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From Mice to Men

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Nearly two years ago Dr. Elliott asked me to present a paper before The College of Physicians of Philadelphia. At that time it was my intent to prepare an overview of our studies of populations of house mice in structured environments. During the delays attendant to our selecting a mutually acceptable date, I was asked to participate in a symposium titled "Man in His Place," organized by the Royal Society of Medicine. There I gave a paper, "Death Squared: The Rapid Growth and Demise of a Mouse Population" (19), originally intended for presentation here. Some aspects of this phenomenon will be discussed here. However, at this London meeting a comment was made which serves as the point of departure for my comments tonight. At the close of my Royal Society of Medicine paper a member of the audience asked if I would comment on the possible implications for the human scene of the insights I had gained from studying societies of mice. Professor J. Z. Young, the well-known comparative anatomist, chaired this session. He remarked that I should be very cautious about making any extrapolations from mice to men. This remark, coming as it did from a comparative biologist, troubled me considerably. We all recognize that mice, rats, dogs, monkeys and men are different types of creatures, each with its own species-specific characteristics. And yet we equally recognize that all are mammals, by which commonality of heritage they share many close similarities in anatomy and physiology. At these two levels of organization, progress in biomedical science assumes sufficient correspondence between form and function from lower mammals to man as to warrant fairly direct transfer of principles, subject to remaining alert to possible slight species-specific expression when insights derived from animals are applied to man.

A very contemporary statement of this attitude appeared in the NIH Record (March 27, 1973, page 8):

> A new study of triple-drug therapy for systemic lupus erythematosus, SLE, an inflammatory disease of connective tissue, is being initiated on the basis of animal investigations at the National Institut of Arthritis, Metabolism, and Digestive Diseases and at Walter Reed Army Medical Center. . . . the researchers believe that evaluation of similar treatment in human SLE patients may be warranted.
>
> Because the hereditary SLE-like syndrome of NZB/W mice is an excellent model for human SLE, these studies may provide the experimental rationale for undertaking controlled clinical trials of combination immunosuppressive drug therapy in human SLE nephritis.

A reference (1) more pertinent to the issue being explored here is titled "Experimentally induced gastric lesions. Results and implications of studies in animals." This review points out that the incidence of gastric ulcers in rats and monkeys is influenced by psychological stress and states of fear accompanying differential handling by the experimenters, demand for avoidance learning, or modifications of social communication resulting from crowding. This review carries the clear implication that

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comparable changes in psychological processes or patterns of social living on the human level may be expected to influence the incidence of gastric ulcers. That is to say, current opinion holds that animal studies are useful in understanding human pathologies even on the psychosomatic level.

The above reference contains the word "lesions." It is a word so commonly used by the medical profession that among its practitioners it is often assumed that "lesion" only applies to some major damage to the structure or function of an organ. Although this usage may be traced back to Galen and earlier, it was so used earlier as a special example of the broader meaning of disruption of any function or structure including physical property, social relations and moral fiber (2). Lesion in some of these latter senses is codified in Scottish law. Current restriction of usage of lesion mostly to its biomedical sense reflects a semantic myopia produced by science that inhibits us from either viewing aberrations in the sociocultural system as pathologies, or of profiting more fully from experiences gained from the study of societies of lower animals. We are still weighted down by the heritage of Descartes' dualism of mind and body. We are prone to accept the similarities of body, of structure and physiological function, shared by man and other animals, but hold out for a human uniqueness of mind, that is to say, awareness and consciousness. That we are beginning to recognize the universality of mind, in mammals at least, is reflected in the article by Harry Harlow and his associates titled "Monkey psychiatrists" (3). Principles of behavior therapy appropriate to ameliorating the impact of early deprivation of social experience have applicability to both men and monkeys. And yet our linguistic heritage, imbued as it is with considerations of human uniqueness, inhibits our profiting from animal studies. Consider the word "personality." By historical usage it is restricted to the human species-specific assembly of attributes of mood, emotion, attitudes and states of action or being. Many of the attributes which we include in human personality, such as fear, aggressiveness, passivity, emotional arousal, possessiveness, protectiveness, etc., are also recognized among a wide range of animals. We are left with such terms as "animality" and "bestiality" to refer to the character of animals other than man. And the term bestiality carries the connotation of brutality as the dichotomous distinction of all animals other than man from his quality of humanity. Without resolving this linguistic dilemma, the Smithsonian Institution's symposium, "Man and Beast: Comparative Social Behavior," goes a long way, intellectually, to clarifying the degree to which man and other animals share attributes (4). If the word "personality" is to be reserved solely for human species-specific attributes, then a perfectly rational approach demands that we eliminate from personality all aspects of every attribute which has comparable expression in any other animal. This might be a good exercise; we would find out how unique man really is. Following this logic we would be driven to the nearly absurd position of speaking of dogality, catality, ratality, etc. to give each kind of organism its species-specific dues. As we begin to break our historical intellectual bonds, I believe that we will profit more by relinquishing some of our anthropocentrisms and intentionally utilize such words as personality in a broader sense, as some authors have already had the temerity to do (5).

Concepts, which at one stage of our intellectual evolution as a species prove

profitable to separate, often become a block, or mental lesion, to further development if the dichotomies remain unbridged. Lancelot Whyte (6), in discussing the origin of the Freudian concept of the unconscious, dwells at some length on the origin of Descartes' methodology of separating mind from body, and the later impact of this dichotomy on Descartes. The vision of this new truth came to Descartes in a series of dreams of sufficient strength to serve as an imprinting experience that fixated his whole pattern of life thereafter. Of the "lonely self-awareness" resulting from this experience Whyte says:

> But his life story proves that there remained an intense nervousness, a disquieting sense of insecurity, producing an impression of insincerity, as we may easily understand. Descartes' conscious clarity was partial, and rested on a treacherous dissociation. One may suspect that all static concepts, just as they neglect process, may produce in those who surrender their minds to them an uncomfortable lesion.

Here Whyte is using lesion as a disturbance of mind very much in the same vein of its earlier usage as some disruption or damage to moral fiber. Our historical bias of considering any attribute characteristic of man as uniquely human, and therefore not applicable to any other animals, represents such a mental lesion. We have taken the position of assuming that each other species is guilty, i.e., is not capable of expressing the attribute, until proven innocent in the sense of scientific verification of comparability. I believe that it would prove stimulating to research endeavor to accept the legal doctrine of innocence until proven guilty. That is to say, the burden of proof should always be on demonstrating differences. Until that is done any principle or process revealed to hold for one species should be assumed to be universally applicable to all species. As an example of the trap we can get into by assuming guilt, let me take a statement by the biological philosopher, Marston Bates, and follow it with an observation made during some studies using a strain of domesticated rats as subjects. In attempting to clarify the bases of similarity and differences between man and other animals Bates (7) says:

> Man has retained his animal constitution which forms, however distantly a background for his actions; but his actions are more than those of just an animal. Nutrition and reproduction, for instance, are universal biological drives found in all organisms. Yet food behavior in man cannot be understood in purely biological terms. What one eats, when one eats, how one eats, with whom one eats will vary from culture to culture and are clearly learned patterns of behavior. . . .The hunger drive may be thwarted by fasting, for cultural reasons, and sometimes men will die rather than eat food they believe unfit.

In essence he says that man is unique in developing values that markedly influence his social and other behaviors, and that these learned patterns of behavior can become strong enough to lead to death of some individuals who hold them. By implication he says that lower animals can not develop such strong learned values.

We developed an instrument that could teach rats either positive or negative cooperation. It consisted of two parallel and adjacent wire channels. A lever was located at the end of each channel. Depending upon whether the lever was locked or unlocked, a rat could obtain a drop of water if it pressed the lever. For any group of rats one of two possible conditions had to be met for the levers to be unlocked. The first demanded that a rat be positioned in front of the lever in each channel. With two

rats so positioned the lever in front of each rat was unlocked, and thus each could get a drop of water each time the lever was pressed. This condition requiring positive cooperation was termed COOP for cooperation. When there was only one rat present under this condition its lever remained locked until a companion joined him. Rats learned this requirement with great precision. In the full-fledged expression of this cooperative behavior one rat would go to the instrument, stand in front of one channel and wait for a companion to come and stand in front of the other channel. Then they would both enter the channels simultaneously. The second condition demanded that only one rat be present in the instrument for the lever on its side to unlock. If another rat came into the opposite channel, both levers would lock, and thus neither rat could obtain water. This condition we called DISOP for disoperation, a kind of negative cooperation in which the rats learned to cooperate in the sense of not interfering with another. Rats subjected to this condition learn it very well.

