SOCIOBIOLOGY: BEFORE AND AFTER*

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THE publication in 1975 of E. O. Wilson's '*Sociobiology: The New Synthesis*' marked the official birth of a new discipline in biology; and almost ever since, a spate of reviews, criticisms, extensions, implications and critiques of not only the book but also of the discipline of Sociobiology has appeared. It is perhaps true to say that few publications in science have attracted in recent years as much attention as this one has. The reason is two-fold. Wilson's book is a masterly review of animal societies from molds to man. Himself a student of social insects, the sure touch Wilson displays in discussing the origin, nature and evolution of animal societies is that of an expert. It is this unrivalled and extensive understanding of the mass of recent work of animal societies that has won him admiration.

The other reason for the notice which the book received lay in its final few pages where Wilson attempted to interpret man's behaviour in terms of his biological evolution. This notice ranged from outright condemnation of Wilson's ideas of the sociology of man to a lukewarm vindication of his position. Perhaps no one came to Wilson's defence as forcefully as Wilson himself and that was weak not only for him but also for the views he was expressing on man's behavior. That homosexuality, incest, philanthropy, celibacy, slavery, martyrdom and altruism in man could be explained on evolutionary terms like any other structural trait; that the divisions of labour among the sexes which exist in man today could be derived genetically from the biases which the hunter-gatherer society of early man exhibited; that generally 'patterns of human social behavior, including altruistic behavior, are under genetic control' were attacked by both biologists as well as by sociologists. For, these ideas came dangerously close to the socially pernicious doctrine of evolutionary positivism of Herbert Spencer and the more recent loathsome creeds of Nazi Germany.

Sociobiology is a systematic study of all forms of social behavior in animals and in man. Sociologists have in the past attempted to explain behavior patterns without adequate reference to evolutionary origins. The role of sociobiology is to place social sciences within a biological framework taking into account genetics, ecology, population biology and evolutionary studies, particularly those of the brain.

Two recent theories which attempt to interpret man's behavior have now been nearly abandoned. Konrad Lorenz's view that aggression is the major driving force and all, or most, human behavior is born out of the aggressive instinct, which needs periodically to be relieved, has been given up. The behaviorist school, led by B. F. Skinner, which attempts to explain man as a 'Stimulus-response machine' is also unsatisfactory. Man's behavior is far more varied and complex than can be explained by simple laws and theories, and appears to have its basis both in his genetical origins as well as in his cultural evolution. The determination of the extent to which each has made its contribution is the role and function of sociobiology. The great debate following the publication of Wilson's book is concerned with this 'extent'. One can go to either extreme; Wilson presented an appearance of tending to do so with reference to biology and made the mistake of attributing many of man's behavioral traits to his genetics. Naturally he drew most of his fire from sociologists, anthropologists and psychologists who felt that the cultural evolution of man was supreme and thus denied, to the extent that they deserved, the considerations of biological evolution whose processes produced, in the first place, man.

BIOLOGY AND SOCIOBIOLOGY

How relevant are biological theories to sociology? To what extent can the sociologist draw parallels from what is seen in animals, to explain man's behavior? These questions have been in the minds of both biologists and sociologists almost ever since Charles Darwin established the indissoluble link between animals and men. The 'hard' facts of organic life —anatomy, physiology, morphology, cytology—have established the origin of man from lower animals: they have also helped interpret organic diversity. It was therefore as natural for the 19th century biologist to talk of Social Darwinism as for the 20th century sociologist to propound justification of rare theories. The discovery that several animal species form] societies nearly as complex as those of higher animals and of man brought into sharp focus the question: Has human social behavior its origins in animals?

To the keen student of animal societies that Wilson was, the temptation was vastly alluring, and even if we

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generously accept his subsequent disclaimers that he did not intend the meanings and interpretations his critics put into his statements, he certainly was so carried away by his enthusiasm for biology and biological evolution that he failed adequately to appreciate the role of culture in the origin, maintenance and evolution of several behavioral traits in man. His later statements in defence of his position made things worse; and Wilson, after his initial reaction to the 'intimidating' tactics of his adversaries, many of whom were eminent biologists and geneticists, in addition to sociologists, was forced to see much of the untenability of his earlier position and to concede that in so far as man was concerned, other important forces than genetics were in operation, and that in addition to the 'genes having culture on the leash', it is perhaps as true to say that culture has the genes on the leash too.

