

sity, has been elected professor of ethics in Cornell University.

THE promotion of Associate Prof. George F. Atkinson to the professorship of botany at Cornell University will be followed by a reorganization of the courses of instruction in the department which will go into effect at the opening of the coming year. Assistant Prof. W. W. Rowlee has been promoted to the highest grade of assistant professor; E. J. Durand, Sc. D., has been appointed instructor in botany, and K. M. Wiegand, assistant. The following advanced and graduate courses in botany are offered for the coming year: By Prof. Atkinson and Instructor Durand, comparative morphology and embryology, mycology and algology. By Assistant Prof. Rowlee and Assistant Wiegand, comparative histology, systematic botany and dendrology.

ADJUNCT PROF. W. H. ECHOLS has been elected by the Board of the University of Virginia to the full chair of mathematics to succeed Prof. C. S. Venable, who retires on account of ill-health. J. Morris Page, of Johns Hopkins University, has been elected adjunct professor.

THE senate of Cambridge University has rejected the proposition to appoint a committee to consider the question of conferring degrees upon women by a vote of 186 to 171.

DISCUSSION AND CORRESPONDENCE.

HEREDITY AND INSTINCT.*

IN his able posthumous work on *Post-Darwinian Questions, Heredity and Utility*, the lamented G. J. Romanes sums up the evidence for the inheritance of acquired characters in the final statement that only two valid arguments remain on the affirmative side; and to each of these arguments he has devoted considerable space. One of these arguments is from what he calls 'selective value,' and the other from the 'co-adaptations' found in the instincts of animals. He says (p. 141): "Hence there remain only the arguments from selective value and co-adaptation." If we take the in-

stincts as illustrating also the application of the principle of 'selective value,' we may gather the evidence which Mr. Romanes was disposed to cling to for the inheritance of acquired characters into a single net, and enquire as to the need of resorting to the Lamarckian factor in accounting for the origin of instinct. I wish to suggest some considerations from the psychological side, which seems to me entirely competent to remove the force of these two arguments, and to show to that extent that the instincts can be accounted for without appeal to the hypothesis of 'lapsed intelligence,' as the use-hypothesis, as applied to this problem of instinct, is called; in other words, to show that Darwin and Romanes were not correct in considering instinct as 'inherited habit.'

The argument from co-adaptation requires the presence of some sort of intelligence in an animal species; the point being that since the coördination of muscular movements found in the instincts are so co-adapted they could not have arisen by gradual variations. Partial adaptations tending in the direction of an instinct would not have been useful; and intelligence alone would suffice to bring about the coördinations which are too complex to be accounted for as spontaneous variations. These intelligent coördinations then become habits by repetition in the individual and show themselves in later generations as inherited habits due to 'lapsed intelligence.' Assuming, then, with Romanes—whom we may take as the most recent upholder of the view—the existence of some intelligence in a species antecedently to the appearance of the instinct in question, we may be allowed that supposition and resource.

I. But now let us ask how the intelligence brings about coördinations of muscular movement. The psychologist is obliged to reply: Only by a process of selection (through pleasure, pain, experience, association, &c) from certain alternative complex movements which are already possible for the limb or member used. These possible combinations are already there, born with him, or resulting from his previous habits. The intelligence can never, by any possibility, create a new movement, or effect a new combination of movements, if the

* Discussion (revised), following Prof. C. Lloyd Morgan before the New York Academy of Sciences, January 31, 1896.

apparatus of brain, nerve and muscle has not been made ready for the combination which is effected. As far as there are modifications in the grouping, even these are very slight functional variations from the uses already made of the muscles involved. This point is no longer subject to dispute; for pathological cases show that unless some adequate idea of a former movement made by the same muscles, or by association some other idea which stands for it, can be brought up in mind the intelligence is helpless. Not only can it not make new movements; it can not even repeat old habitual movements. So we may say that intelligent adaptation does not create coördinations; it only makes functional use of coördinations which were alternatively present already in the creature's equipment.*

Interpreting this in terms of congenital variations, we may say that the variations which the intelligence uses are alternative possibilities of muscular movement. But these are exactly the variations which instinct uses, except that in instinct they are not alternative. That this is so, indeed, lies at the basis of the claim that instinct is inherited habit. The real difference in the variation involved in the two cases is in the connection in the brain whereby in instinct the muscular coördination is brought into play *directly* by a sense stimulation; while in intelligence it is brought into play *indirectly*, *i. e.*, through association of brain processes, but by the same sense stimulation or a similar one. Now this difference in the central brain connections is, I submit, not at all a great one relatively speaking, and it might well be due to spontaneous variations. The point of view which holds that great co-adaptations of *musculatur* are to be acquired *all at once* by the creature is quite mistaken.