Rats in these studies were maintained in small pens, 2.5 × 5 feet, surrounded by two foot high partitions topped with an electrified wire to prevent rats in one pen from going over into an adjoining one. Usually this precaution was quite effective in preventing adjoining groups from intermixing. During one set of studies two groups of 16 rats were housed in adjoining pens. One was on COOP and one DISOP. At this group size all rats on the COOP condition procured sufficient water. However, since it took twice as much time each day of instrument use for the rats on DISOP to meet their water requirements, the members of this group occasionally experienced intermittent episodes of mild deprivation. One member learned to climb up on top of the water reservoir in its pen and jump over the electrified fence to the top of the reservoir in the COOP pen. Once in this pen the chances were much greater than in his home pen that no other rats would be at the drinking instrument. Shortly after the DISOP rat entered one channel, the cooperative altruistic value ingrained into the COOP rats dictated that one of them would come over and join the invader. Although the presence of the COOP rat enabled the DISOP rat to obtain water, the very presence of another rat beside the DISOP rat became disturbing to him. His learned value dictated that drinking should be pursued in solitude. He would shortly back out of his channel, grasp the offending COOP rat by the rear, tail, or hind feet and pull him out. This behavior sequence persisted for many days until half the COOP rats died from wounds and I felt constrained to terminate the lives of the remainder because of their extreme wounding. In all this process the COOP rats never fought back, despite the pain inflicted upon them. To them the DISOP rat was always behaving correctly.

Judged strictly by the observed behavior, the COOP rats had learned an altruistic value including a taboo against aggression toward associates whose basic behavior met the requirements of the setting. In the natural ecological setting of the wild species from which this strain had been derived, the probability of encountering a situation requiring the development of such a value system is extremely small. One might counter this example by saying that the species did not generate the condition which generated the value, whereas many of the values held by man have arisen directly out of human endeavor. Although this latter may be true for the species as a whole, in so far as any maturing individual is concerned, the settings and opportunities encountered are in effect

imposed by an outside force beyond our consciousness. Left to our own devices, that is, to a dependency on our hereditary constitution alone, few of us indeed could manage to match the complexities of values and behavior characterizing our pre-cultural ancestors, those simple hunter-gatherers of fifty millenia ago—a time at which our genetic constitution likely differed little from that which we possess today. The point here is that all animals possess preadaptations for coping with situations never experienced during the prior history of the species. We certainly would not expect any species of mammal to surmount all of its neural limitations and biases and differences of capacity for responding and behave exactly like man in settings which simulate those of human experience. However, this study of DISOP and COOP rats alone points up the feasibility of conducting studies with lower mammals that give promise of gaining additional understanding of phenomena thought by many to be unique to man. The study mentioned here has been presented in more detail elsewhere (8, 9).

Our willingness to extrapolate to man insights gained from studies with other animals on the body-physiology level, coupled with greater reluctance with regard to making similar extrapolations at the mind-behavior, particularly social behavior, level presents the possibility of our getting into a real trap if this myopic mental lesion persists. As an example of such a trap possibly developing, I wish to take the case of vitamin A. It is well recognized that an adequate intake of vitamin A is necessary to prevent night blindness and other hypovitaminosis A pathologies (10). In humans a daily intake of 2500 international units (i.u.) is adequate to prevent the hypovitaminosis A pathologies. In many parts of the world the minimum daily requirement has been given at 3750 to 5000 i.u. as a precaution to cover possible genetic variability in requirements. Most recognized hypervitaminosis A pathologies, mainly anatomical or physiological, do not appear until after sustained daily intakes in excess of 50,000 i.u. There is probably no other field of biomedical research where insights about a natural element of diet has relied more on research with rats. It is to be noted, however, that the rat subjects used have universally been housed within the confines of small cages that preclude expression of social and other behaviors of which the species is capable of in the natural ecological setting. Under these restricted conditions, the results of many investigators led to the conclusion that moderate elevation of vitamin A intake increased body growth and reproductive success. As a consequence commercial producers of laboratory animal foods increased the vitamin A content of their products. In a series of studies I engaged in concerning social behavior and population dynamics of rats in large structured habitats (11), the diet contained four times the normal level of 3 i.u. of vitamin A per gram of diet. At the time I was unaware of the increase to 12 i.u. per gram of diet, but during the course of the studies, I noted certain physiological pathologies that suggested something wrong with vitamin A metabolism. As a consequence the studies were repeated utilizing a synthetic diet (12) in which only vitamin A was varied. One diet contained 3 i.u. of vitamin A per gram of diet and the other 12 i.u.

The general character of these studies has been presented elsewhere (13). For the present purposes it suffices to note that the population was initiated with a group of rats born in the setting to introduced near-term females. The young of these females slightly exceeded in number what I suspected was the ideal

number of rats for this setting. They were designated as Tier 1. Later two other tiers of equal number, Tier 2 and Tier 3, were allowed to survive as young born to prior tiers. Tier 3 was born when conditions had become particularly stressful from crowding. Table 1, based on data in prior publications (8, 9, 14), summarizes the main points bearing on the question of pathologies arising from moderate elevation of vitamin A intake by rats.

By nearly seventeen months of age considerable vitamin A was stored in the livers of rats on both diets, but 31% more had been stored by those on the higher vitamin A diet. Rats on this higher dosage diet engaged in much less intense aggressive acts as indicated by reduction in amount of wounding. This reduction in aggression by elevation of vitamin A in the diet is particularly indicated by the even greater reduction of wounds on the lumbar-sacral region. In status interactions the loser often is bitten on the rear as it turns and flees. The lesser amount of scar tissue developing on this region of the body also indicates a reduction of aggressiveness associated with the higher vitamin A diet. At first sight one might consider reduction in aggression as a positive asset to increasing vitamin A intake. However, other measures were taken that threw an entirely different light on the situation. Observations were made of the frequency of each rat being active in those regions of the habitat where social interactions more often took place. This measure of activity was called "social velocity," or just shortened to "velocity." As group size increases the average velocity decreases. That is to say, crowding suppresses degree of social activity. Since the velocity of rats on the higher vitamin A diet was greater than that for those on the lower vitamin A diet, it appeared that in some way vitamin A protected the rats from the effects of crowding. This, too, seemed at first to be a positive consequence of elevating the vitamin A content of the diet. However, at comparable levels of velocity the 12 i.u. rats engaged in 30 percent fewer social interactions; they became less involved socially. As a final test a number of males on each diet were removed for a week at a time and placed alone in apparatuses which recorded the start and stop times of several behavioral states, essentially the entire repertoire possible in the restricted test situation. Rats on the higher vitamin A diet engaged in thirty percent more episodes of behavior per day. This meant that their behavior had become more fragmented than those on the normal diet, and thus were less capable of executing longer sequence, more complex behaviors. These same rats also exhibited deficits in selecting appropriate sex partners. We finally concluded that an elevation of vitamin A intake to four times the normal level impedes the capacity to perceive complex gestalts and to execute complex behaviors. For this reason the rats on the higher vitamin A diet were sufficiently out of social contact to buffer them from the stresses of crowding.

The data for females is less in scope, but much more dramatic. During the formation of the third tier, nest boxes were opened more frequently than usual in order to determine which females were the mothers of particular litters. Such disturbance by the investigator aggravated behavioral aberrations already present from crowding. Both contributed to a reduction in effective maternal behavior. With sufficient interference with maternal behavior the young are not reared to weaning. Considering all litters, females on the higher vitamin A diet exhibited a 55 percent decrease in ability to rear young to

weaning. For litters disturbed when the young are very immature, before three days of age, this loss of maternality was 85 percent more for females on the 12 i.u. diet. When both sexes are involved directly in a particular act, such as that leading to conception, the deficit exhibited by rats on the higher vitamin A diet is even more dramatic. In uncrowded situations conception rarely occurs before 80 days of age. Thus the frequency of earlier conceptions can be construed as an indication of some upset in normal behavior. It may be noted that the 12 i.u. females exhibited a 189% increase in these earlier conceptions. The question here is not whether females can or cannot conceive from a physiological point of view, but whether they should. Under the complexities of living in a complex physical and social environment female rats do not achieve 50% of maternal adequacy until after 210 days of age. Thus evolution has led to timing of behavioral development such that intercourse is normally delayed until related environmental learning has begun to unfold more adequately. This complex behavioral development has evolved with the rats exposed to a diet close to the 3. i.u. of vitamin A per gram of diet level. I can only conclude that an increase in vitamin A in the diet to four times the normal level alters the neurophysiology to a point that it is not in harmony with life in a complex socio-environmental setting.

