the interaction between different ecological principles and quite unknown factors which must be integrated in the determination of physique, and which leads to many exceptions in the application of any one explanation. D. F. Roberts and D. R. Bainbridge, *Amer. J. Phys. Anthropol.* 21, 341 (1963); J. Hiernaux, *La Diversité Humaine en Afrique Subsaharienne* (Inst. Sociol. Univ. Libre. Bruxelles, 1968).

F. Roberts, *Amer. J. Phys. Anthropol.* 11, 533 (1953): E. Schreider, *Nature* 165, 286 (1950); E. Schreider, *ibid.* 167, 823 (1951): M. T. Newman, *Ann. N.Y. Acad. Sci.* 91. 617 (1961).

S. Weiner, *Amer. J. Phys. Anthropol* 12. 615 (1954); M. H. Wolpoff, *ibid.* 29. 405 (1968); E. V. Glanville, *ibid.* 30. 29 (1969).

T. Steegmann, Jr., *Hum. Biol.* 39. 131 (1967); "Thermal responses to cold in Hawaii," *Amer. J. Phys. Anthropol.*, in press.

Baker, *Science* 163, 1149 (1969).

S. Weiner, J. *Roy. Anthropol. Inst. Gt. Brit. Ireland* 94, 230 (1964).

W. Newman, "Why man is such a sweaty and thirsty naked animal: A speculative review," *Hum. Biol.*, in press.

M. C. Lee and G. W. Lasker, *ibid.* 31, 252 (1959).

B. Livingstone, "Polygenic models for the evolution of human skin color differences," *ibid.*, in press.

S. Kip, "Measurement and regional distribution of functioning eccrine sweat glands in male and female Caucasians," *ibid.*, in press.

views of the anthropological significance of basal metabolic rates by E. A. Wilson [*Amer. J. Phys. Anthropol. 3,* 1 (1945)]. N. A. Barnicot [*Sci. Progr. London* 153, 124 (1951)], and D. F. Roberts [*J. Roy. Anthropol. Inst. Gt. Brit. Ireland* 82, 169 (1962)] indicate that the world distribution of basal metabolic rates is inversely related to mean annual temperature even when due allowance is made for differences in stature and weight; there remains some doubt concerning what fraction of this adaptation is inherent, because rates change in migrants.

nong asymptomatic subjects, A. E. Davis and T. Bolin [*Nature* 216, 1244 (1967)] report that all 15 Chinese, 4 of 5 individuals from the Indian subcontinent, and 2 of 12 Caucasians had abdominal pain and diarrhea after ingesting 80 grams of lactose. The Chinese restaurant syndrome was described by H. H. Schaumburg, R. Byck, R. Gerstl, and J. H. Mashman [*Science* 163, 826 (1969)].

Walcher, *Zentralb Gynaekol.* 29, 193 (1905).

Fishberg, *Ann. N.Y. Acad. Sci.* 16, 155 (1905).

Boas, *Changes in Bodily Form of Descendants of Immigrants.* Senate document 208, 61st Congress, 2nd Session. Washington, D.C. (1910).

L. Shapiro, "The Chinese population in Hawaii." Preliminary paper prepared for the 4th general session of the Institute of Pacific Relations, New York (1931), pp. 3-29: *Migration and Environment* (Oxford Univ. Press, New York, 1939).

K. Ito, *Hum. Biol.* 14, 279 (1942): G. W. Lasker, *Amer. J. Phys. Anthropol.* 4, 273 (1946); F. P. Thieme, *Pap. Mich. Acad. Sci. Arts Lett.* 42, 249 (1957).

T. Bowles, *New Types of Old Americans at Harvard and at Eastern Women's Colleges* (Harvard Univ. Press, Cambridge, 1932); A. Damon, *Amer. J. Phys. Anthropol.* 29, 45 (1968).

S. Goldstein, *Demographic and Bodily Changes in Descendants of Mexican Immigrants* (Univ. of Texas, Inst. of Latin Amer. Studies, Austin, 1943).

W. Lasker, *Hum. Biol.* 24, 262 (1952); *ibid.* 26, 52 (1954); ——— and F. G. Evans, *Amer. J. Phys. Anthropol*, 19, 203 (1961).

S. Hulse, *Arch. Suisses Anthropol. Gen.* 22, 103 (1957).

A. Kaplan, *Amer. Anthropol.* 56, 780 (1954).

M. Tanner, in *The Biology of Human Adaptation*, P. T. Baker and J. S. Weiner, Eds. (Clarendon Press, Oxford, 1966), pp. 45-66.

