

I FOLLOW Prof. Lankester in the use of bionomics to designate the science treating of the relations of species to species. If the theory of evolution is true, bionomics should treat of the origin, not only of species, but of genera, and the higher groups in which the organic world now exists.

In his very suggestive review of "Darwinism," by Mr. A. R. Wallace, in NATURE of October 10, 1889 (p. 566), Prof. Lankester refers to "his (Mr. Wallace's) theory of the importance of the principle of 'like to like' in the segregation of varieties, and the consequent development of new species." Prof. Lankester has here alluded to a principle which I consider more fundamental than natural selection, in that it not only explains whatever influence natural selection has in the formation of new species, but also indicates combinations of causes that may produce new species without the aid of diversity of natural selection. The form of like to like which Mr. Wallace discusses is "the constant preference of animals for their like, even in the case of slightly different varieties of the same species," which is considered not as an independent cause of divergence, but as producing isolation which facilitates the action of natural selection. If he had recognized this principle, which he calls selective association, as capable of producing in one phase of its action sexual and social segregation, and in another phase sexual and social selection, he would perhaps have seen that its power to produce divergence does not depend on its being aided by natural selection.

Mr. Wallace's view is very clearly expressed in the following passages, though I find other passages which lead me to think that the chief reason he does not recognize segregation as the fundamental principle in divergence is that he has not observed its relations to the principle of like to like. He says:—"A great body of facts on the one hand, and some weighty arguments on the other, alike prove that specific characters have been, and could only have been, developed and fixed by natural selection because of their utility" ("Darwinism," p. 142). "Most writers on the subject consider the isolation of a portion of a species a very important factor in the formation of new species, while others maintain it to be absolutely essential. This latter view has arisen from an exaggerated opinion as to the power of intercrossing to keep down any variety or incipient species, and merge it in the parent stock" ("Darwinism," p. 144).

I think we shall reach a more consistent and complete apprehension of the subject by starting with the fundamental laws of heredity, and refusing to admit any assumption that is opposed to these principles, till sufficient reasons have been given. Laws which have been established by thousands of years of experiment in domesticating plants and animals, should be, it seems to me, consistently applied to the general theory of evolution. For example, if in the case of domesticated animals, "it is only by isolation and pure breeding that any specially desired qualities can be increased by selection" (see "Darwinism," p. 99), why is not the same condition equally essential in the formation of natural varieties and species? If in our experiments we find that careful selection of divergent variations of one stock does not result in increasingly divergent varieties unless free crossing be between the varieties is prevented, why should it be considered an exaggeration to hold that in wild species "the power of intercrossing to keep down any variety or incipient species, and merge it in the parent stock," is the same. Experience shows that segregation, which is the bringing of like to like in groups that are prevented from crossing, is the fundamental principle in the divergence of the various forms of a given stock, rather than selection, which is like to like through the prevention of certain forms from propagating; and I think we introduce confusion, perplexity, and a network of inconsistencies into our exposition of the subject, whenever we assume that the latter is the fundamental factor, and especially when we assume that it can produce divergence without the co-operation of any cause of segregation dividing the forms that propagate into two or more groups of similars, or when we assume that segregation and divergence cannot be produced without the aid of diverse forms of selection in the different groups. The theory

of divergence through segregation states the principle through which natural selection becomes a factor promoting sometimes the stability and sometimes the transformation of types, but never producing divergent transformation except as it co-operates with some form of isolation in producing segregation; and it maintains that, whenever variations whose ancestors have freely intergenerated are from any combination of causes subjected to persistent and cumulative forms of segregation, divergence more or less pronounced must be the result. The laws of heredity on which this principle rests may be given in the three following statements:—

(1) Unlike to unlike, or the removal of segregating influences, is a principle that results either in extinction through failure to propagate, or in the breaking down of divergences through free crossing.

(2) Like to like, when the individuals of each intergenerating group represent the average character of the group, is a principle through which the stability of existing types is promoted.