Regarding these studies I wrote in 1967 (8):

> If this increased intake of vitamin A has effects on the behavior of humans comparable to those on the behavior of rats, we may anticipate some very bizarre alterations in the fabric of social relations as an increasingly larger proportion of the adult population becomes characterized by high circulating levels of vitamin A. At this early state of experimental research and with little known about the effect of vitamin A on human behavior, it is extremely hazardous to make projections. I merely wish to point out that when a chemical compound can produce changes such as vitamin A apparently does in rats, we can slowly set an ecological trap of such magnitude that, once caught, society might experience extreme difficulty in extricating itself.

Recently, for reasons I am not familiar with, the Food and Drug Administration has begun to alter regulations in a way that will make it more difficult for human individuals to procure, or be exposed to taking in more than 10,000 i.u. per day in excess of that in natural foods. For man 10,000 i.u. of vitamin A per day is approximately equivalent to 12 i.u. per gram of diet for rats. Professor Linus Pauling has recently (15) argued for permitting everyone the opportunity to increase his daily intake to 25,000 i.u., that is, to ten times that known to be physiologically necessary. In making this recent statement, Professor Pauling said that he knew of no known data that indicated that such dosages were in any way deleterious. I can only remark that in response to an inquiry from him all of the details of the studies cited above on rats, including that which has just now reached press (9), had been made available to him. In any case, we might briefly consider his theory of "ortho-molecular psychiatry" (16). During evolution each species developes more and more elaborate biochemical machinery to process more effectively each substance that it obtains in its natural diet, or as a breakdown of it. There is some average rate of acquisition of each substance. In general, evolution of more complex biochemical machinery ceases at about 91% of maximum efficiency since each successive slight increase in efficiency requires ever larger increments in complexity of the added biochemical capacity. When a mutation occurs that blocks the normal transformation of

some substance, individuals of the species may be kept alive despite these inborn errors of metabolism provided sufficient quantities of the missing substance is provided. Depending on how one measures the metabolic rate, for example growth rate, as dosage of the missing substance is increased a curve such as shown in Figure 1 results. Increasing the dosage sufficiently permits metabolism to exceed that of the 91% of the maximum which characterizes the normal organism.

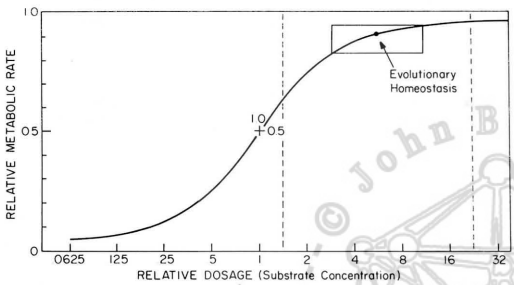

Fig. 1. Generalized curve of the impact of substrate concentration on metabolic rate. According to Linus Pauling evolutionary homeostasis is reached at a substrate concentration permitting about 91% efficiency of metabolism. Normal metabolism holds within a range of one half to two times the substrate concentration producing 91% metabolic efficiency. Extreme pathologies, physiological, psychological, or behavioral presumably follow any decrement of substrate below one fourth normal or above four times normal.

Dr. Pauling's thesis is that we can assist the organism to achieve maximum efficiency by providing even the normal organisms with excesses of substrates beyond that normally available to it directly through its diet, or as a by-product of metabolizing substrates in the diet. Furthermore, he maintains that since we can synthesize so many of these required substrates so cheaply, we *should* enable everyone to attain maximum biochemical efficiency. I believe that there is a serious flaw in his thesis, which may be particularly dangerous in the case of vitamin A. As a rough approximation of the natural availability of vitamin A we may take the range of 1250 to 5000 i.u. per day for man and 1.5 to 6.0 i.u. per gram of diet for rats as approximate equivalents for these two species in terms of the conditions under which they evolved. These extremes are noted by the left and right hand sides of the rectangle in Figure 1 depicting the variability about the evolutionary norm of 2500 and 3 i.u. respectively as criteria for the normal metabolic requirements of the two species. By one fourth the normal level, hypovitaminosis pathologies characterize both species. Thus, it seems well grounded that a reduction of substrate availability to one fourth that compatible with the evolutionarily determined normal rate of metabolism produces pathology.

By the same logic we might anticipate some types of pathology to appear when the substrate availability is increased four fold. The fact that major hypervitaminosis A pathologies, particularly those "body" ones of gross changes in physiology and anatomy, generally do not appear until more than ten times the intake of vitamin A above normal, does not invalidate the possible existence of pathologies affecting the "mind" in ways that take longer to detect as the individual through its mind and behavior interacts with its complex environment—an environment normally much more complicated than that of an individual rat or human living out its days in a barren cell. At the present time it must be admitted that this one study of mine, which shows that rats do exhibit marked pathologies of behaviors requiring mediation of mind when vitamin A intake is four times normal, can only be taken as suggestive of possible comparable pathologies on the human level. However, I might add that such pathologies are insidious in the sense that much of the

TABLE I.
Influence of Vitamin A on the Social Behavior of Osborne-Mendel Strain Rats

Item No.	Item Description	Diet		Percentage change by rats on 12 i.u. diet
		3 i.u.	12 i.u.	
1.	Mean i.u. vitamin A/whole liver at 16.5 months of age. Tier I, males + females.	31,631	41,510	+31
2.	Mean i.u. vitamin A/whole liver at 6 to 7 months of age. Tier 3. Males + females.	15,216	20,999	+38
3.	Mean No. of wounds between 9 and 15 months of age. Tiers 1 and 2, males.	21.8	13.7	−37
4.	Mean No. of lumbar-sacral wounds only	11.0	5.0	−55
5.	Mean lumbar-sacral scar tissue index. 10 high velocity and 10 low velocity males. Tiers 1 and 2.	3.75	2.55	−32
6.	Mean social velocity. Tiers 1 and 2 males.	25	34	+37
7.	Relative No. of social status interactions at the same degree of velocity.	100	70	−30
8.	Behavioral states per 24 hours	95	124	+30
9.	Percentage of conceptions before 80 days of age	14.7	42.3	+189
10.	Percentage of young of Tier 3 generation reared to weaning under conditions of severe crowding. Average age at disturbance by investigator circa 10 days	53.8	24.2	−55
11.	As 10, but mother disturbed by investigator when young were 2 or less days of age.	49.5	7.5	−85

outward behavior of affected individuals appears extremely normal. Most complex behaviors and capacities for perception are influenced first. These slight deficits are magnified by the interaction of individuals similarly affected.

In this connection particular attention needs to be called to Item No. 2 in Table I. Third tier (generation) rats were born in a population already marked by severe overcrowding. When the study was terminated, the members of this generation were between six and seven months of age. Although those on the higher vitamin A diet had stored 38% more vitamin A in their livers, rats of Tier 3 on both diets had stored twice as much for their age as would have been anticipated by the rate of storage required to produce the level of storage of the older Tier 1 rats who had matured under less crowded and disturbed conditions. I conclude from this that increase in vitamin A storage is a normal mechanism for protecting the individual against chronically present disturbing social stimuli. At six to seven months of age rats in a normal social setting reach their prime with regard to participation in sexual and social activities. At the termination of the populations in this study, all subjects were autopsied except for four males and four females in the Tier 3 generation. Like most of their companions of this generation they presented an excellent physical appearance unlike the more scarred and scruffy appearance of the older associates of Tiers 1 and 2. That is to say, they had been able, presumably as a result of heightened circulating levels of vitamin A, to avoid becoming embroiled in social conflict despite the crowded conditions. In this now low density situation these Tier 3 rats failed to engage in sufficient sexual activity to culminate in conceptions. In our later studies with mice populations (17, 18, 19) we have called

such physically attractive, but behaviorally inadequate, individuals the "beautiful ones."