Before Sociobiology

This however is not a review of Wilson's book. It is an appraisal of the contributions of several others who preceded Wilson in appreciating the links that were discernible in the behavior of man among animals. For, Wilson's was by no means the first attempt at integrating animal with human behavior. Others, notably Maynard Smith (*The Theory of Evolution*, 1958), and G. C. Williams (*Adaptation and Natural Selection*, 1966) had seriously considered the possibilities of extrapolating animal studies to those of man. There were others too—W. D. Hamilton; T. H. Clutton-Brock; D. Lack; R. L. Trivers; U. C. Wynne-Edwards; G. A. Parker—who had made distinctive contributions to animal social behavior, its causation and its development. Even altruism which Wilson regarded as the central theme of his book was noticed by J. B. S. Haldane (*The Causes of Evolution*, 1932). But none of these had the supreme advantage which Wilson had of extensive and deep knowledge of animal societies. Also, perhaps they were too prudent or too unventuresome to make the leap into postulating that many aspects of man's behavior lay almost entirely in his animal heritage. They were correct and conservative; not audacious and precipitate as Wilson was.

It is the work of these earlier students of evolution of societies that this review is about*. Edited by T. H. Clutton-Brock of Cambridge and Paul Harvey of Sussex, two keen students of primate societies, it puts together 19 papers on the functional and evolutionary aspects of social behavior and while it is not claimed by the editors that nearly all important contributions are included, several, particularly those dealing with theoretical considerations, have found a place. Almost all of them predate the publication of Wilson's book and only two, both by Clutton-Brock and Harvey, cite *Sociobiology* as a reference.

The book is divided into four sections. Understandably it is not possible to achieve either continuity or coherence when one is dealing with themes as wide as altruism, reproductive behavior, parent-offspring conflict, primate ecology, etc. But all have relevance to social behavior.

Altruism

The central theme, both in Wilson's book as well as in the present one is altruism. Altruism can be defined as behavior that benefits another individual at the cost of one's self. Here again, Wilson was not the pioneer. Sewall Wright made some valuable studies on altruism and J. B. S. Haldane came close to understanding its significance in evolution. Indeed, Darwin himself considered the role of selection among families of social insects in their evolution. It was picked up for a rather extensive analysis by W. D. Hamilton (whose paper is included in the book). Evolution depended on the exploitation of morphological, physiological and behavioral differences between individuals, not only competing for resources but also for the realization of reproductive success, measured in terms of the offspring reared to reproductive age. Darwin was not aware of and if he was could not adequately explain, intraspecific differentiation on the basis of hierarchies between haves and have-nots. That some individuals act to their own detriment but for the good of the group, population or species, appeared not only new and interesting to the evolutionary theoretician but also in conflict with the Darwinian concept of individual competition. It was important to explain the presence of altruism (alarm calls of birds, cleaning symbiosis in fishes and the whole panorama of parental manipulation and kin selection among several groups of animals); it was also necessary to account for its maintenance in evolution. The extent to which 'group' or 'kin' selection was in conflict with selection for individual fitness was the article for debate; out of which has arisen the admission that altruism is eventually in the interest of the species, that intergroup selection can override the selection between individuals and that the two processes can run concurrently. Wynne-Edwards, Maynard Smith and particularly W. D. Hamilton develop the relationships between selfishness and altruism. B. C. R. Bertram has studied 'kin selection' among lions. Incidentally, Hamilton was not the originator of the term 'kin selection'. Indeed he used 'inclusive fitness' to express the idea. However, Maynard Smith while engaged in a study of intraspecific selection applied the expressive terms 'kin selection' for

* *Readings in Sociobiology*, Ed. T. H. Clutton-Brock and Paul H. Harvey, W. H. Freeman and Company, 1978.

relatives within a group, and 'group selection' for groups more or less isolated from one another.