W. Greulich, *Amer. J. Phys. Anthropol.* 15, 489 (1957); P. B. Eveleth and J. A. de Souza, *Hum. Biol.* 41, 176 (1969).

J. W. Burrell, M. J. R. Healy, J. M. Tanner, *Hum. Biol.* 33, 250 (1961); K. P. Sabharwal, S. Morales, J. Mendez, *ibid.* 38, 131 (1966); V. G. Vlastovsky, *ibid.* 38, 218 (1966); K. Bojlén

FROM: M.H. Logan and E.E. Hunt (eds.),
Heath and the Human Condition,
Duxbury Press, North Scituate, MA (1978)

George J. Armelagos
Alan Goodman
Kenneth H. Jacobs

The ecological perspective in disease

Introduction

The role of infectious disease in the evolution of human and non-human populations has long been of interest to historians, physicians, and anthropologists. While earlier scientists speculated on the significance of disease to the extinction of species (Young 1931:123) and races (Moodie 1917), Haldane (1949) developed the theoretical framework necessary to the study of the impact of culture on human epidemiology. Through an analysis of the effects of agriculture on human population, Haldane discussed the impact of disease on the biology of those groups. Research on this subject has intensified in recent years (Alland 1966, 1967, 1970; Armelagos 1967; Armelagos and Dewey 1970; Armelagos and McArdle 1975; May 1958, 1961; Montgomery 1973: Polgar 1964), but the basic perspective has not changed since Haldane. Models of the disease process continue to rely upon the traditional concept of a simple cause and effect relationship between pathogen (defined in the broad sense as any disease-causing agent) and host.

We will deal briefly with the historical roots of this concept and in more detail with its implications for the study of the evolution and ecology of disease. A model will be presented which attempts to relate in a systemic fashion the full spectrum of variables which influence the disease process. This model will enable researchers to focus on specific components of the disease-host complex in more detail, while retaining the ability to integrate such studies into a more comprehensive evolutionary and ecological framework than is now current.

The model will be discussed in two sections: the potential of various aspects of the inorganic, organic, and cultural environments to serve as insults to the organism and, thus to cause disease will be investigated; the impact of disease on the cultural system of the host population and the nature of the response to these insults will be discussed.

Steps toward an Ecology of Disease

If there is a common thread which runs through models of disease used by Western scientists, it is that which Duboś (1959) has identified as "the doctrine of specific etiology." Its basic tenet is that for every symptomatically identifiable disease

A revised and expanded version of "Disease and the Ecological Perspective," *The Ecologist*, 6 is a single factor which, acting upon the individual, destroys the equilibrium ealth and creates a "dis-ease" state (Cohn 1960). This causal chain has re- ed sacrosanct whether implied within the context of theories of demoniac ssion (Osterreich 1930) or of the germ theory of disease. In this view, a n, upon entering the individual's body precipitated a clearly pathological ition; amelioration of this condition necessitated exorcism of the demon.

Replacing demons with microbes, the scientific expansion of the 17th and centuries spawned an increasingly sophisticated classification of disease ties" (DeKruif 1926). Stimulated by the apparent classificatory successes of innaean taxonomy, and operating within a social context which placed a value on description, definition and classification (Eiseley 1958), this view was ntial in shaping the theories of subsequent workers. The tremendous impor- of acute microbial diseases in the 19th century provided a context within Pasteur, Koch and others would continue in this tradition and further devel- the doctrine of "specific etiology" (Dubos 1959, 1965).

The basic assumptions of this "one germ-one disease" theory are optimized och's famous postulates, each of which must be satisfied before any disease e considered "classified." One must be able to isolate a pathogen from a ed animal; this pathogen must then be grown on a culture medium; a sample this new growth must cause the disease when injected into a laboratory l; one must then be able to reisolate the pathogen from this second animal. ne vast majority of then-prevalent diseases, classification by these criteria was possible. Furthermore, the identification of pathogenic agents which were ated with some of the major scourges of the period greatly aided in attempts dically treat or prevent these disorders.

The germ theory continues to be of undisputed utility in the clinical area. minor modifications to accommodate the *rickettsiae* and viruses, it is the ation of much modern medical and public health practices. Medical interven- n the form of antiobiotic therapy or vaccination, and public health measures, as the draining of swamps in malaria control efforts, have done much to se the infectious disease load on modern populations. Yet the evolutionary of disease requires a consideration of a wider array of variables than is usually le within the theoretical confines of the germ theory. By definition, the germ accepts as the dominant, and in most cases the only relevant, variable the ce or absence of a pathogen. Emphasis upon this single variable is not satis- y for many purposes.