The historical conditions leading to the production of "beautiful ones" illustrate another type of animal experimentation, which can provide insights applicable to man and ones that are less easily ascertainable from the natural experiments in which we might be involved. A few mice were introduced into an environment providing resources for a very large population and eliminating most causes of mortality other than from aging. Under these conditions the population grew rapidly, social groups formed with each establishing a portion of the physical space as its domain. Effective playing of social roles was only in the context of social groups. Eventually most desirable physical space was filled with social groups. At that time there were many more well nurtured subadults maturing than normally would be the case with customary mortality factors operating. Rejection of the attempts of these younger mice to enter and participate in the established social groups overtaxed the territorial males to the point that they expressed only minimal, spatially restricted, mild threats. Nursing females then assumed the territorial defense role. Their heightened aggression generalized to their own young. Many of the young were maimed and killed during the first few days of life, suggesting a parallel to the "battered child" syndrome. Females, presumably less disturbed and less aggressive, continued to nurse their young until they became furred and eyes opened, and they began to wander about the nest compartment. Then several days before weaning—a long time in the life of a mouse—mothers attacked their young, often breaking their tails near its juncture with the pelvis. These young then left home prematurely without having developed strong affective bonds with any adult. In the then dense social milieu any attempt at developing an interaction with an associate was mechanically interrupted—an interruption of action cycles—by some other mouse moving between the two. As a consequence of these processes, most of the last generation never learned to relate effectively. Not courting, there was no mating, and with no mating there were no conceptions. Eventually all members of this large population of mice died from old age with no recovery even after the population had greatly declined. Thus the ultimate effect of such a history of overcrowding is to produce individuals incapable of those complex species-specific behaviors necessary for species survival. For mice these most complex behaviors involve the repertoire of courting, mating, and territorial defense. Their loss is reflected in zero fertility. It has been my prediction that a comparable history affecting mankind would indicate its origin in just the opposite—an increase in fertility. The most complex behaviors for the cultural human animal are ideational, the creation and utilization of ideas. Fragmentation of ideation should inhibit the capacity of individuals to comprehend the complex ecological, economic, and social ideas that are essential to motivate couples to limit their family size. That this process is in fact operating has recently been revealed by a detailed study of demographic data for the city of Chicago by Professor O. R. Galle and his colleagues at Vanderbilt (20). They confirmed much of my earlier conclusions with crowding in rats (11, 13). They found that behavioral and physical pathologies did accompany crowding in man. However, they also found that, regardless of ethnicity, socio-economic status or education, fertility went up with crowding.

My last example of the opportunities

for gaining insight into human phenomena based on animal studies involve mice and churches. Consider mice first. Most individuals of most species studied eventually settle down with attachment to a particular home site from which they engage in excursions into surrounding habitats. Traps can be set in the habitat which capture the mice alive. They are then marked, released and recaptured at later times in similar baited traps at other locations. Once a large number of such captures have accumulated it is found that per unit area there are relatively many captures near the home, and ever fewer with increasing distance from it. In other words, density of responses declines with radial distance from home. The exact pattern of decrease conforms to the bivariate normal distribution curve (14). This says that 38% of responses occur within a one sigma radius from home, 86% within a two sigma radius, and 99% within a three sigma radius (Figure 2). When one examines the several species of mice and shrews inhabiting extensive tracts of woodlands, it is observed that different species vary with regard to the size of their home range as so measured. In general species whose members have large home ranges are more recently evolved ones, while those with small ranges generally have a history extending farther back in the paleontological record. After selective removal of individuals with large home ranges, those normally having smaller ranges immediately enlarge their ranges to about the size of those individuals previously removed. Clearly, the more advanced, adaptable species have a capacity to inhibit the normal tendency for ranging of more ancient traditional types.

If these principles characterizing mice and shrews represent a more universal process of the organization of living matter, then their expression should

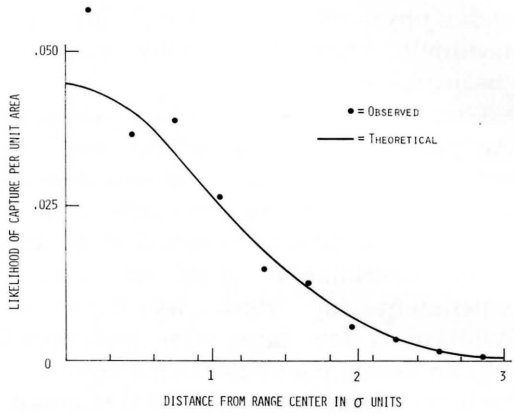

Fig. 2. Home range of mice. One sigma defines the radial distance from the home site within which 38% of the responses to resources occur. 99% of such responses are encompassed within a radial distance of three sigma. (See Ref. 14 for details of the mathematical formulation of home range.)

characterize a quite different level. Then I thought: "Suppose human institutions behave like mice and shrews?" Churches seemed an appropriate type of institution—they have recognized physical home sites, church edifices—from store fronts to cathedrals. If churches are like mice, they must "travel" out into the surrounding habitat and seek resources; sinners will do; to be brought in and saved and convinced to become affiliates of the church. Confirmation that the individual is in fact a resource for the church is represented by the individual departing from the church, going home and then returning to the church on a later occasion. Thus the homes of members of a church represent the place of response by the church. Figure 3 depicts the analysis of such responses by the Warner Memorial Presbyterian Church of Kensington, Maryland. The home range of this church conforms to the same mathematical distribution as that observed for mice. From that point I examined the ranges of Protestant churches for the District of Columbia and suburban Maryland adjoining it.

Without engaging in fine theological distinctions, it is possible to roughly categorize denominations and faiths along a spectrum from liberality (emergent evolutionary adaptation) to orthodoxy (traditional preservation of earlier modes of adaptation). As with mice and shrews it was found that more recently evolved liberal types of churches had larger ranges, drew their members from longer distances. And as with small mammals the somewhat more orthodox, conservative, or traditional churches are more numerous because their ranges are smaller, and having smaller ranges they make more effective use of resources within their range. Extremely orthodox or conservative churches, like species of small mammals that are adapted to specialized niches that permit them to avoid competition with more generalized and widely adapted species, are relatively few in number and spatially isolated from other similar churches.

Obviously there is no one-to-one identity of correspondence between the elements, mice and churches. Yet each kind of element represents an organization of matter with capacity to acquire resources and interact with other elements of their own kind to express isomorphic processes reflecting awareness of and responsiveness to surrounding environment. As with the impact of overcrowding on fertility in mice and man cited above, so here in the case of home range an isomorphic process may operate at both levels of organization, although its complexity of expression is much greater at the higher level involving man. The central thrust of evolution results in an orthogenetic increase in awareness and responsiveness as successively more complex units interact with each other. Understanding a lower level of evolved consciousness and responsiveness can assist in understanding a higher level. The changes through time from one level to another appear to be unidirectional. Whyte (6) remarks: "The search for adequate conceptions of one way changes still continues, and its successful culmination would mark an important step in the rational potentialities of the human brain-mind."

Whyte further remarks: "To postulate the existence of the two separate realms, one of which is characterized by awareness, as Descartes did, may prove one of the fundamental blunders made by the human mind." Progress in remedying this blunder is essential to enabling the biomedical and behavioral sciences to maximize their contribution to human well-being and continued participation in the evolutionary process. It is similarly essential to the more adequate utilization of studies with animals to enhance our understanding of man. Formulations of Meldman (21) and Bertalanffy (22) help to give direction to the resolution of the mind-body dilemma:

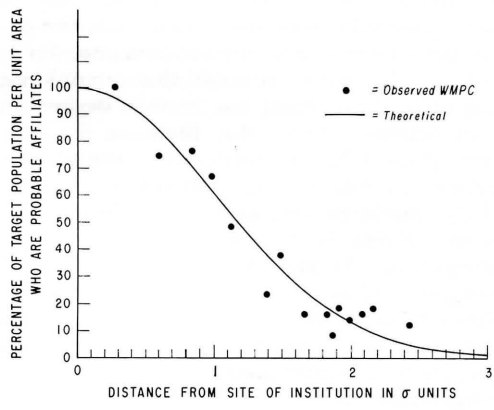

Fig. 3. Home range of a church. Each dot represents the percentage of residents at a given distance from the church who are members of this church.