That the disadvantage to the individual altruist was more than made up by the benefit conferred in the long run on the group or on the species is the theme of Maynard Smith's paper on Alarm Calls in Birds. Here it is essentially 'kin selection'. The interest in bird alarm calls is that the danger to the altruist becoming exposed to the predator is minimised consequent on the development by the caller of notes which are usually difficult to locate on account of their high pitch with a small range of frequencies. An unlocatable call has an enormous advantage over a locatable one, and during the course of evolution has been able to diminish or almost completely nullify the disadvantages of altruism (to the caller) without depriving the flock of the benefit consequent on the altruistic act.

The origin and maintenance of the altruistic trait requires the acceptance of both 'group' and 'kin' selection, because in both, individual fitness is sacrificed at the altar of group fitness.

Reciprocal Altruism

Perhaps the most thoughtful presentation on altruism is that by R. L. Trivers who examines in detail and with excellent examples the evolution of reciprocal altruism. His essay deals largely with altruistic behavior in unrelated organisms and so concerns itself with 'group' rather than 'kin' selection. The chapter gains added significance consequent on its references to altruism in man; this is the only paper which deals in any measure with the sociobiology of man. Friendship and altruism are closely related and it is probable that friendship followed altruism in the evolution of man, not the other way around. But this is debatable; while in experimental situations one sees more altruistic behavior toward friends than toward neutral individuals, others have seen friendship evolve after mutual altruism has appeared. Indeed, Trivers feels that reciprocal altruism is seen extensively in man, and 'there is no direct evidence regarding the degree of reciprocal altruism practised during human evolution, nor its genetic basis today, but given the universal and nearly daily practice of reciprocal altruism among humans today, it is reasonable to assume that it has been an important factor in recent human evolution and that the underlying emotional dispositions affecting altruistic behavior have genetic components'. Trivers' contribution, exhibiting a synthesis of psychology with genetics, behavior and anthropology is a notable attempt at extrapolating the observations on animals to man. Many of the concepts Trivers develops would apply to the hunter-gatherer man rather than to the evolved man of today and while it is difficult to be sure of the validity of these concepts, it seems necessary that in-depth studies be made by both biologists and sociologists in the understanding of man's behavior.

The evolutionary process is grounded in competition between individuals; yet animals often assist each other. Co-operative courtship occurs in several birds. Co-operative rearing is common among certain mammals. How do we explain co-operation from the evolutionary point of view ?

Most group-living animals exhibit one or the other kind of co-operation—symbiosis, kin selection, reciprocal altruism. Increased efficiency in food-finding, greater assurance of regular access to the opposite sex and more effective defence against predators are obvious advantages. Selection is likely to favour those individuals that obtain more advantages than they are prepared to extend; that is where cheating comes in. Also, conflicts, particularly between parents and offspring, are not uncommon. In the baboon, for instance, these conflicts may last for weeks or months involving competitive reactions of a particularly violent nature.

Reproduction and Parental Investment

While group benefit, co-operation and disruption form the major themes dealt with in the book, a section is devoted to reproductive strategies. Reproductive success is central to evolution and natural selection ensures a maximization of the spread of genes through the individual's offspring and occasionally through the offspring of relatives. Breeding patterns, life-history variables, growth rates, parental care—all these are important strategies in evolution. Selection favouring high fecundity and rapid development (*r*-selection) is distinguishable from that of lower fecundity and slower development (*k*-selection). E. R. Pianka has shown that while a whole range of variations occurs in nature (and in a single order of mammals, the Rodentia), a more or less clear demarcation can be made between them. Land vertebrates are good examples of *k*-selection while in insects *r*-selection is common. Clearly evolution has favoured both, and while climate, life-span and natural cycles are factors that determine if a group of organisms is either *r*-selected or *k*-selected, other factors like body size and generation time influence selection.

Parental investment in the offspring also varies among animals. Generally speaking, the female parent invests more in its progeny than the male, in most vertebrates. In mammals for example, pregnancy and lactation are huge investments. This is related to sexual selection. Trivers argues that where one sex invests more than the other, members of the sex which invest less will compete among themselves to mate with members of the other sex which invest more. Competition between males for access to females should be stronger, and traits favouring this competition, like weapon development, body size, fighting skills, should be better developed in the males. But this is not always the case. In monogamous animals, the number of offspring of the male is the same as the number his mate can produce, and the sex differences in breeding competition are minimal and intrasexual competition is reduced. Trivers cites the recent studies on birds and primates to emphasize his point. Conversely, in polyandrous species, one would expect strong breeding competition among females and the usual sex differences to be reversed. While this is generally so, not all species where females are larger are polyandrous. Clearly, other mechanisms should be operative to account for these sex differences.

