

terrestrial abode. And the time scale for the varied events which take place in the interaction of these millions of suns is not less imposing when expressed in familiar terms. A million years is the smallest unit suitable for estimating the history of a star, although the record of that history is transmitted to us through the interstellar medium by vibrations whose period is so brief as to almost escape detection.

Measurements and calculations have thus made known to us a range of phenomena which is limited only by our sense perceptions, sharpened and supplemented by the refinements of mathematical analysis. In space and mass relations these phenomena exhibit all gradations from the indefinitely small to the indefinitely large; and in time they point backward to no epoch which may be called a beginning and forward to no epoch which may be called an end. Dealing chiefly with those aspects of phenomena which possess permanence and continuity, or at least a permanence and a continuity compared with which all human affairs appear ephemeral and fleeting, measurement and calculation tend to raise man above the level of his environment. They bid him look forward as well as backward, and they assure him that in a larger study of the universe lies boundless opportunity for his improvement.

But while that sort of knowledge which has been reduced to quantitative expression has done more, probably, than all else to disclose man's place in and his relations to the rest of the universe, it would appear that mankind makes relatively little use of this knowledge and that we are not yet ready, as a race, to replace the indefinite by the definite even wherein such substitution is clearly practicable. It is a curious and a puzzling, though perfectly obvious, fact that mankind as a whole lives less in the thought of the present than in the thought of the past, and that as a

race we have far more respect for the myths of antiquity than we have for the certainties of exact science. Our ships, for example, are navigated with great success by aid of the sextant, the chronometer, and the nautical almanac; but what company would dare set Friday as the day for beginning the transatlantic voyage of a passenger steamer? From time immemorial tradition has dominated reason in the masses of men. Each age has lived, not in the full possession of the best thought available to it, but, rather, under the sway of the thought of some preceding age. We are assured even now, by some eminent minds, that the highest sources of light for us are nearly all found in the distant past; and a few go so far as to assert that modern science is merely furbishing up the half-lost learning of ages long gone by.

The work of academies and other scientific organizations is therefore nowhere near completion. Great strides toward intellectual emancipation have been made during recent times, but they have served only to enlarge the field for, and to increase the need of, that sort of knowledge which is permanent and verifiable. Measurement and calculation have furnished an invaluable fund of such knowledge during the two centuries just past, and we have every reason to anticipate that they will furnish a still more valuable contribution to such knowledge in the centuries to come.

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*'NATURAL HISTORY,' 'ÆCOLOGY' OR  
'ETHOLOGY'?*

A STUDY of recent literature reveals the fact that zoologists are much in need of a satisfactory technical term for animal behavior and the related subjects which go to make up what is variously known as 'natural history,' 'æcology' and 'biology'

in the restricted German sense. The need is also apparent in recent discussions in *SCIENCE*. As the number of workers in the field above indicated is rapidly increasing, any attempt to fix the terminology, if at all feasible, is certainly timely. In the opinion of the writer all the terms above mentioned are open to serious objection and should be avoided at least by zoologists who use the English language.

Most objectionable is the term 'natural history' on account of the number of its connotations. Not only may it be understood to include everything from mineralogy to anthropology and ethnology,\* but even its more special meanings are most confusing. To convince ourselves of the truth of this statement we need go no further than the writings of Huxley. In his well-known essay 'On the Educational Value of the Natural History Sciences' (1854) and the 'Study of Biology' (1876) he uses the term as synonymous with 'biology.' After tracing the introduction of the word 'biology' to Lamarek and Treviranus† he says (p. 268): "That is the origin of the term 'biology' and that is how it has come about that all clear thinkers and lovers of consistent nomenclature have substituted for the old confusing name of 'natural history' which has conveyed so many meanings, the term 'biol-

ogy.'"

Nevertheless, in the introduction to his little classic on the crayfish (p. 4) he speaks of "that accurate, but necessarily incomplete and unmethodized knowledge which is understood by 'natural history.'" To this subject he devotes the opening chapter of the work above mentioned, and it is clear that he uses the term in one or both of two senses: first, to designate an historical or phyletic stage in the development of biological science, and second, as the name of a special discipline, which, though the oldest of all the biological disciplines, still survives and deserves to be cultivated. In view of this multiplicity of meanings, it would certainly be most expedient if we could restrict the term 'natural history' so that it would apply only to certain historical aspects of zoology and botany.

