if the larval condition of the insect is often so superior to the imago for purposes of nutrition, did the animal ever advance to a more intricate life stage? Why did it not persist in its better adapted ancestral form. This question it may not be difficult to answer. There have been very great changes in natural conditions, and the relations of insect life have varied accordingly. Insects were, in all probability, the first flying animals. If so, the possession of powers of flight was a highly advantageous condition. It enabled the original insects to escape from their enemies on the land, and they had no foes in the air. At this period, then, there was probably no retardation in the larval stage, and the imago stage may have long continued. Such a condition persists in some species of insects. Later, however, the air became the home of other flying animals, and the insect lost the security which it had previously enjoyed. In the weaker and more exposed tribes, natural selection produced a lessening of the length of the imago life period, and a hastening of the reproductive activity. But as mature life was checked, larval life was lengthened. A certain degree of nutrition was necessary, and could now be more safely attained in the larval stage.

The same variation of conditions may have acted to produce the larval retardation of the Crustacea, the Echinodermata and other tribes. The soft-bodied and helpless Medusa seems particularly subject to danger from foes. In its original development it may have been much less so. A subsequent rapid destruction of the mature animals may have caused the development of the better protected colony of Hydrozoan larvæ.

Some final consideration of the method of developmental changes seems desirable. There are inherent in the germ energies and tendencies, chemical, molecular, or whatever we choose to call them, adapted to the complete unfoldment of the typical form. But, as appears evident, their operation can be checked by influences from external nature. There is a struggle between these contact influences and the innate organic energies. The latter are the resultants of numerous previous contacts which have acted on the whole ancestral line of the animal. The mind, in its inherited tendencies, represents these ante-natal forces. The action of inherited instincts acts as a check to larval nutrition, and tends to bring the animal into conditions of quiescence and shelter in which its further development may proceed.

Probably the unfoldment of the mental conditions continues even while the animal is active in its larval nutrition. The new awakening instincts more and more vigorously oppose the existing habits. Eventually the instincts gain precedence, through some check to larval nutrition, active life ceases, and the animal process of growth is replaced by the vegetative process of organic synthesis. At the end of this period oxidation of tissue is resumed, and the animal starts again into active life, with new organs, new powers and new instincts.

Those insects which pass a period of individual nutritive life in the imago state are those which stand highest in the line of evolution, and highest of all are the ants and bees, in which larval activity and nutrition are largely obliterated, while the imago stage of life is long continued. The same may be said of all animal tribes. Long life after the reproductive organs appear is a sign of a high phase of evolution, and the habits and mental strain attained in this stage are superior, since they arise from the influence of more complex natural conditions.

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PEARLS AND PEARL FISHERIES.

BY W. H. DALL.

PART II.—MARINE PEARL PRODUCTS.

THE marine mollusks which chiefly produce the pearl and pearl-shell of commerce, are generally known as "pearl-oysters." They present little or no resemblance to the oysters with which we are familiar, though they are related to them biologically. They belong to the genera Avicula and Meleagrina of Lamarck, and are of three or four species, distributed nearly in the same latitude in different parts of the world. The most ancient and famous fisheries are on the coast of Ceylon and in the Persian gulf. These were known to Pliny; Ceylon by the name of Taprobane, and the Bahrein islands of the Persian gulf as the Stoides. Beside these the principal fisheries of the present day are on the Coromandel coast, India; the Indo-Pacific islands, especially the Sulu group; Margarita island, St. Thomas and other