The evolution of monogamy, polyandry and polygyny is extremely interesting, particularly in birds and mammals, and is related to parental investment, not only preparatory to mating but also to bring the offspring to maturity. Both G. H. Orians and Maynard Smith discuss this. It is interesting that polyandry is rare compared with polygyny. There is no known case of polyandry among mammals and it is extremely rare in birds. It would appear, wherever polygyny occurs in birds, it is to be advantage of the female to breed polygynously in spite of her heavy investment.

The final section of the book contains observations on the comparative behavior of three sets of animals: The ants by E. O. Wilson, the birds by D. Lack and the primates by Clutton-Brock and Harvey. Wilson draws attention to the enormous potential in the study of ants, pre-eminent among eusocial animals. His account of *Myrmecia*, *Eciton* and several others is of absorbing interest but fails to provide an explanation for the observed differences among them. Lack's interpretation of the adaptive significance of pair-bonding in birds and its relation to diet is more convincing if not conclusive. Finally the extensive review provided by Clutton-Brock and Harvey of the relationship between the social organization of primates and their ecology brings our knowledge up-to-date on these animals. That aggression is minimal both during periods of high as well as of low food abundance but is most common during periods of intermediate food availability is interesting. Several parameters like body weight of the individual, group size, population density, sexual dimorphism, reproductive strategies, are discussed but emphasis is made on the necessity for investigations of quantitative relationship between the several variables. A common failing in reviews of social systems is to draw conclusions based on selected examples. Associations are often misinterpreted as causes, resulting in a misreading of the relationship between ecology and behavior.

Mind, Brain and Behavior

Where, in all this discussion, does the mind figure? Neither Wilson's book nor the present one makes specific reference to it. The extensive index of *Sociobiology* or the more modest one of *Readings* does not list mind. C. H. Waddington reproved in his review of Wilson's book (New York Review of Books, August 7, 1975) the absence in it of mentality, purpose, goal, aim or any other. The 13 authors of the *Readings* do not mention the mind or the brain. Trivers comes closest to them in his paper on reciprocal altruism. Even here, it is more implied than expressed when he discusses his model of the drowning man and his rescuer.

Why is this reluctance to involve the mind in a discussion of behavior in general and social behavior in particular? One reason could be, Wilson (and the others) were actuated by a 'supercaution' against being in the company, even briefly, of 'ferocious philosophers'. Even if this were so with the mind, surely the brain was not forbidden area. The roles of the reptilian, palaeomammalian and neocortical components of the mammalian brain are now abundantly clear and in any discussion of the social behavior of a higher vertebrate the respective contributions of these three brain components as well as the forces that influence and modify them are important. Instinctual functions such as hunting, homing, breeding, choosing a leader and so on are highly relevant aspects of social behavior and are believed to be determined by the reptilian brain—the brain stem, the reticular system, midbrain and the basal ganglia. The effective states of aggressiveness, anger, fear and the emotions are expressions of the limbic and associated systems of the early mammalian brain. The neocortex which attains its greatest development in the brain of man accounts for his culture through language, a unique type of cognitive activity in man, adding new dimensions to his behavior. The neocortex looks to the future and is the brain of anticipation, of prediction, capable of extension of time both backward and forward. Most importantly, it is the brain of self-awareness and has endowed man with creativity which makes his society so distinctive.

No discussion of sociobiology can afford to ignore the involvement of these brain components. It is futile and purposeless to talk of behavior, either of man or of a higher vertebrate without an adequate appreciation of the brain and its evolution. Recent work of neuroscientists has yielded valuable results and the student of behavior who fails to take cognizance of them works in isolation. More recently, split-brain studies have shown that the two cerebral hemispheres of man—the left and the right—are concerned with different areas of his functioning. It seems appropriate, indeed inescapable, that concerted efforts be made by biologists, neuroscientists, geneticists and sociologists to understand human behavior.