The same class of considerations refutes the argument from 'selective value.' This argument holds that the instinct could not have arisen by variations alone, with natural selec-

tion, since partial coördination tending in the direction of the instinct would not have been useful; so the creatures with such partial coördinations merely would have been killed off, and the instinct could never have reached maturity; only variations which are of sufficient value or utility to be 'selective' would be kept alive and perfected.

But we see that the intelligence which is appealed to, to take the place of instinct and to give rise to it, uses just these partial variations which tend in the direction of the instinct; so the intelligence *supplements* such partial coördinations, makes them functional, and so *keeps the creature alive*. In the phrase of Prof. Lloyd Morgan, this prevents the 'incidence of natural selection.' So the supposition that intelligence is operative turns out to be just the supposition which makes the use-hypothesis unnecessary. Thus kept alive, the species has all the time necessary to perfect the variations required by a complete instinct. And when we bear in mind that the variation required is, as was shown above, not on the muscular side to any great extent, but in the central brain connections, and is a slight variation for functional purposes at the best, the hypothesis of use-inheritance becomes not only unnecessary, but to my mind quite superfluous.

II. There is also another great source open to the Neo-Darwinian in this matter of instinct; also a psychological resource. Weismann and others have shown that the influence of animal intercourse, seen in maternal instruction, imitation, gregarious coöperation, etc., is very important. Wallace dwells upon the actual facts which illustrate the 'imitative factor,' as we may call it, in the personal development of young animals. I have recently argued that Spencer and others are in error in holding that social progress demands the use-hypothesis;* since the socially-acquired actions of a species, notably man, are socially handed down; giving a sort of 'social heredity' which supplements natural heredity. And when we come to enquire into the actual mechanism of imitation on the part of a young animal we find much the same sort of function involved

* When we strain our muscles to accomplish a new act of skill we are aiming to use the apparatus in new ways by a selection from possible combinations; and even when we learn to use disused muscles, as those of the ear, we are only stirring up old connections.

* SCIENCE, August 23, 1895, summarized in *Nature*, Vol. LII., 1895. p. 627.

as in intelligent adaptation. The instinct to imitate requires a general tendency to act out for himself the actions which the animal sees, to make the sounds which he hears, etc. Now this involves connections of the centers of sight, hearing, etc., with certain muscular coördinations. If he have not the coördinations he can not imitate; just as we saw above is the case with intelligence, if the creature have not the apparatus ready, he can not use it intelligently. Imitation differs from intelligence in being a general form of coördinated adaptation, while intelligence involves a series of special forms.* But both have to have the apparatus of coördinated movement. So we find, as an actual fact which all agree upon, that by imitation the little animal picks up directly the example, instruction, mode of life, etc., of his private family circle and of his species. This then enables him to use effectively, for the purposes of his life, the coördinations which become instincts later on in the life of the species; and again we have here two points which directly tend to neutralize the arguments of Romanes from 'selective value' and 'co-adaptation.' The co-adaptations may be held to be gradually acquired; since the coördinations of a partial kind are utilized by the imitative function before they become instinctive. And the law of 'selective value' does not get application, since the imitative function, by using these muscular coördinations, supplements them, secures adaptations, keeps the creature alive, prevents the 'incidence of natural selection,' and so gives the species all the time necessary to get the variations required for the full instinctive performance of the function.

III. These positions are illustrated in a very fortunate way by the interesting cases reported by Prof. Morgan in his discussion this evening. He cites the beautiful observation that his young chicks had the instinct to drink by throwing their heads up in the air, etc., but that it came into action only after they had the taste of water by accident or by imitating the old fowl. As Mr. Morgan says, the 'incidence of natural

selection' is prevented by the imitation or instruction or intelligent adaptation (in cases where experience is required). So, in this instance, the instinct of drinking, which has only got so far as a connection of certain muscular coördinations with the sense of taste, is made effective for the life interests of the chick. Thus kept alive the species has plenty of time—in case it should be necessary—to get a connection established also between the sight center and the same coördination of movements; so that future chicks may be born with a capacity for drinking when water is seen only without waiting for instruction, a fortunate accident, or an example to imitate. So we may imagine creatures, whose hands were used for holding only with the thumb and fingers on the same side of the object held, to have first discovered, under stress of circumstances and with variations which permitted the further adaptation, how to make intelligent use of the thumb for grasping opposite to the fingers, as we now do. Then, let us suppose that this proved of such utility that all the young that did not do it were killed off; the next generation following would be intelligent or imitative enough to do it also. They would use the same coördinations intelligently or imitatively to prevent natural selection getting its operation; and so instinctive 'thumb-grasping' might be waited for indefinitely by the species and then be got altogether apart from use-inheritance.