Even the ancient Hippocratic doctrines, which had originally stressed the lationship of myriad environmental and internal factors (the four humours), ecast in a unicausal form. Despite the superficial similarity to Hippocrates' Water, and Places," the etiology of rampant swamp fever, for example, was ently traced to the malefic influence of a single factor, the foul swamp air n: *mal aria*).

The pace of success achieved by the earlier followers of the germ theory of has not been maintained. The germ theory is unable to help solve many

health problems in modern groups. Burkitt has compiled a short list of ailments that "can be considered diseases of the modern economic development (1973: 141)"; the list is composed of the following ailments: coronary heart disease, cancer of the large intestine, appendicitis, diverticular disease of the large bowel, gallstones, varicose veins, obesity and dental cavities. From the attempts to cure these modern ailments it has become increasingly clear that not only are the important "pathogens" of this era of a different nature, but that the causality between pathogen and disease state is not as simplistic as once perceived. The efforts to isolate the cause of cancer as a singular entity should serve as an example (see section on applications).

That the doctrine of specific etiology should prove so tenacious should not be surprising. As noted by Monod (1971), an almost religious adherence to unicausal thinking is a necessary consequence of the belief in a teleological universe inherent to Western thought. Furthermore, in a practical sense, the germ theory of disease has been a useful paradigm in efforts to treat, cure, and eradicate numerous diseases. The drastic reduction in the major epidemics which were the proving ground for the early germ theorists continues to persuade many of the possibility of eliminating all disease (Dubos 1959; Cockburn 1971; Imperato 1975).

Yet the very simplicity which contributes to this model's practical utility makes it less than useful. Recognition of the wide variety of nutritional (Scrimshaw et al. 1968) and psychosocial (Moss 1973) factors which affect disease severity and identification of an increasingly large class of disorders which are not traceable to a single "cause" have convinced many of the necessity of a multifactorial approach. May (1960), expanding upon Sigerist's (1933) notion of an historic and geographic atlas of diseases, sought to formalize the role of the environment in the disease process. May suggested that the host, pathogen, and environment were equally important in the epidemiology of any population. His inclusion of culture under the category environment made his model of special significance to researchers interested in the evolution of human diseases (Polgar 1964; Armelagos and Dewey 1970; Armelagos and McArdle 1975).

Audy (1971) has attempted to transcend May's focus on disease involving organic pathogens by incorporating the notion of "insult" into his model. Insults are physical, chemical, infectious, psychological, or social stimuli which adversely affect the individual's or population's adjustment to the environment. In a later work, Audy and Dunn (1974:329) state that this effect may arise from either an excess or a dearth of a given stimulus (for example, excess social interaction versus social deprivation). These insults may be of external or internal origin. Often the insult of an inappropriate or excessive internal response will be added to that of the original external insult. In this context, disease is defined as a phase in the response to an insult in which the ability to cope (as with an additional insult) is lowered. Health, on the other hand, represents the continuing ability of the individual to rally from insults. Health and disease must therefore be considered on a continuum and not as an either/or situation.

There is much promise in such an approach: it recognizes the disease-causing potential of a wider variety of stimuli than is possible under the germ theory. It suggests ways in which the "Host-Insult-Environment" complex may be subjected to far more rigorous analyses than has been possible previously. As presented, however, it raises several important questions: in what ways are the various insults similar?; what are the implications of these similarities for the ability of the individual to respond?; what are the implications, at both the individual and population levels, for adaptation and evolution? It is to these sorts of questions that the present paper now turns.

The Environment

We have attempted to construct our model (Figure 1) of the environment in a way that would be amenable to evolutionary and ecological analysis. In so doing, the division of the environment into its inorganic, organic and cultural components has been found to be useful. Such a distinction is found in both ecological (Stewart 1955) and evolutionary (Huxley 1958; Dobzhansky 1962) studies, and emphasizes features which are essential to a holistic understanding of health and disease phenomena (Boyden 1973; May 1960).

Temperature, humidity, oxygen pressure, trace elements in the soil and water, ultra-violet and cosmic radiation are some of the many inorganic components of the environment which affect our species. Disorders associated with a lack or an excess of such inputs are familiar and need only briefly be discussed. For example, excess ultra-violet radiation may, at the most, promote dermal carcinoma or, at least, precipitate the destruction of dermal tissue, which may lead to edema, erythema, and severe secondary infections. Insufficient ultra-violet radiation may, in cultures without sufficient dietary sources of vitamin D, lead to rickets in children or osteomalacia in adults (Blum 1961; Loomis 1967). A similar situation exists for all such inorganic inputs. The individual is adapted to function at peak efficiency when each stimulus is within an optimum range. Deviation outside that range, in either direction, will invariably be associated with a deterioration in the individual's condition.