(3) Like to like, when the individuals of each group represent other than the average character of the group, is a principle through which the transformation of types is effected.

In my paper on "Divergent Evolution" (Linn. Soc. Journ., Zoology, vol. xx, pp. 189-274), I pointed out that sexual and social instincts often conspire together to bring like to like in groups that do not cross, and that in such cases there will be divergence even when there is no diversity of natural selection in the different groups, as, for example, when the different groups occupy the same area, and are guided by the same habits in their use of the environment. There is reason to believe that under such circumstances divergence often arises somewhat in the following way. Local segregation of a partial nature results in some diversity of colour or in some peculiar development of accessory plumes, and through the principle of social segregation, which leads animals to prefer to associate with those whose appearance has become familiar to them, the variation is prevented from being submerged by intercrossing. There next arises a double process of sexual and social selection, whereby both the peculiar external character and the internal instinct that leads those thus characterized to associate together are intensified. The instinct is intensified, because any member of the community that is deficient in the desire to keep with companions of that kind will stray away and fail of breeding with the rest. This process I call social selection. The peculiarity of colour or plumage is preserved and accumulated, because any individual deficient in the characteristic is less likely to succeed in pairing and leaving progeny. This latter process is sexual selection. It can hardly be questioned that both these principles are operative in producing permanent varieties and initial species; and in the circumstances I have supposed, I do not see how the process can be attributed to natural selection. Varieties thus segregated may often develop divergent habits in their use of the environment, resulting in divergent forms of natural selection, and producing additional changes; but so long as their habits of using the environment remain unchanged, their divergencies cannot be due to natural selection.

Mr. Wallace's very interesting section on "Colour as a Means of Recognition," taken in connection with the section on "Selective Association," already referred to, and another on "Sexual Characters due to Natural Selection," offers an explanation of "the curious fact that prominent differences of colour often distinguish species otherwise very closely allied to each other" (p. 225). His exposition differs from mine in that he denies the influence of sexual selection, and attributes the whole process to natural selection, on the ground that "means of easy recognition must be of vital importance" (p. 217). The reasoning, however, seems to me to be defective, because the general necessity for means of easy recognition is taken as equivalent to the necessity for a specialization of recognition marks that shall enable the different varieties to avoid crossing. In the cases I am considering, there is, however, no advantage in the separate breeding of the different varieties, and even in cases where there is such an advantage (as there would be if the variety had habits enabling it to escape from competition with the parent stock, but only partially preventing it from crossing with the same), it does not appear how this advantage can prevent the individual that is defective in the special colouring from following and associating with those that are more clearly marked. The significant part of the process in the development of recognition marks must be in the failure of such individuals to secure mates, which is sexual selection; or in the unwillingness of the

community to tolerate the company of such, which might be called social selection.

It is often assumed by writers on evolution that permanent differences in the methods in which a life-preserving function is performed are necessarily useful differences. That this is not so may be shown by an illustration drawn from the methods of language. The general usefulness of language is most apparent, and it is certain that some of the laws of linguistic development are determined by a principle which may be called "the survival of the fittest;" but it is equally certain that all the divergences which separate languages are not useful divergences. That one race of men should count by tens and another by twenties is not determined by differences in the environments of the races, or by any advantage derived from the difference in the methods. So easy recognition of other members of the species is of the highest importance for every species; but difference in "recognition marks" in portions of a species separated in different districts of the same environment is no advantage. Under the same conditions, habits of feeding may become divergent; but, since any new habit that may be found advantageous in one district would be of equal advantage in the other district, the divergence must be attributed to some initial difference in the two portions of the species.

I have recently observed that, of two closely allied species of flat-fish found on the coasts of Japan, one always has its eyes on the right side, and the other always on the left. As either arrangement would be equally useful in the environment of either species, the divergence cannot be considered advantageous.

Osaka, Japan.

JOHN T. GULICK.