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There is information at hand which points to an excess of loops in the families of both Mr. and Mrs. A. But relying simply on the records contained in the prints from the persons here mentioned, there seems to be good reason to conclude that there is a decided tendency to hereditary transmission of the type or general class of patterns. This is further supported by resemblances in the lesser characteristics of the patterns studied, such as their general regularity, the fineness of lines, slope and size of the loops, the sub-class of whorls where they occur, and the general symmetry of the prints. When these are considered it appears fairly certain that a decided family likeness in finger patterns is transmitted to the children and the grandchildren.

FACTORS OF EXTINCTION.

BY HERBERT OSBORN.

While we have come to recognize clearly the fact of extinction of animal types and their replacement by other forms of life there appears to have been less attention to the special factors concerned in such extinction, or, to put it differently we have been devoting our attention especially to the factors concerned in the production of new types, the variation and evolution of animals, rather than the factors of extinction. It is true that these may bear a close relationship and present mutual dependencies and possibly we might take them as necessary corollaries or consider factors of extinction as merely negative factors of evolution, but it seems to me worth while to attempt a distinct formulation of those factors especially concerned in the elimination of life forms even if for no other purpose than to emphasize those factors of progressive evolution against which they contrast.

In the first place there is a certain kind of elimination which can hardly be called extinction in the proper sense. I refer to the progressive evolution by which a particular

form is evolved into a more highly organized or specialized one. In the course of time the species, possibly the genus, has become entirely replaced by the more modern type, but to say that the earlier forms have become extinct is merely to recognize their gradual transmutation into the later form. If representatives of the older type persist and are finally pushed to the wall by the newer one we must still recognize that there is a chain in the direct line of descent for the newer type in which extinction is not the proper or at least the most significant term. Eohippus, Orohippus, Mesohippus, Protohippus must be looked upon as links in an ancestral chain individually extinct but represented in the modern horse; that is, a persistent type. The Ammonites on the other hand furnish an example of an extinct type. "Extinction" in the one case is certainly a very different thing from what it is in the other. The former is evolution not extermination or elimination of the type.

Direct evolution is perhaps the prime factor in the dropping behind of particular forms of animal life, extinction as we have been accustomed to call it.

Of factors causing total elimination of a form or type of life we may note first; changes in the physical environment as these are perhaps the more certain and widespread in effect. It should be noted of course that certain forms may respond to such changes and by rapid evolution adapt themselves to the change when they would fall into the preceding category, but there have been undoubted cases where over an extensive area the changes have been so radical and rapid as to obliterate a certain kind of fauna.

For example the obliteration of cretaceous seas of central North America, the present plains region of the west, was accompanied by the extinction of a host of marine forms which seem neither to have escaped to other parts of the ocean or to have evolved into any other form fitted for terrestrial or fresh water existence. Striking among these are the Baculites, Ammonites and other Tetrabranch Cephalopods; also a large contingent of marine saurians.

It is perhaps unsafe to assert that other factors may not have come in as the immediate agents in extermination when the animals had reached a state of decadence due to unfavorable environment, but so far as we can see the continuance of cretaceous conditions would have permitted the survival of some at least of its characteristic fauna.

While the change in this instance was one of elevation of land surface and obliteration of ocean we can suppose similar destruction of land fauna by the submergence of land areas. In fact we have pretty strong evidence for particular cases of extinction during quaternary times as a result of extensive submergences. Even in marine life depression if taking place more rapidly than adaptation can follow must result in extermination. Corals limited to certain depths are killed by submergences to lower depths and for species limited to certain areas extinction of the species would result.

Encroachments of seas upon the land or land upon the seas may each result in destruction of life, possibly the extinction of species though usually such changes are too slow to result in complete extermination. They result rather in migration or variation.

Advance of polar ice cap and its subsequent retreat has very probably resulted in some extinctions particularly among animals of fixed habit.

Changes of climate from humid to desert or hot to cold in any area if occurring rapidly would certainly influence the fauna and possibly result in extinction.

Competition among related forms or among forms requiring similar conditions has perhaps been most commonly recognized as a factor in extinction. The "survival of the fittest" is here most strikingly illustrated and observation on existing forms leads to more ready appreciation of its force. Closely related species struggle for mastery in a limited area and one of them is crowded out, or, species in widely separated groups may be thrown into competition in a particular region and one or the other must give way. The Indian gives way to his white competitor, the wild

animals inimical to man are driven out and operations of similar nature doubtless occurred among lower forms before man appeared upon the earth.