Meldman:

At the bottom of Descarte's psychology lies his dualism of soul (mind) and body.... It seems to be a severe stumbling block; impeding progress at all levels of behavioral investigation.... The births of psychology with its

methods of investigation, and physiology with its methods of investigation are a direct consequence of the mind-body dichotomy. The attempt at synthesis through psychophysiology is an attempt to repair that which was originally torn apart. . . . The idea that emotions cause bodily disease, rather than both being responsive and subordinate to a commonly shared transcendental variable, is a concrete result of the mind-body dichotomy. . . . As suggested by Bertalanffy, a liberating concept is needed to further transcend and synthesize behavioral events.

The purpose of this communication is to present a concept of attention which may prove useful in resolving the mind-body problem. . . . On the one hand [attention] has been used to refer to processes that determine an organism's degree of alertness or vigilance (how effectively behavior is being controlled by the stimulus field as a whole). This general arousal aspect of attentive activity is mediated by the caudal portion of the ascending reticular activating system and is concerned with quick startle and arousal responses as well as the general transition from sleep to waking. The notion that a stream of consciousness is being replaced by that of a volley of consciousness. . . . On the other hand, the term attention has been applied to the selective process that determines which elements of the stimulus field (including the person) will exert a dominating influence over behavior. . . . The transition from mere awakening and arousal to a state of differential responsiveness, to focusing selectively on a single perceptual mode and focusing attention within that mode, seems anatomically related to reciprocal feed-back actions between the ascending reticular activating system, the nonspecific nuclei of the thalamus and the diffuse thalamo-cortical projection system.

Attention is the scanning process which scans for symbolic representations in the circumspective phase of thinking. . . . Attention . . . controls energy distribution in the initiation and maintenance of motor actions. . . . It is the subject of attention that we focus our attention in order to find a liberating concept capable of freeing us from the confines of the mind-body shackles. This model assumes that attention is of information and energy and transcends all behavioral events while simultaneously responding to all subordinate subspheres in a never-ending reciprocal feed-back. Attention may be abstractly construed for theoretical purposes as a particular kind of information—as a node of coded information in a universal sea of messages. Just as (Nobert) Wiener said: "information is information and not matter or energy," so (Paul D.) MacLean said: "Psyche is information, not matter or energy." To this we add, "Attention is information." . . . Behavioral scientists are engaged in decoding attention in much the same way others are decoding nucleic acids. . . . Attention is thus the synthesis for the mind-body problem."

Bertalanffy:

Without attempting to decide whether there is a true numerical increase [in psychosomatic disease] due to the stress of modern life, or whether we have only become more aware of the problem, there is no question that psychosomatic disease is a medical problem of the first order. "Psychosomatic" is, of course the mind-body problem expressed in medical terms. . . . A second point is what may be called the *methodological helplessness of psychiatry.* That psychiatry wavers between such extremes as drilling a hole in the skull, with insult to the most important system of the body, and the mere pep talk of some forms of psychotherapy is an expression of the deep-seated insecurity prevailing in this field. This is not a question of ignorance which may be overcome by some new discovery tomorrow . . . rather, it seems as if our ways of thinking, or basic concepts and categories are inadequate. A reconsideration of fundamentals is thus imperative—an important part of this is the old problem of body and mind. . . . Inconsistencies and paradoxes in modern psychiatry are largely due to the fact that psychological theory is based on an obsolete belief in the dualism of body and mind. . . . The dualism between material brain and immaterial mind is a conceptualization that has historically developed, and is not the only one possible or necessarily the best one.

We shall have to concede that a monkey or dog sees, feels pain, has certain desires and anticipations. If we do, there is no break somewhere lower on the evolutionary ladder. . . . Two fundamental principles of ethology should be emphasized: the Umwelt of a given species is determined by the latter's organization—in particular, the structure of its receptor and effector organs; and the human Umwelt—the world as we experience it—is only one of countless universes of living beings. . . . As Lorenz has emphasized, neither man nor any other living being would have long survived if its perceptions did not mirror—in whatever distorted way—those features of the universe upon which the life of the species depends.

In the world picture of modern science, no

ultimate reality is claimed for the little billiard balls and an immaterial mind to play with or be affected by them. . . . Rather there is a reality which in exteroceptive experience is observed as a world of things, and in proprioceptive experience as ego. In science, this is described, with respect to certain structural aspects, by physical and psychological theories. . . . Physics and psychology (both taken in a wide sense) are conceptual constructs representing certain aspects of reality. The first consequence is that we have to relinquish so-called reductionism. Both the worlds of physics and of psychology are constructs to bring certain aspects of the experienced universe under the rule of law. . . . We must postulate an *isomorphism* between the constructs of psychology and neurophysiology in order to relate them. . . . Recent theory construction in cybernetics, information theory, general system theory, game and decision theory, etc., elaborate constructs precisely of this kind—constructs that are neither physical nor psychological, but are applicable to both fields.

The fact that 50% or so of hospital populations is psychiatric patients is the most dramatic illustration that something is fundamentally wrong with conventional principles. . . . As a matter of fact, with notions such as emphasis on activity and creativity, self-realization, and the like, psychology has already escaped the fetters of the S-R model and is tending toward new concepts of the kind I tried to indicate. Much is said . . . of existential neurosis arising from . . . the meaningless of life in modern society, a world in which values, purposes, and goals have collapsed. . . . The affliction may be sufficient to provoke suicide. Or in the problem of delinquency . . . it has been said that a new style of crime has appeared—crime not because of need, for material gain, or out of passion, but crime for "thrills." . . . These are disturbances which originate in a breakdown of the value system, loss of goals of life and of spiritual orientation—that is, they come from that third realm, other than matter and mind.

Both physics, including neurophysiology, and psychology, including unconscious processes, are theoretical constructs aimed at explaining, predicting, and controlling observable events; they are connected with the latter only by extensive chains of reasoning. Both are progressively deanthropomorphized, that is, the properties characteristic of human experience and Umwelt are progressively eliminated. What eventually remains are conceptual models and relations serving the purposes of explanation, prediction, and control. This process is far advanced in physics and beginning in psychology.

The classical dualism omitted precisely that realm which is specific to human, as compared to animal behavior and psychology: the field of culture, symbols, values, etc., which are neither "physical" nor "mental," but have their own autonomous laws. Basic as well as clinical psychology must recognize this realm because it is precisely the sphere of specifically human behavior, and new developments in both fields may be expected from a proper acknowledgement of this fact.

Despite his earlier remarks with regard to the fact that other animals share with man the third Umwelt realm of being imbedded in an environmental milieu of objects and processes, Bertalanffy, in his closing statement, falls into the customary anthropocentric trap of considering the total uniqueness of man with regard to his capacity for altering his mental-behavioral template as a result of the historical flow of events of whose flow he is a part. We are all subject to the bias of our own historical experiences that block the expression of both rationality and intuition—Bertalanffy no less than the rest of us. He as a physiologist, lacking the experience of detailed observation of the social life of animals in complex environments extending over consecutive generations, must perforce be myopic to his own logic. Elsewhere (23) he says:

> It is the zoomorphic or rattomorphic fallacy—the expressed or implicit contention that there is no essential difference between rat and man—which makes American psychology so profoundly disturbing. That there is a thing called *human culture* with its myriads of manifestations, and that there is nothing of the sort in pigeons and monkeys, is an observed fact . . . .

Rather, I hold that all organisms, from those with the simplest neural net to man, develop their being out of the interrelationships of the triune realms of

body, mind and environment. Attention as information unites mind and body in harmony with the perceived environmental Umwelt. But this attending is more unconscious than conscious. Most of long term memory storage in man (and presumably in lower animals) is not subject to immediate recall. Much less are we aware of the biochemical processes that mediate awareness or are affected by it. Nor through direct experience can we be cognizant of the nature of the complex ecological and social processes transpiring all about us and affecting each moment of our lives. Even more in darkness remain those animals with lesser capacity for attention than man. Long ago Immanuel Kant (6) recognized this pervading darkness:

> Only we can be indirectly aware that we have a perception, though at the same time we are not directly aware of it. Such perceptions are called *dark*; the others clear.
>
> The field of our sense perceptions and sensations, of which we are not conscious, though we undoubtedly can infer that we possess them, that is, the dark ideas in Man (and so also in animals), is immeasurable. The clear ones in contrast cover infinitely few points which lie open to consciousness; that in fact, on the great map of our spirit only a few points are illuminated: this can lead us to marvel regarding our own nature.

