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## THE ADVANCING PENDULUM OF BIOLOGICAL THOUGHT

THE specialist often finds it interesting, and sometimes profitable, to pause in the intensive pursuit of his own little field and take time to contemplate the general trend of thought in biological science.

In my own case it is often borne in upon me that the zoological public is little interested in the group of animals, the Hydroida, with which I work, and it is a positive relief to contemplate the broader aspects of the field of natural science.

Let this, then, be my excuse for presenting a paper that is non-technical in form and more of the nature of a general survey of the path along which we have traveled in the acquisition of general biological truth.

Upon taking such a survey it at once becomes evident that progress has been made along a sharply zigzag road, with successive swings to right and left, involving abrupt changes of accepted theories. In fact this path is that which would be traced by a pendulograph as made by an advancing pendulum. The actual movements would be mainly to the right and left of a median line representing actual progress, but each swing of the pendulum would make a slight but sure advance along that median line.

The idea is not really new and has been incidentally touched upon by various writers; but it seems to me that it would be profitable to consider with some care a few of the comparatively recent swings of the pendulum, to note the advance made by each, and possibly to arrive at some general

statements as to our attitude toward the work and our fellow workers.

For this purpose let us give our attention to some of the more important swings of our pendulum that have taken place since the appearance of that epochal event, the appearance of Darwin's "Origin of Species by Means of Natural Selection."

As is usually the case, the workers immediately following Darwin were inclined to outdo their leader, to out-Darwin Darwin and to overwork the theory which he advanced, making natural selection the sole efficient cause of the origin of species.

By far the ablest and most prominent writer who thus swung the pendulum away from the sane and reasonable path along which Darwin had advanced was August Weismann, who startled the world with his declaration that acquired characters were not inherited, and advanced the theory of the continuity and stability of the germplasm. This fascinating and minutely worked out scheme for advancing and clenching the argument for natural selection found many opponents and many ardent advocates. The battle was raged round the chromosomes as the center, and their intricacy and theoretical details were elaborated by Weismann and others until germplasm and somatoplasm, determinants, ids and idents were the stock in trade of every callow as well as learned biologist, in spite of the fact that these latter were unknown and unknowable. Indeed the whole fabric bid fair to break down by the very complexity of the concepts borne of an endeavor to imagine a machinery adequate to account for the increasingly intricate requirements of the known facts of heredity and evolution.

At the present time these terms have been in part abandoned and in part supplanted by others, but the pendulum had not only swung far to one side, but had actually advanced. This advance is probably best shown in the almost universal acquiescence at present in the idea that acquired characters are, at best, seldom inherited and that such cases are too few to be seriously considered as affecting greatly the trend of evolution.

But another, and perhaps more important gain was in the impetus given to the study of cytology, particularly the behavior of the nucleus, and the consequent marvelous improvement in the technique of the study of the chromosomes and the fascinating phenomena of fertilization and cell division. These are indeed important gains, however much the details of the Weismannian doctrine may be modified by subsequent discoveries.

But suddenly the pendulum began to swing the other way. Theodore Eimer in Germany vigorously, if somewhat unwisely, attacked the position of Weismann, being followed by others in Europe and by many of our own countrymen led by our famous paleontologist, Professor E. D. Cope. These latter formed what was then known as the "American School" of Neo-Lamarckians, who believed that acquired characters were inherited and that variations appear in definite directions and "are caused by the interaction of the organic being and its environment."

Few of the younger naturalists present can have any conception of the heat of the battle waged between the Neo-Darwinian and Neo-Lamarckian schools in the last decade of the nineteenth century. Professor Cope himself was a born controversialist and one of the most trenchant and quick-witted debaters among American biologists. Many of the older zoologists will picture to themselves his alert pose, his square-cut chin and the light of battle in his eye as he debated the question in meetings of this association; and discussed cat-

agenesis, kinetogenesis, physiogenesis, bathmogenesis and mnemogenesis.

The advance made by this Neo-Lamarckian swing of the pendulum was not so great nor so sure as its immediate predecessor. The battle in the main went against the Neo-Lamarckians. But they were a notable company, embracing many of the foremost names in the biological roster of that time. Such names as Hyatt, Cope, Dall, H. F. Osborn, Packard, Riley, Eigenmann and many others are significant of the standing of that notable group.

But there was some advance made by the Neo-Lamarckian swing. Cope's "law of the unspecialized" was a direct contribution to our understanding of the course, if not the cause, of organic evolution in its broader aspects; and Eigenmann's argument for the inheritance of acquired characters drawn from his masterly studies of blind vertebrates has not, so far as I am aware, been successfully controverted. To this day a very respectable body of zoologists are inclined to feel, deep down in their consciousness, that, as Geddes and Thomson say:

> It is idle to say that what living creatures do or fail to do has no racial importance.[1]

The remaining swing of the pendulum that demands our attention has just reached its maximum, and may well be designated as the "Mendelian swing." Not entirely Mendelian, either, but partly de Vriesian. This was in a direction tending to a wide departure from the position that had been taken by practically all workers since Darwin; *i. e.*, that natural selection had worked mainly, if not exclusively, by the gradual summation of small but appreciable individual variations. De Vries, with his famous evening primrose, had demonstrated, to his own satisfaction at least, that species arise by sudden mutations and thus sprung full-orbed into being and that ordinary variations never produced species by their summation. He claimed, however, that his theory was a direct contribution to Darwin's theory of natural selection.