The origin and use of the term 'œcology' are well known. It was first introduced by Haeckel in his 'Generelle Morphologie' (1866, Vol. II., pp. 235, 236) as Professor Bessey has stated\* and not as Dr. Bather supposes† in the 'Natürliche Schöpfungsgeschichte,' although a more expanded definition of the term occurs in the various editions of this work and in the 'Anthropogenie.' It should be noted that in the work just mentioned Haeckel distinguished accurately between 'œcology' and 'chorology,' including both, evidently as coordinate subjects under his third ('relational') subdivision of physiology.‡ The term 'œcology,' thus originally proposed by an eminent zoologist, has been adopted by the

\* Conf., e. g., Leunis' 'Naturgeschichte' and Woods' 'Natural History of Man.'

† Incidentally it may be remarked that the use of this term to cover both botany and zoology appears to be older than Huxley and other recent writers have supposed. According to Father E. Wasmann S.J. ('Biologie oder Ethologie?' *Biol. Centralbl.*, Bd. 21, No. 12, 1901, p. 392) who can write with authority on this question, the word was used by the schoolmen: "Aristotelian scholastics designated the study of living beings as 'biology.' The 'Biologia inferior' treated of organic human, animal and plant life; the 'Biologia superior' of the psychic life of man and animals," etc.

\* *SCIENCE*, Vol. XV., No. 380, p. 593.

† *SCIENCE*, Vol. XV., No. 384, p. 748.

‡ Dr. Bather stigmatizes those who use the term 'chorology' as 'pedants,' overlooking the fact that we are not in the habit of applying this name to Haeckel and Huxley, both of whom must have found the word decidedly more concise and euphonious, and therefore better, than 'zoogeography,' 'phytogeography' or even 'geographical distribution.'

botanists, its spelling has been altered, apparently with no other gain than that of saving a letter, or rather part of a letter, and the meaning has often been modified till it is almost equivalent to 'chorology,' or at any rate 'chorological œcology.' And now the zoologists are reappropriating this term, modified spelling, meaning and all, in a manner which reminds one of the case of the good old German word 'Faltstuhl' (Eng. faldstool) which was boggled by the French to 'fauteuil' only to be again reappropriated, with much unction, in its unrecognized form by both English and Germans. It seems to the writer that it would certainly be expedient, not to say generous, for the zoologists to leave the botanists in undisputed possession of the term 'œcology,' especially as they seem to set some store by it. For, in the first place, the term was not a very happy one to begin with, no matter how we interpret the *oikos* part of the word. Haeckel intended it to mean something like the economy of nature ('die Lehre vom Naturhaushalte'), but one is at first inclined to understand it as referring merely to the habitat, or even to the dwelling or nest of an organism. This sense, in which it has been understood by Wasmann (*loc. cit.*, p. 392) and many other zoologists, not to mention botanists, is too narrow for the purpose we have in view, as will appear from the sequel.

Ever since the botanists adopted the word 'œcology' and applied it to the important subject which they are exploiting with such zeal and profit, there has been comment to the effect that the zoologists have been unduly neglecting a very promising province of their science. This certainly involves some misconceptions. The zoologists have perhaps distinguished somewhat more rigidly than their botanical brethren between 'chorology' and the

proper province of 'œcology,' and in both of these subjects work worthy of the greatest admiration has been accomplished. If we confine our attention to zoological 'œcology' we find that it begins with Aristotle and Pliny, and a rapid survey of recent centuries shows that investigators like the following have devoted whole years of their lives to work in this field: Redi, Swammerdam, Roesel von Rosenhof, Réaumur, Bonnet, Buffon, Trembly, White of Selbourne, Erasmus and Charles Darwin, Wallace, Bates, Belt, Hudson, Romanes, Audubon, Wilson, Coues, Brehm, Houzeau, Leuckart, von Siebold, Semper, Steenstrup, Fritz Müller, Fabre, Francois and Pierre Huber, Giard, Plateau, Adler, Forel, Lord Avebury, Wasmann, Moggridge, McCook, Adlerz, Janet, Marchal, von Buttel-Reepen, Maeterlinck, Riley, Grassi, Lang, Dr. and Mrs. Peckham, Poulton, Silvestri, Erich Haase, Dahl, Escherich, etc. These are but few of the many whose works are scattered through the whole wide range of zoological literature. And there are undoubtedly many others who have investigated subjects like animal migration and the myriad problems suggested by whole groups of animals with which the writer has only a superficial acquaintance. That some botanists, and some zoologists, too, for that matter, have failed to appreciate the importance of the work accomplished by the above-mentioned 'œcologists' is easily explained. One observes that only a small minority of these investigators worked under university auspices. It is only too evident—and only too humiliating—that Schopenhauer's diatribes apply to the zoologists as well as to the metaphysicians, for the investigators above mentioned were 'amateurs' in the true sense of the word, *i. e.*, lovers of animal life, and most of them therefore lived and worked untrammelled by the interminable 'Rück-

sichten' and 'Nachsichten' of university life. Here one is inclined, with Schopenhauer, to put a higher estimate on their investigations than on many of the publications of academic 'professionals,' especially as the work of the latter is coming to be more and more the expression of ephemeral laboratory fads, inflated with the intellectual infection so inseparable from 'schools' and 'tendencies' of all kinds.