For both man and other animals most of their nature lies in darkness. Within this darkness many similar processes—physiological, mental and environmental—determine what the individual is and may become. Comparative studies encompassing physiology, psychology and ecology, if pursued in an holistic, synergistic manner have the power of shedding light on the degree to which processes operate regardless of the evolutionary level considered. However, if studies with animals other than man are to make an effective contribution to the understanding of man, we must have a good appreciation of the nature of man, as well as the scope of studies on animals that may further elucidate this nature.

ON THE NATURE OF MAN

If studies on animals, beyond those involving just physiology, are to have implications relevant to man, the investigator himself, must gain considerable insight into the nature of man. The following is a collage of comments by authors who have attempted to come to grips with the nature of man. They represent one-half of one percent of a larger collection of such excerpts which I assembled to give me background for my own research with animals (24).

Early Evolution

Hockett, Charles F. and Ascher, Robert (24.01)

We know that long ago, over a long period of time, our own ancestors abandoned the trees for the ground and developed effective machinery for bipedal locomotion. This seems beyond dispute, because the prehominoid primates were aboreal and we ourselves are bipedal ground walkers. But when we ask *why* the change, we must remember that our ancestors of the time were not striving to become human. They were doing what all animals do: trying to stay alive. We shall call (this survival principle) "Romer's Rule," after the paleontologist, A. S. Romer. We phrase the Rule as follows: "The initial survival value of a favorable innovation is conservative, in that it renders possible the maintenance of a traditional way of life in the face of changed circumstances."

Some of the descendents of the protohominoids moved out of the trees and became erect ground-walking bipeds.

Geological evidence suggests that at one or more times during the East African Miocene a climatic change gradually thinned out the vegetation, converting continuous tropical forest into open savannah with scattered clumps of trees. As the trees retreated, some bands of hominoids retreated with them, never abandoning their classical arboreal existence. Other bands were caught in isolated groves of slowly diminishing extent. In due time, those bands whose physique made it possible for their numbers to traverse open country to another grove survived; those that could not, became extinct. Thus, for those bands, the survival value of the prerequisites for safe ground travel was not at all that they could, therefore, begin a new way of life out of the trees, but that, when necessary, they could make their way to a place where the traditional arboreal way of life could be continued. The hominoids that were successful at this included those ancestral to the great apes and to ourselves.

Sometimes the band forced to try to emigrate from a grove would be the total population of that grove. More typically, we suspect, population pressure within a diminishing grove would force bands into competition over its resources, and the less powerful bands would be displaced. Also, when a migrating band managed to reach another grove, it would often happen that the new grove was already occupied, and once again there would be competition. Thus, in the long run, the trees would be held by the more powerful, while the less powerful would repeatedly have to get along as best they could in the fringes of the forest or in open country. Here is a double selective process. The trees went to the more powerful, provided only that they maintained a minimum ability to traverse open country when necessary. Some of these successful ones were ancestral to the great apes of today. Our own ancestors were the failures.

Burton, Arthur (24.02)

In the evolution of man as a species, his upright or vertical stance has been most impressive to biologists and to man himself. There seems to be an evolutionary principle in all biological species, and particularly notable in genus *Homo*, that calls for a reaching out and extension of the organism to wider and wider experience—to more and more environments—to maximal development. In this the ability to stand upright and to comprehend the earth from above must be ranked on a par with the evolvement of a more sensitive nervous system.

The Big Brain

Eiseley, Loren (24.03)

The lost significance of Alfred Russel Wallace lies in this: five years after the publication of the *Origin of Species*, Wallace, passing one step beyond Darwin, perceived that with the emergence of the human brain, man had, to a previously inconceivable degree, passed out of the domain of the particulate evolution of biological organs and had entered upon what we may call history. We, as human beings in whom the power of communication had arisen, were leaving the realm of phylogeny for the realm of history, which was to contain, henceforth, our essential destiny. After two billion years of biological effort, man alone had seemingly evaded the oblique trap of biological specialization. He had done so by the development of a specialized organ—the brain—whose essential purpose was to evade specialization. Pere Teilhard has sought to extend Wallace's insight.

Bruner, Jerome S. (24.04)

What is most unique about man is that his growth as an individual depends upon the history of his species—not upon a history reflected in genes and chromosomes but, rather, reflected in a culture external to man's tissue and wider in scope than is embodied in any one man's competency. Perforce, then, the growth of mind is always growth assisted from the outside.

Huxley, Julian (24.05)

It is to man's higher level of intelligence that he owes his evolutionary dominance. (Note that Huxley says "dominance," not "difference.")

Huxley, Julian (24.06)

During the biological evolution of animals, the upper level of organization of awareness has been steadily raised. This has led to a steady increase in the extent and elaboration of what we may call the animal's significant world, that part of the universe which has meaning for the organism. It utilizes the raw material of its experience and transforms it into characteristic patterns of awareness which then canalize and help to direct its behavior. This I venture to call psychometabolism. About 10 million years ago, purely biological evolution reached a limit, and the breakthrough to new advance was only brought about by further psychometabolic apparatus of mind and brain. This gave rise to man: it endowed him with a second method of heredity based on the transmission of experience, and launched a new phase of evolution operating by cumulative tradition based on ideas and knowledge. In man, organization of awareness became part of the evolutionary process by being incorporated in cultural tradition.

Communication

Dryer, Bernard V. (24.07)

The growth of our civilization over fifty centuries has in large part depended upon man's ability to record his observations, assumptions, thoughts, and personal and social adaptations—called knowledge—and to receive such recordings in word or in writing from others who communicate it to him.

Muller, Herman J. (24.08)

Among the qualities of man most generally valued are a genuine warmth of fellow feeling and a cooperative disposition, a depth and breadth of intellectual capacity, moral courage and integrity, and an appreciation of nature and art, and an aptness of expression and communication. It has been through the exercise of these faculties that man has raised himself to his present estate.

Titchner, James L. (24.09)

Freedom is an inner finding of the self, an expanding recognition of one's choices of ways to be human. It entails an unguarded freedom of communication with others. There is no peace, only an essential human restlessness.

Hinkle, Lawrence E., Jr. (24.10)

Because man is a social animal who accumulates an extensive culture and lives in complex societies, a very significant proportion of the human environment is made up of the people who surround a man, and the society of which he is a member. His interaction with these "social" and "personal" aspects of his environment is fundamentally communicative in nature. In-

formation from this part of his environment, obtained through his sense organs and evaluated in his central nervous system, leads him to display patterns of gross behavior of organ function which may significantly influence the course of his disease, or the circumstances of its occurrence.

Transmission

Etkin, William (24.11)

In the behavior of lower mammals the motivation and the action patterns generally seem as fixed by genetic determination as in lower vertebrates. However, the relation of the stimulus to the activation of the behavior seems generally much more complex and more subject to modification by experience. In culturally determined behavior, as I see it, the manner of expression of a drive as well as the stimuli eliciting such expression are largely determined by social learning, that is, by example furnished by other members of the group. The motivational factor energizing the behavior, however, may still be largely dependent upon genetically determined physiological processes. In this concept, man's motivational organization is basically innate, that is to say he shares with other vertebrates such drives as territory, status, sexuality, socialization, and learning. He differs from lower mammals primarily in that the manner of expressing such motivation is determined by social learning.

Skinner, B. F. (24.12)

In general, the evolution of man has emphasized modifiability rather than the transmission of specific forms of behavior. Inherited verbal responses are fragmentary and trivial. By far the greater part of behavior develops in the individual through processes of conditioning, given a normal biological endowment. Man becomes a social creature only because other men are important parts of his environment. The behavior of a child born into a flourishing society is shaped and maintained by variables, most of which are arranged by other people. These social variables compose the "culture" in which the child lives, and they shape his behavior in conformity with that culture, usually in such a way that he in turn tends to perpetuate it. The emergence of a given form of social behavior from nonsocial antecedents is exemplified by imitation. An inherited repertoire of imitative behavior in man is insignificant, compared with the product of certain powerful contingencies of reinforcement which establish and maintain behaving-as-others-behave. Most social behavior arises from social antecedents. Transmission is more important than social invention.