At about the same time that de Vries was working with his primroses, the Austrian monk, Mendel, was working with sweet peas and made discoveries whose importance was not recognized until, in 1900, his results were verified by de Vries, Bateson and others in Europe and Castle, Davenport and others (a little later) in America. This was another epochal event in biological advance, and the scientific world was soon plunged into a warm discussion of the "Mendelian Law." Dominant and recessive, segregation, homozygotes and heterozygotes, determiners and factors, genotypes and phenotypes, were the order of the day. But worse was still to come. Factors of four kinds, determiners of three kinds, potencies of three kinds; then inhibitors to explain why the thing did not work. Allelomorphs, sex-limited inheritance and side chains, sweet peas and white mice, guinea-pigs and chickens, filled the circumambiant atmosphere. Biological laymen endeavored to steady their whirling brains while filled with admiration for the warm imagination of these new prophets. Intricate genealogical tables of new and fearful mien stared at us from blackboard, chart and printed page, and we tried, with indifferent success, to look intelligent.

Bateson, in his address as president of the Britsh Association, capped the climax when he added to the world-stupefying clamor of the opening war with the following verbal bomb:

> We must begin seriously to consider whether the course of evolution can at all reasonably be represented as an unpacking of an original complex

[1] "Evolution," 1911, p. 201.

which contained within itself the whole range of diversity which living things present.

Man simply an unpacked amœba! The mammal but a released protozoan! *Amœba proteus* a Prometheus bound! Not only the myriads of factors which represent "the whole range of diversity which living things present," but also the inhibitor for each waiting to assist in the unpacking and the thing that did the unpacking, all encompassed within the confines of a primordial cell! Also an implied super-Mosaic Diety that foresaw all this and did the original packing. The good old Presbyterian doctrine of foreordination absolutely outdone at last! Regeneration in its original theological sense biologically affirmed! And why not? Since we are told that unchastity in women is a unit character, chastity is attained by the miraculous release brought about by an inhibitor that is brought to a sense of its sinfulness and abandons its wicked ways; and the poor woman is started on the way to total sanctification!

Surely, we have now witnessed the extreme swing of the pendulum along the Mendelian path, and the reverse swing is due.

But no one will deny, all jesting aside, that real progress has been gained by the Mendelian swing, nor that this doctrine has contributed a distinct advance in our biological thinking. Few will fail to acknowledge that the factorial hypothesis explains much that has been obscure; that dominant and recessive are terms that will endure; that mutation will solve many a perplexing problem, possibly not of species in a state of nature, but surely of varieties under cultivation and of hybridization.

The idea of rhythm or swing has been in the minds of many thinkers. It is at the center of biological activities. Geddes and Thomson, in speaking of the historical oscillations between the mechanistic interpretation of the living organism and the vitalistic appreciation of it, say:

> Now it is a machine and again it is a spirit, now an automaton and again a free agent, now an engine and again an entelechy. The pendulum of thought continues to swing.[2]

Numerous illustrations of this biological rhythm will occur to each of us. Cell division and conjugation, medusa and hydroid colony, growth and reproduction, anabolism and katabolism, life and death. These are all swings of the pendulum. But there is also a steady advance. The life of the individual includes both swings, but there is also a real advance in the complexity of the species; and from these advances new species arise, whether by mutation or by the accumulation of variations.

The question as to what causes the advance will be answered when we at last find the real cause of evolution itself.

In contemplating this swinging and advancing pendulum of thought certain fundamental principles of wide application come to occupy the focus of attention:

1. While the pendulum swings regularly to right and left, it never actually retraces its course; but advances with each swing. There is a net gain which records definite progress, and this progress is, in general, along the line of evolution.

2. The extreme of each swing is actually further away from the real path of progress than the mean, away from the main direction of advance. The extremest is almost invariably wrong, in the main. He lets his imagination run away with him and carry him much too far, and the wise man will not follow him, but stops far short of the extreme and usually actually pulls back. This is the really valuable service of the conservative mass of thinkers in any

[2] "Evolution," 1911, p. 202.

province of thought; they tend to a return to the mean of wisdom and sanity. To change our simile for a moment, the extremist carries the ball far to the left or right in an end run; but he advances it somewhat, and the conservative mass of his colleagues brings the ball back to the center of the field and more directly in front of the goal.

It is almost hopeless to-day to look for a Weismannian in the extreme sense, but there is a practical acceptance of the idea of the continuity and stability of the germplasm. Probably no one now would give adherence to Cope's complete program, but many believe that, somehow, acquired characters play a real part in the advance of species. In my opinion, too, there are very few indeed who would frankly subscribe to the extreme of Bateson's doctrine regarding the unpacking process, but there are very many who admit that the Mendelian law is a very important thing in heredity, whether it really advances evolution or not.