We may say, therefore, that there are two great kinds of influence, each in a sense hereditary; there is *natural heredity* by which variations are congenitally transmitted with original endowment, and there is '*social heredity*' by which functions socially acquired (*i. e.*, imitatively, covering all the conscious acquisitions made through intercourse with other animals) are also socially transmitted. The one is phylogenetic; the other ontogenetic. But these two lines of hereditary influence are not separate nor uninfluential on each other. Congenital variations, on the one hand, are kept alive and made effective by their conscious use for intelligent and imitative adaptations in the life of the individual; and, on the other hand, intelligent and imitative adaptation become congenital by further progress and refinement of

* That they are really the same in type and origin I have argued in detail in my work *Mental Development in the Child and the Race* (2d ed., Macmillans, 1895).

variation in the same lines of function as those which their acquisition by the individual called into play. But there is no need in either case to assume the Lamarckian factor.

The intelligence holds a remarkable place in each of these categories. It is itself, as we have seen, a congenital variation: but it is also the great agent of the individual's personal adaptation both to the physical and to the social environment.

The emphasis, however, of the first of these two lines of hereditary influence gives prominence to instinct in animal species, and that of the other to the intelligent and social coöperation which goes on to be human. The former represents a tendency to brain variation in the direction of fixed connections between certain sense centers and certain groups of coöordinated muscles. This tendency is embodied in the white matter and the lower brain centers. The other represents a tendency to variation in the direction of alternative possibilities of connection of the brain centers with the same or similar coöordinated muscular groups. This tendency is embodied in the cortex of the hemispheres. I have cited 'thumb-grasping' because we can see in the child the anticipation, by intelligence and imitation, of the use of the thumb for the adaptation which the simian probably gets entirely by instinct, and which I think an isolated and weak-minded child, say, would also come to do by instinct.

IV. Finally there are two general bearings of the position taken above regarding the developmental function of intelligence and imitation which may be briefly noted:

1. We reach a point of view which gives to organic evolution a sort of intelligent direction after all; for of all the variations tending in the direction of an instinct, but inadequate to its complete performance, *only those will be supplemented and kept alive which the intelligence ratifies and uses for the animal's personal adaptations.* The principle of selective value applies to the others or to some of them. So natural selection kills off the others; and the *future development of instinct must at each stage of a species' development be in the directions thus ratified by intelligence.* So also with imitation. Only those imitative actions of a creature

which are useful to him will survive in the species; for in so far as he imitates actions which are injurious he will aid natural selection in killing himself off. So intelligence, and the imitation which copies it, will set the direction of the development of the complex instincts even on the Neo-Darwinian theory; and in this sense we may say that consciousness is a 'factor' without resorting to the vague postulates of 'self-adaptation,' 'growth-force,' 'will-effort,' &c., which have become so common of late.

2. The same consideration may give the reason in part that instincts are so often coterminous with the limits of species. Similar structures find the similar uses for their intelligence, and they also find the same imitative actions to be to their advantage. So the interaction of these conscious factors with natural selection brings it about that the structural definition which represents species, and the functional definition which represents instinct, largely keep to the same lines.*

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PRINCETON UNIVERSITY, February 5, 1896.

INSTINCT.

EDITOR OF SCIENCE: Some remarks appended to my letter published in SCIENCE No 62, on the subject of Prof. Morgan's views on instinct by 'The Writer of the Note,' in view of the importance of the subject are worthy of further consideration.

Before drawing conclusions from observations on domestic animals, it is well to consider similar facts in connection with their wild congeners, especially if such conclusions are of a far-reaching character, and it cannot be too well borne in mind that our experiments are very clumsy imitations of nature in a large proportion of cases.

* In conversation with Prof. Lloyd Morgan I was glad to find that he was inclined to interpret the facts which I have quoted from him (and others) in somewhat the same way—that is, as pointing to general conclusions similar to those reached above. While I have reached my conclusions quite independently and from a psychological point of view, any confirmation which they get from so expert and eminent a biologist gives them much greater weight.