THE NEW SYNTHESIS

Nor need biologists 'run scared' of philosophers. Behavioral scientists can no longer escape the involvement of 'purposive action'. The mind should now be accepted as worthy of inquiry by scientific methods (in addition to other methods) and Consciousness has acquired repute and dignity. Perhaps it will do biology a world of good by stepping out a bit to see what the other non-scientific disciplines are doing to better understand man and the human condition. In this context, eastern philosophies have a great deal to offer. '*The New Synthesis*', to be really new and truly a synthesis, should integrate not only biology and sociology; but it should also explore possibilities of identifying areas outside the natural sciences which help in a fuller and more complete understanding of man.

POTENTIAL ENERGY CURVES AND DISSOCIATION ENERGIES OF HYDRIDES, DEUTRIDES, OXIDES AND FLUORIDES OF SOME RARE-EARTH ELEMENTS

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ABSTRACT

The potential energy curve in different electronic states of LuF, YbF, HoF, TbF, LuH, YbH, LuD, YbD, LuO and PrO have been calculated using RKR method. The dissociation energy of these molecules in their ground state has also been calculated using an empirical electronegativity potential function. The dissociation energy thus obtained has been compared with the other values reported in literature.

1. INTRODUCTION

A KNOWLEDGE of the variation of potential energy of a diatomic molecule with internuclear distance is of fundamental importance in a wide variety of physical problems arising in astrophysics, gas kinetics, chemical reactions, molecular spectra, etc. This widespread applicability has resulted in a very extensive program of obtaining reliable potential energy curves for different electronic states of diatomic molecules. One of the most widely employed and reliable procedures is to make use of the observed energy levels to obtain the classical turning points by a procedure first suggested by Rydberg[23] and by Klein[14]. Their graphical procedure was changed into an analytical procedure by Rees[21] and later by Vanderslice *et al.* [28]. In the present note we give classical turning points for a number of different electronic states of several diatomic molecules containing rare-earth atoms.

Such studies have been sadly lacking in spite of the importance of rare-earth molecules in a variety of technical applications. Spectroscopic data about the deutrides, hydrides, oxides and fluorides of some of the rare-earth elements have recently become available making such study possible. We have also compared the actual potential energy curve with an empirical function suggested by Szoke and Baitz[27] to fix the dissociation energies of the molecules under considerations.

2. METHOD OF CALCULATIONS

The true potential energy curve has been calcuated using the RKR method which is in reality a W.K.B. procedure where one starts with the known energy levels and finds out the classical turning points. The classical turning points r_{min} and r_{max} are given by

$$r_{min} = \left(\frac{f}{g} + f^2\right)^{1/2} - f$$

$$r_{max} = \left(\frac{f}{g} + f^2\right)^{1/2} + f \qquad (1)$$

where

$$f = \left(\frac{h}{8\pi^2 c\mu\omega e xe}\right)^{1/2} \cdot \ln\left[\frac{(\omega e^2 - 4\omega e xe\, U)^{1/2}}{\omega e - (4\omega e xe\, U)^{1/2}}\right] \qquad (2)$$

$$g = \left(\frac{2\pi^2 \mu c}{h\,(\omega e xe)^3}\right)^{1/2} \Big[a_e\, (4\omega e xe\, U)^{1/2} + (2\omega e xe\, Be - a_e\, \omega e) \ln\left[\frac{(\omega e^2 - 4\omega e xe\, U)^{1/2}}{\omega e - (4\omega e xe\, U)^{1/2}}\right]\Big] \qquad (3)$$

The term U denotes the total energy of vibrational levels and other symbols have their usual spectroscopic meaning. Since in the case of these molecules the rotational vibrational constants of only a few vibrational levels are known, we have used the RKR method where ωe, $\omega e xe$, Be and a_e are taken to be the same for all vibrational levels.

The true potential energy curves for 31 states, *viz.*, $X^1\Sigma$, $A^1\Sigma$, $B^1\Pi$, $E^1\Pi$ and $F^1\Sigma$ states of LuF (Effantin *et al.*[7], X and A states of HoF (Robbins and Barrow[22]; Zmbov and Margrave[29]); $X^2\Sigma$ and $A^2\Pi_{3/2}$ states