Such competition may have arisen between forms indigenous to a particular region but is evidently most striking when species of different faunæ are brought into contact as when from migration a species is introduced to a new locality. European butterflies, sparrows, and other forms including man brought to America by design or accident, are prone to supplant the native species. Such migrations and consequent competitions we can safely assume to have occurred in prehistoric as well as in historic times and that species have been exterminated thereby we can scarcely doubt.

The opening of some barrier permitting the projection of one fauna upon another would intensify such action producing for a number of forms the conditions that ordinarily occur accidentally. Thus the establishment of land connection between Europe and America permitting migrations of whole faunas and their intermingling has resulted in intense competition. Asiatic and African faunas have probably been projected upon European and rapid evolution of European types is thus explained. Lack of such connection and competition may account in part for the conservatism of the Australian fauna.

Quite different from these it appears to me is the extinction which follows some extreme specialization which has fitted the animal to some very limited sphere of existence. For example, parasitic animals have acquired such a dependence upon a host form that extinction without this host is inevitable. Extermination of the Great Auk doubtless carried with it extermination of the parasites peculiar to that species. Further, the parasites dependent on two or more hosts must be exterminated by the destruction of one of such hosts.

The liver fluke is doomed to extinction whenever one of its necessary hosts is wanting or even whenever the necessary association on common ground of its essential hosts becomes impossible. What occurs locally would be gen-

eral and the species would be totally exterminated if such separation could be made to cover all points where the species occurs.

Other cases of extreme specialization are to be found among those forms that have adapted themselves to desert conditions and which can hardly be conceived as having the possibility of survival if forced back into humid conditions with competition with forms of life of more general character. The cave animals cannot survive under ordinary conditions of light and outer air. Subterranean animals must have their peculiar environment or perish and deep sea animals are totally inadequate to the more general conditions prevailing at shore line or in the shallow reaches of the sea. Some of our domestic animals are practically dependent on man, some species of flies depend solely on their resemblance to certain bees to get entrance to nests and stores of food, while certain ants which have adopted slaveholding are said to be entirely unable to carry on the ordinary duties of the colony but are dependent upon their slaves for their very existence. So, too, some species of insects are dependent on a particular food plant and will perish without it.

Specialization in such cases means a kind of limitation and total unfitness for existence outside of certain conditions and hence extinction if those conditions fail. Possibly we might call this a form of change in environment but it must certainly rank as a special form of environmental change.

This differs essentially in the fact that such forms have in a certain way selected the route along which they have traveled and thus foredoomed themselves to extinction. In every case we must assume that such extremely specialized forms have been derived from more normal or generalized forms; parasitic from free forms; desert forms from those occurring in more humid regions; cave forms from those occurring above ground; deep sea from surface or shallow water species, and so on, and that the occupation of the particular niche in nature has been one of selection

on the part of the animal or rather of some members of its ancestral line.

Finally there is the form of elimination which occurs apparently as the termination of a long course of gradual decadence or senility and in which distinct elements of destruction are difficult to discover. A process which we may designate as exhaustion. It may be compared perhaps to that running out or deterioration which cultivators recognize in a variety or race that has been kept through a long course of generations. Such exhaustion appears to occur in certain protozoans as paramoecium after a period of fission and which seems to be counteracted by the process of conjugation. Upon such a basis as this we may account for the disappearance of certain types of animal life which so far as we can see have not been forced out by the other factors. Or it might be looked upon as a protoplasmic exhaustion which rendered the type susceptible to the action of other factors or a combination of factors no one of which could be counted as predominant.

To summarize these factors then we may recognize:

First.—That extinction which comes from modification or progressive evolution; a relegation to the past as a result of the transmutation into more advanced forms.

Second.—Extinction from changes of physical environment which outrun the powers of adaptation.

Third.—The extinction which results from competition.

Fourth.—The extinction from extreme specialization and limitation to special conditions the loss of which means extinction.

Fifth.—Extinction as a result of exhaustion.

I realize that these groups do not represent a classification based on hard and fast lines and such groups are seldom found in nature but it seems to me that they indicate in a tentative way what may be recognized as a number of quite different processes by which organic groups may suffer disappearance.