A large proportion of the input we face emanates from the organic component of the environment. However, as a species, we use a considerable portion of the organic input as a source for nutrition. Human adaptation may be viewed in this light as the process by which we obtain optimal caloric input in the face of caloric expenditure. Yet we ourselves provide energy for a wide range of predator species; these predators are not the large canivores familiar to other consuming species, but are, rather, innumerable protozoan, metazoan, bacterial, Rickettsial and viral organisms. Epidemiologists have long recognized that such "predators" bear responsibility for a majority of human ailments. Malaria, schistosomiasis, tuberculosis, scrub typhus and influenza are well-known examples from each of these categories.

The cultural component is comprised of our species' technological, social and ideological systems; it functions within the total environmental framework in two

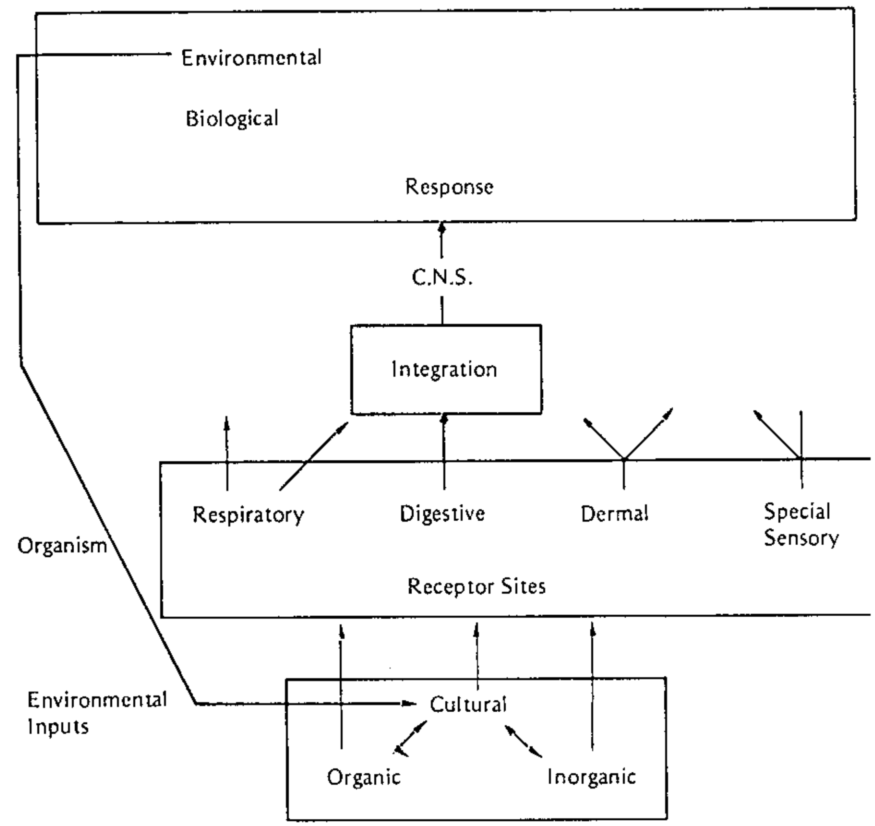

Figure 1. Ecological Model of Disease

ways. It may alter the frequency and intensity of exposure to inorganic and or inputs. It may also create a set of informational inputs which are uniquel own (Armelagos and McArdle 1975). The use of clothing, or the addition of min D to dairy products, are both ways in which the social environment medi population's interaction with the (other parts of the) environment. The impa ultra-violet radiation on the population will be altered. In a similar fashior clearing of tropical forest, and the subsequent use of slash-and-burn agricu techniques, can be expected to alter a population's relationship with or inputs. In this instance, an environment conducive to the development of enc malaria will have been created (Livingstone 1958; Wisenfeld 1967).

In cases where there is already disease, social environment also func through medical practices, to influence the distribution and prevalence o disease. It is most effective in cases where knowledge of the causative proc the disease has been achieved, i.e., in infectious diseases where a pathogen has isolated. Even this is no guarantee of success, however, as other aspects c social environment may be influencing the disease in the opposite direction. S he case with syphilis, for example. Knowledge of the pathogen, its life cycle, anti-›iotic treatment, have as yet proved insufficient to the task of eradicating the lisease, largely because social relations, and specifically sexual relations, are of a 'orm which is highly favorable to the spread and persistence of the disease (Rose-›ury 1971).