Educability

Dobzhansky, Theodosius (24.13)

The crucial adaptation in human evolution has been the ability to learn a great variety of ideas and to make a great variety of inventions, not to learn fixed ideas and only a certain invention. It seems to me on the whole more likely that natural selection has established in man a drive toward what Maslow denotes as "self-actualization" and avoided fixation of the means whereby the self-actualization may be achieved. Waddington steers clear of the pitfalls in which previous theories of evolutionary ethics were trapped. He recognizes that natural selection has provided man not with ethics and values but with a capacity to acquire ethics and values. Values are products of human culture,

not of the human genotype. But in order to become an "ethicising being," man must be an "authority acceptor," a receiver of socially transmitted information. The process of evolution has produced a human species capable of entertaining ethical beliefs; the biological function of ethics is to promote human evolution.

Erikson, Erik H. (24.14)

Care is a quality essential for psychosocial evolution, for we are the teaching species. Only man can and must extend his solicitude over the long, parallel, and overlapping childhoods of numerous offspring united in households and communities. Once we have grasped this interlocking of the human lifestages, we understand that adult man is so constituted as to *need to be needed* lest he suffer the mental deformations of self-absorbtion, in which he becomes his own infant and pet.

Hulse, Frederick S. (24.15)

The inborn plasticity of the human phenotype is certainly one of the factors concerned. Our minds, too, are plastic and flexible. They are capable of developing the most diverse preferences, prejudices, and perceptions, all in accordance with the social group within which they are raised and trained. Indeed, educability is probably the most vital aspect of human plasticity, for it is intimately concerned with the development of human culture, and human culture is our true ecological niche. Orthoselection to improve the capacity for culture has been the most outstanding characteristic of human evolution. Variety, in truth, is a mark of mankind's success.

Deutsch, Karl W. (24.16)

Human beings are not "single-game" or "single-purpose" units. They are at the very least "multipurpose" units, and any single-purpose calculation is likely to underestimate seriously their over-all value. (Highest) purposes (are) the preservation of growth of "life," "mind," (and) "order in the universe."

Meaning

Vickers, Geoffry (24.17)

What distinguishes us from the primates whose biology so closely resembles our own is our greater capacity not merely to handle information but to develop the personal and cultural frames of reference which give this information meaning.

Gardner, John W. (24.18)

All that makes us most human—communication, self awareness, sympathy, conscience—is dependent upon interaction with other beings of our own kind. Man is in his very nature a seeker of meanings. He has throughout history shown a compelling need to arrive at conceptions of the universe in terms of which he could regard his own life as meaningful. He seeks conceptions of the universe that give dignity, purpose and sense to his own existence. But, renewal—of societies or of individuals—depends in some measure on motivation, commitment, conviction, the values men live by, the things that give meaning to their lives.

Becker, Ernest (24.19)

To lose self-esteem, to lose a "game," and to lose an object, are inseparable

aspects of the loss of meaning. Meaning is the elaboration of an increasingly intricate ground plan of broad relationships and ramifications. It is the establishment of dependable cause-and-effect sequences which permit ego-mastery and action. Meaning is at the heart of life because it is inseparable from dependable, satisfying action. Man's symbolic life is an imbibing of meaning and a relentless creating of it. This symbolic elaboration of meaning is *Homo sapiens'* "home brew," so to speak, brought by him onto the evolutionary scene and manufactured solely for his use and delight. By means of it, man intoxicates himself into the illusion that his particular meaning fabric, his culture's concoction of symbols and action, is god-given and timeless.

Yarmolinsky, Adam (24.20)

A movement that focuses on moral goals, no matter how noble, without addressing itself to the institutional means to achieve these goals, reflects neither a meaningful commitment to morality nor a practical hope of improving the human condition.

Ethics

Erikson, Erik H. (24.21)

The moral sense, in its perfections and its perversions, has been an intrinsic part of man's evolution, while the sense of ideological rejuvenation has pervaded his revolutions, both with prophetic idealism and with destructive fanaticism.

Simpson, George Gaylord (24.22)

In the evolutionary context, the problem really becomes one of why organic evolution produced an animal capable of cultural evolution and of the ethicizing that helps to mediate cultural progress. There is no real doubt that the capacity, or, one can say, the necessity for ethicizing is in fact a *biological* characteristic of the human species developed by natural selection because it is adaptive for that species. In general biological but nontechnical terms, the direction of human adaptation early became one depending on individual flexibility with mainly learned abilities, with alternatives of action and necessary choices among them, with foresight as to the results of action, and with consequent responsibility for those actions. This kind of adaptation has always been carried out in a cooperative social milieu. It follows inevitably that men must and do learn, both from their fellows (parents, elders, priests, etc.) and from their own experience and introspection, to consider some actions "right" and some "wrong."

Huxley provides criteria for improvement by exemplifying it, notably as "evolution towards greater capacity for feeling, knowing, willing and understanding." However, this concept of improvement, and of evolutionary progress is strictly *ad hoc.* Among all the millions of living species, it is fully relevant to only one: *Homo sapiens.* It may also apply in part and with rapid dilution to a few of man's closer or more distant relatives among the higher vertebrates. It is not a general tendency in evolution, but a tendency limited to a very small minority of evolving organisms and fairly continual in late phases of the ancestry of a single one only. An ethic so derived is not based on the nature of evolution but on the nature of man. A workable naturalistic ethics is derivable not from the evolutionary process in general, but from the evolutionary status of man in particular.

Fulfillment

Thompson, Laura (24.23)

Mankind, through its propensities to create and evolve cultures and micro-races, is unique as earth's only organic species endowed with the power to develop its own potentials for freedom. This may be accomplished by means of community processes whereby each human group so builds its culture, within the limitations of its organic heritage and its existential situation, into institutions, behavior patterns, attitudes, and values, to afford its members opportunities for optimum self-fulfillment as human organisms.

Becker, Ernest (24.24)

For man, the esthetic object is the consummatory object; contemplation of the esthetic object draws the multiple fragmentations of felt experience into one fused whole. The esthetic object embodies, in one moment for all to see, the vision that fulfillment is possible.

Entering into the World-Environment Process

Crow, James F. (24.25)

Man is unique in that most changes in the environment are of his own doing.

Weatheral, R. (24.26)

"It is the great prerogative of Mankind above other Creatures, that we have also the power of considering, comparing, altering, assisting, and improving them" (*i.e.* the "marks of Nature") "to various uses." Thus did Robert Hooke open the Preface to his Micrographia, published in 1665.

Lee, Douglas H. K. (24.27)

The very gift which lifts him above the subhuman forms, the ability to operate upon instead of merely adjusting to his environment, contains the seeds of its own destruction.

Cowan, Ian McTaggart (24.28)

It is the unique revelation of man that he is not only consciously sensitive to his own environment, but also relates himself to much larger and more complex processes in which he plays a part. His image of the world then becomes an important element in the process of the world itself.

Boulding, Kenneth E. (24.29)

The manifest processes are those in which the awareness of the process itself—that is the image of the nature of society and the social processes in the minds of men—plays a significant role. With man comes self awareness and awareness of a whole system in which the self is imbedded. Therefore, the image of the world possessed by its human participants is a vital element in the overall dynamics of the system. We cannot tell what the system will do unless we know what the people in it think of it, for what they think affects their behavior and their behavior affects the system.

Dobzhansky, Theodosius (24.30)

Man is not the center of the universe physically, but he may be the spiritual center. Man and man alone knows that the world evolves and that he evolves with it. By changing what he knows about the world man changes the world that he knows: and by changing the

world in which he lives man changes himself. Changes may be deleterious or improvements; the hope lies in the possibility that changes resulting from knowledge may also be directed by knowledge.

Threat

Steiger, William A. (24.31)

Science's great accomplishment has been the utilization of the conceptual separation of body and soul, object and subject, a separatism which cannot be made in reality. This conceptual separation allows man to be viewed as any object, and thus to be weighed, measured, dissected and analyzed. For example, the performance of a blood sugar in a patient is not basically different from measuring the carbon content of a piece of steel. Now, unfortunately, this view of man as an object has become more than a method of study, it has become man's view of man. Thus automation replaces one thing, man, with another, a machine; tranquilizers arise from the concept that man is a physico-chemical machine.