3. We should be exceedingly hesitant in unreservedly condemning the leaders of the past, or the theories they advanced. Each one of them has done good service and each has been the vehicle of some important truth. Perhaps none of the theories advanced by Darwin has been so mercilessly ridiculed as that of pangenesis. Yet I find in one of the most recent utterances of T. H. Morgan the following:

> There is extensive evidence from cytology, experimental embryology and regeneration to show that all the different cells of the body receive the same hereditary factors.[3]

The swing of the pendulum back from the extreme position taken by Bateson has surely commenced, as the following quotations will show.

Castle, one of the leading American authors in Mendelianism, says:

> The more carefully we scrutinize the mutation theory the more serious do our doubts become, whether it is a secure foundation to build on, and again whether sport variation has had any part in the evolution of species is accordingly very doubtful.[4]

The veteran zoologist, Wm. H. Dall, says, in commenting on Bateson's address:

> We may admit the value of the Mendelian discovery in its relation to low and relatively simple organisms, like plants, and also that in higher organisms Mendelian effects can sometimes be traced, but that unbridled hypothesis should be permitted to cover our colossal ignorance is not what we expect from such a source. When the observed facts flatly contradict a hypothesis a truly scientific expositor says "I can not account for it," and does not cover up (to the lay mind) his ignorance by the phrase of "an inhibitory factor."[5]

No more honored name is at present on the roster of American biologists than that of E. B. Wilson, and the following quotation from him has a weight that all must recognize:

> And yet, as far as the principle is concerned, I am bound to make confession of my doubts whether any existing discussion of the problem affords more food for reflection, even to-day, than that contained in the sixth and seventh chapters of the "Origin of Species" and elsewhere in the works of Darwin.

The next swing of the pendulum lies in the immediate future, and we know not what it will bring forth; but we do know that it will be the means of a new advance along the road to a better understanding of nature's methods.

In the meantime, what should be the attitude of the systematist? Bateson would say that he is out of the game altogether, as the following quotation will show:

[3] "Mechanism of Mendelian Heredity," 1915, p. 42.

[4] SCIENCE, Vol. XLI., p. 98.

[5] SCIENCE, 1914, p. 245.

> Their (the systematists') business is purely that of the cataloguer, and beyond that they can not go.[6]

After full and calm reflection it seems to me that it is not too much to say that this utterance is proof positive that its author is hardly competent to pass an opinion on the work of his colleagues in other fields of biology however great his achievements in his own province. Castle expresses the following opinion:

> It is easy to dispose of the work of the systematist by assuming that he does not know his business, but is it wise to do so?[7]

As a matter of fact it seems to me that the systematist is affected not at all by Mendelianism. His species must be limited on phenotypic grounds alone, because the external appearance and morphology are all that can possibly be known of all but an infinitesimal fraction of the hundreds of thousands of species that must be dealt with. He cares little about what is done with domesticated animals, nor is he greatly interested in forms produced under abnormal conditions of captivity, cross fertilization or other forms of enforced biological immoralities. Of the 10,000 species of modern birds, for instance, how many can be established on factorial grounds? When it comes to the half million or so of insects, a few score, or perhaps hundreds of species might be worked out in the laboratory by Mendelian rules; but the laboratory conditions are usually highly unnatural, and it is safe to say that the results would be endless contradictions and confusion worse confounded; and the remaining hundreds of thousands of species would still have to be dealt with phenotypically or not at all.

So, too, with the innumerable marine forms of invertebrates, a single order of which is a man's job for a life-time, if he is to distinguish them phenotypically alone. The task is absolutely hopeless if treated genotypically.

The systematist knows that species differ from each other in very numerous small characters, and that, even if they would lend themselves to factorial analysis, the result would be much more perplexing than the present system which continually evokes the wrath of our nonsystematic colleagues.

Nor will our work be exclusively, or even mainly, that of the cataloguer. With the aid of our friends the morphologists, embryologists and paleontologists we will continue to unravel the tangled skein of descent; and our opinion will be valued in proportion to the honesty, patience and skill which we bring to our work, just as it always has been.

And so, I think, we can rest easy in the continuance of our job. Meanwhile we can greatly admire the man who busies himself with the microcosm of the cell, and bid him God-speed. We can contemplate with sympathetic delight the experimental zoologist as he shakes the eggs of the sea urchin and salts them with various kinds of salt.

We can even derive pleasure and much entertainment from the marvelous feats of our ultra-Mendelian friend, in full assurance that he will produce a factor that will meet every possible requirement; and that if he doesn't produce the factor he will have an inhibitor at hand to explain why the thing doesn't work. And we can rest calm in the faith that, if neither factor nor inhibitor is forthcoming, he will in no wise be abashed, but will calmly declare the form under scrutiny to be nothing but a fluctuating variety, and will smilingly cast it into the discard along with the systematist, who will just as smilingly proceed with his customary activities.

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[6] Science, August 14, 1914, p. 245.
[7] Science, XLI., p. 98.