The failure of zoologists to cultivate the province of their science corresponding to the 'œcology' of the botanists is more apparent than real for a second reason; viz., the great complexity of the zoological as compared with the botanical phenomena to be organized and methodized. And this leads us to a further reason for abandoning the term 'œcology' in zoology, and for suggesting the adoption of one essentially different. While botanists and zoologists alike are deeply interested in the same fundamental problem of adaptivity, they differ considerably in their attitude, owing to a difference in the scope of their respective subjects. The botanist is interested in the effects of the living and inorganic environment on organisms which are relatively simple in their responses. The zoologist, however, is more interested in the expressions of a centralized principle represented by the activity of the nervous system or some more general and obscure 'archæus' which regulates growth, regeneration and adaptation, carrying the type onward to a harmonious development of its parts and functions, often in apparent opposition to or violation of the environmental conditions. This finds its vaguest and most general expression in what we call 'character' or in what systematists feel, but are often unable to describe, the 'habitus.' Its deeper manifestations, however, are of the nature of instinct and intelli-

gence. This language may be tinged with metaphysics, not to say mysticism, but those who have finally learned to find animals most interesting when not 'fixed' in some fluid recommended in a German laboratory, or converted into skins, skeletons, shells, cadavers or fossils, will comprehend at least the intention of the writer.\*

The only term hitherto suggested which will adequately express the study of animals, with a view to elucidating their true character as expressed in their physical and psychical behavior towards their living and inorganic environment, is *ethology*. This term has been employed to some extent by French zoologists and, as the writer infers from Dr. Bather's article, attempts have already been made to establish its English usage. Dahl† has advocated its introduction into Germany in the place of 'Biologie' (in the German sense) a term which in that country has been very generally preferred to Haeckel's 'œkologie.' On the other hand, the retention of 'Biologie' has been ably defended by Wasmann (*loc. cit.*), and it is probable that it will remain in general favor, notwithstanding the ambiguity of the word. This danger is perhaps not so great in Germany, where every zoologist or botanist does not style himself a 'biologist' or at least give a course of lectures in 'general biology.' Be this as it may, however, the question is one to be settled by the Germans themselves, and we are at perfect liberty to use 'eth-

\* The difference between the interests of the botanists and zoologists is most clearly seen in the difference of the problems suggested by 'plant societies' and by social animals.

† 1. 'Vergleichende Untersuchungen über die Lebensweise der Aasfresser,' *Sitz. Ber. Akad. Wiss. Berlin*, II., III., 16. Jan., 1896; 2. Experimentelle statistische Ethologie, *Verhand. Deutsch. Zool. Gesel.*, 1898, pp. 121-131; 3. 'Was ist ein Experiment, was Statistik in der Ethologie?' *Biol. Centralbl.*, 21. Bd., 1901, p. 675.

ology,' especially as the German usage of 'biology' among English or American zoologists is almost without precedent.

The word 'ethology' is singularly happy in its derivation from *ἦθος*, which embraces in the wealth of its connotations, all the aspects of the zoological discipline for which a concise and appropriate name is so much needed. The origin of the word *ἦθος* from *ἔθος*, custom, usage, is clearly given in Aristotle.\* The general Greek usage of *ἦθος*, especially in the plural *ἦθη*, as the accustomed seat, haunt, habitat or dwelling of men or animals, admirably expresses the chorological aspect of 'ethology'; its usage in the sense of habit, manners, etc. (Lat. *consuetudo*, *mores*) expresses what we mean by animal behavior, while the signification of *ἦθος* as character, disposition, nature, etc. (Lat. *indoles*, *ingenium*, *affectus*) is well suited to express the psychological aspects of 'ethology.' Certainly no term could be more applicable to a study which must deal very largely with instincts, and intelligence as well as with the 'habits' and 'habitus' of animals. It is apparent from a moment's reflection that the term may be readily made to include all and more than is meant by 'Biologie' in the German sense, or 'œcology' in the Haeckelian sense.

There may be a possible objection to the use of 'ethology' on the ground that it has been employed in English in two senses besides the one here advocated, viz., as the name of the science of ethics and as mimicry, or pantomime.† But the latter usage appears to be quite obsolete, and an authority on moral philosophy informs the writer that he has never encountered the

word 'ethology' in the sense of 'ethics.' Hence this usage must be too uncommon to prevent the zoologist from appropriating the term for technical purposes.