Becker, Ernest (24.32)

The individual needs a feeling of primary value, and the experience of the exercise of his powers. We know further that when he does not have them, he tends to withdraw into his own fantasy world. Periods of being cut off from the external world deprive the individual of the ability and the desire to cope with it.

Boulding, Kenneth E. (24.33)

One sees a distant trap—the trap of inanition. Man is a profoundly problem-solving animal. He reacts best to situations of challenge and difficulty. If he succeeds in solving the problems which now so thoroughly possess him, will he not in the very moment of his success die of sheer boredom?

The Future Seeker

Wagar, W. Warran (24.34)

Man by nature is a prophesying animal. "Farther than any other creature, man lives in the future; the effectiveness of his living depends on the sagacity of his forecast." (Hocking, The Coming World Civilization)

Becker, Ernest (24.35)

An animal with distance receptors like sight and memory has much greater spans to bridge in order to bring itself into satisfied contact with the world. On the human level the task of attaining satisfaction is prodigious. The ordinary separation of subject and object is pushed to a point of extreme complexity. Man is presented with a whole new range of integrative problems: time, space, identity, anticipation, hope, belief. For a symbolic animal integration is immensely complicated. The use of symbols in coping with the world magnifies the problem of a straining organism. Dualisms are felt in several areas. There is a difference between the private motive and the social motive; the "inner pole" of the self and the "outer pole" are not congruent. We may feel either hopelessly separated from the social—as in loneliness; or, we may feel helplessly monopolized by it—as in shame. Finally, there is the often deep antagonism between old rules and new experience. None of these are absolute dualisms. But they are felt dualisms. The self-conscious symbolic animal, furthermore, feels

them very keenly. This complex of strains, tensions, drifts, antagonisms, plagues man like no other animal in nature is plagued. Modern man is slowly realizing that symbol-systems *should be turned upside down and inside out:* that they were made precisely for that, that man's business is precisely to *become.*

Laswell, Harold D. (24.36)

Among the advanced forms of life, human beings, at least, are relatively distinguished by discontent with "solutions." This inner-generated discontent presumably comes from the intricacy of the brain, the body, and the sociophysical environment.

Rapoport, Anatol (In Hoagland and Burhoe, Eds.) (24.37)

The most characteristic human creative thing about man's uniqueness is his ability to deal with dilemmas by getting outside of the dilemma situation by a radical re-examination of the evaluating process, of the language, of the metaphysics, of the philosophy, of the framework of assumptions—whatever has led to the dilemma in the first place. Instead of our trying to patch it up, we are sometimes given a beautiful opportunity to make an entirely different kind of formulation in which the dilemma becomes resolved.

Erikson, Erik H. (24.38)

Man's socio-genetic evolution is about to reach a crisis in the full sense of the word, a crossroads offering one path to fatality and one to recovery and further growth. But the processes of socio-genetic evolution also seem to promise a new humanism, the acceptance by man—as an evolved product as well as a producer, and a self-conscious tool of further evolution—of the obligation to be guided in his planned actions and his chosen self-restraints by his knowledge and his insights.

Becker, Ernest (24.39)

Space, too, is of two kinds: a habitual action space, circumscribed by the individual's body movements; and an abstract, measured, conceptual space: the kind we draw on a map, or conceive as the shape and bounds of the cosmos. Many primitives have built the action space of their home territories solidly into their every movement. Lived, action space is built into the organism by behavior; distance spanned by habit becomes part of the organismic expectancy and rhythm. Conceptual space too becomes part of our cognitive world; but even though we have the road map we are strangers until we have traveled the road. The development of abstract categories of space and time, in the center of which the individual places himself, is unique in nature.

World Brain

Lord Brain (24.40)

Many years ago, H. G. Wells pointed out the need for what he called a 'world brain' to correlate information and extrapolate it on the world scale, and I hope that one day we shall achieve something like that. As individuals, we are all receptors, capable of supplying the higher centers with information. What information they get, therefore, depends upon us. We are also the motor nerves, and what society does is done by us. But we are again, collectively, ourselves the higher centres, the forebrain, which mediates for the social mind the difficult task of receiving the information, learning from past experience,

reacting to it emotionally, yet controlling its emotions, and, above all, looking to the future.

Dobzhansky, Theodosius (24.41)

[Teilhard de Chardin] chose to designate the direction in which evolution is going as "The Point Omega." This is "a harmonized collectivity of consciousness, equivalent to a kind of superconsciousness. The Earth is covering itself not merely by myriads of thinking units, but by a single continuum of thought, and finally forming a functionally single Unit of Thought of planetary dimensions. The plurality of individual thoughts combine and mutually reinforce each other in a single act of unanimous Thought."

Dryer, Bernard V. (24.42)

There is now underway a widespread effort to create a set of common notations, a symbolic language, to express whatever analogies we can make between many actions of the human nervous system and the activity of computers. With this convergence of mathematical physics and neurophysiology, we have a kind of intellectual sandwich—one half of which is covered by words from the world of electric circuitry, such as input, output, redundancy, feedback, and channel capacity—the other half of which, perhaps more familiar to most of us, from the neurophysiology laboratory, such as facilitation, recruitment, summation, and refractory period.

ENVIRONMENTAL CHALLENGE

When these comments are considered in conjunction with other knowledge of the evolution of man, it is apparent that a great deal of the uniqueness of the human animal, including all the complexities of modern culture, results from exploitation of pre-adaptive genetically-determined capacities that characterized our hunter-gatherer ancestors of fifty thousand years ago. All animals, particularly many species of highly social mammals, have capacities for adjusting to situations not previously encountered. If we are to make studies with mammals most fruitful for gaining insight into phenomena expressed on the human level, it follows that such studies must confront the animals with environmental conditions their species have never encountered before. This increasing complexity of the environment should particularly focus on enhancing opportunities for communication, increasing freedom and diversity of choice, demanding higher levels of diversity and complexity of behavior, reinforcing cooperation, establishing values and diversity among them, facilitating learned imitative behavior, and providing opportunities that foster group cohesion. Then, given the limitations of neural capacity, perception and motor abilities, it is possible to gain insight into the processes through which changed environmental circumstances interact with the pre-adaptive capacities of the species to produce higher levels of social organization and information "metabolism."

Only in the context of such studies can studies on mammalian physiology, including neurophysiology, gain their maximum relevance to man. For example, in so long as we conduct physiological studies of laboratory animals on subjects reared and maintained in the barren confines of cages, any results from them should only be applied to humans similarly reared in a social and environmental void. It is a common property of most genes that they affect several avenues of phenotypic expression (pliotropism). Some genes influence rate

of growth, but this does not rule out their influence through other metabolic pathways on social behavior. In closing, I wish to reiterate that, though I recognize that mice, and rats, and cats and monkeys are not human and are certainly not capable of developing our complex culture, many species are capable of exhibiting quite complex societies and complex learned behavior with respect to their physical environment. Exploiting these capacities, beyond their normal expression in the environments where the species have evolved, will mark a new era in the contribution of animal studies to human welfare.

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Vitamins[1] (except A)	gms./100 kilo
Cod liver oil U.S.P.*	500.00
K (menadione sodium bisulfite)*	100.00
E (DL alpha tocopherol N.F.)*	25.00
E (DL alpha tocopherol acetate N.F.)*	25.00
B (nicotinic acid)*	7.50
D concentrate	2.75
thiamine hydrochloride	0.50
riboflavin	0.75
pyridoxine hydrochloride	0.63
calcium pantothenate	5.00
choline hydrochloride	250.00
p-amino benzoic acid	6.00
biotin	0.03
folic acid	0.05
niacinamide HCL	3.75
B_{12}	0.01
ascorbic acid	50.00
inositol	25.00
	1001.97

[1] All weights except those followed by an asterisk based on Table I, p. 403 of Greenstein, Jesse P., Sanford M. Birnbaum, Milton Winitz, and M. Clyde Otey. Quantitative nutritional studies with water-soluble, chemically defined diets. I. Growth, reproduction and lactation of rats. Archives of Biochemistry and Biophysics, 1957, *72*, 396–416.

Remainder of diet (except Vitamin A)	% of 99 Kilo Remainder
Vitamin free casein	18
corn starch	30
sucrose	30
Crisco (fat component)	10
alphacel	8
H. M. W. salt mixture[1]	4
	100

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