Father Wasmann (*loc. cit.*, pp. 398, 399) defines 'ethology' (or rather its equivalent, 'Biologie') as 'the science of the external conditions of existence which pertain to organisms as individuals and at the same time regulate their relations to other organisms and to the inorganic environment.' It therefore embraces in its restricted sense: "first, a knowledge of the mode of life of animals and plants, their nourishment, dwelling, mode of propagation, the care of offspring and their development, in so far as these present external manifestations; hence also, second, a knowledge of the life-relations that obtain between individuals of the same and different species (including all the phenomena of parasitism, symbiosis, etc.), and hence also, third, a knowledge of the conditions of existence which are essential to the life and maintenance of animals and plants." It occurs to the writer that it would be better to substitute 'general' for 'external' in this definition. Of course, 'general and special' are open to the same objections as 'external and internal' on account of the impossibility of drawing a hard and fast line between the two alternatives. But it seems better, on the whole to emphasize the former alternatives on account of the large element of general comparative psychology, physiology, morphology and embryology, which must enter into ethological investigation. 'Generality' also expresses in a more satisfactory manner the central position of 'ethology' among the remaining zoological disciplines. Whenever we undertake the detailed or exhaustive study of an ethological problem we are led imperceptibly into the details of physiology, psychology, morphology, embryology, taxonomy or

\* "Τὸ γὰρ ἦθος ἀπὸ τοῦ ἔθους ἔχει τὴν ἐπωνυμίαν. ἡθικὴ γὰρ καλεῖται διὰ τοῦ ἐθίζεσθαι." 'Ethica Magna,' II., 6.2; 'Ethica Eudemia,' II., 2.1. Ed. Bekker.

† Century Dictionary.

chorology, according to the particular aspect of the subject under consideration. On the other hand, the interests of all these various sciences are slowly but surely converging to a point which is not far from the center of gravity of 'ethology.' This is apparent in the 'types' and 'habitus' of the systematist and morphologist, in the conceptions of the 'individual,' in experimental embryology and the study of growth and regeneration, in the conceptions of 'adaptivity' among the 'neovitalists,' in the mystic zoology of a Maeterlinck, in the theories of 'determinate variations' and 'orthogenesis,' in recent experimental work on the origin of mutations, etc. In all this work there is apparent a turning away from the 'mechanical' and 'environmental,' a realization of the prematurity and inadequacy of all biological 'explanations' couched in terms of *existent* chemistry and physics, and an appreciation of greater depth and mystery in the life activities than had been previously conceded.

So numerous are the signs of the time that it requires little prophetic insight to discern that we are on the eve of a renaissance in zoology. There have been voices crying in the wilderness for many years, and it may be well to hark back to some of these and catch the full force of their intention. First there was Goethe, who glowed with the magnificence of the problem:

"Was ist doch ein Lebendiges für ein köstliches, herrliches Ding! wie abgemessen zu seinem Zustande, wie wahr, wie seiend!"

Then there was the father of developmental science, Karl Ernst von Baer, who began to doubt whether the field he had himself cultivated with such success would yield more than a small portion of the desired harvest:

"Wissen möchten wir ob das 20. Jahrhundert nicht, wenn man die Kunst *das Leben im Leben* zu beobachten, wieder gelernt hat, über die Selbstzufriedenheit des 19. lächeln wird, mit der es glaubt, aus dem Leichnam das Leben in seiner ganzen Fülle erkennen zu können, fast vergessend, dass mit dem bildenden Leben ein handelndes innig verbunden ist, das dem Messer und dem Mikroskop sich entzieht."

And among the latest there is Jules Fabre, indefatigable observer and incomparable writer, who points to the old, sure method of all science as *the* method of 'ethology':

"Large part faite à l'anatomie, précieuse auxiliaire, que savons-nous de la bête? A peu près rein. Au lieu de gonfler avec ce rien d'abracadabrantes vessies, glanons des faits bien observés, si humbles soient."

WILLIAM MORTON WHEELER.

AUSTIN, TEXAS,

May 17, 1902.

#### THE LAW OF VON BAER.

BASED ON SCHOLION V.

THE writings of von Baer have been subject to much interpretation, and have yielded under the nursing hand of 'productive' scholarship, meanings which in reality they do not contain. It seems therefore worth while to reconsider what is the great generalization at which he arrived; and to those interested in the historical side of embryology, this attempt to follow the reasoning of a masterly investigator may be not unwelcome.

#### I.

#### THE PREVAILING VIEW THAT THE EMBRYO PASSES THROUGH THE ADULT STAGES OF LOWER ANIMALS.

At the time when the first volume of the 'Observations and Reflections on the Development of Animals' was published (1828), no propositions in embryology en-