The perpetuation of culture depends upon the persistence of symbolic com-nunication among members of the social unit. Even symbolic interaction is capable ›f producing stimuli in the form of information. Constantly changing relationships ›f the individual to the social and ideological systems, and thus constantly varying nformational input, often create a situation in which the individual may undergo ›sychological or social stress (Moss 1973). An example of the consequences of such ı situation may be schizophrenia; a socially precipitated "double bind" situation the presentation of simultaneous contradictory messages, to which there is no :orrect response) may be crucial in the etiology of this disorder (Bateson et al. 1956; Singer and Wynne 1966).

In summary, in our model disease is seen as the result of an inappropriate :onstellation of inputs. Admittedly this constellation of inputs is complex. As will ›e seen, the organism instantly attempts to adjust to these inputs. Disease may ırise in cases of under input, over input, improper input.

The Organism

Vital to a comprehension of the impact of the various inputs discussed above is an understanding of the ways in which these inputs are received by the organism. Previous ecological models have tended to de-emphasize this aspect of the Organ-ısm-Environment complex. The environment is dealt with in all of its complexity, while the individual organism is treated very much like a "black box." It is assumed that, in the presence of inputs, the organism will react in an anticipated manner. Such a scheme neglects the intricacies of the reception and reaction processes. While we can never accommodate the total variety of such processes within our model, we hope they are divisible into meaningful categories. Thus, for reception, we have isolated four subsystems: respiratory, digestive, dermal and special sensory.

We interact with a wide variety of inorganic and organic inputs through our respiratory system. Most inorganic material is either integrated into the body tissue or expelled without noticeable trauma. One aspect of our cultural evolution, however, has been the development of new methods for the extraction of energy from the earth. A by-product of the use of these energy sources, for the most part fossil fuels, has been an increase in the amount and diversity of inorganic inputs to which we are exposed. This increased exposure to chemicals such as carbon monox-ide (Lave and Seskin 1970) and asbestos (Oliver 1974; Rohl et al. 1975) has conse-quences which are only beginning to become apparent. It seems increasingly likely that controlling inorganic inputs will be of far greater importance in maintaining our health status than has previously been the case. The respiratory system is also actively involved in our interaction with numerous organic inputs. Tuberculosis,

bubonic plague, smallpox and influenza are only a few of the infectious diseases which are contracted through the respiratory system. Asthma, hay fever, and othe allergic conditions also stem from respiratory contact with antigenic substances

The normal input for the digestive system is quite obviously nutritive. Th system is designed to extract useable energy from a variety of foods. Both organi and inorganic input is required, the former for the actual energy, which is release through digestive processes, and the latter are the essential mineral metabolite necessary for the organism's biochemical reactions. In either case, an excess or lack of these stimuli leads to well-recognized problems. Zinc deficiencies (Weinber 1972) and an excess of iron (Weinberg 1974) have been associated with an increas in the severity of infectious diseases. Vitamin deficiencies, such as pellagra c beri-beri, and more rarely, vitamin excesses, are associated with imbalances. O ganic imbalance is reflected in obesity and its cardiovascular correlates in the cas of overnutrition, and in syndromes such as marasmus and kwashiorkor, in instance of undernutrition. Disorders arising from sensitivity to a specific dietary stimul are also common. They can be caused by a heritable lack of an essential digesti enzyme, as in lactase deficiency (McCracken 1971; Harrison 1975), or by an in munologically mediated allergy to a component of the diet, as in celeac diseas The digestive system may also be the focus of stimulation by many organic path gens. Such pathogens may be of external origin, as with cholera or typhoid feve In other cases, disruption of the intestinal environment may alter the pathogenici of otherwise innocuous indigenous microbiota (Dubos 1965). Such a process seer to underlie disorders like Traveler's Diarrhea (Gorbach et al. 1975).

Our skin, or dermal system, is also in continuous contact with the enviro ment. It harbors an intricate web of nervous tissue, whose function it is to monit numerous inorganic inputs, such as temperature or solar radiation. It is a site whe several essential physiological processes are carried out, for example the dissipati of excess body heat and the production of vitamin D, and also functions as shield, preventing entry into the body of a wide variety of inputs. It is not, ho ever, a perfect shield. Various organic inputs gain access to the body by penetrati the dermal system. Schistosomes are able to actively bore through dermal tiss other diseases, such as malaria and yellow fever, also enter through the skin, alb with the assistance of insect vectors.

The final method of reception combines our inputs from special sens modalities: hearing, seeing, taste, smell, and touch are the most well known. M of the information received through the special senses is channeled into the cen nervous system. A great deal of nervous activity takes place in which the chan interact with each other and stored information. The strength of the inputs, t effect on the organism, may be varied by symbolic interpretation and percept The often-noted psychological difficulties attending the development of inst tionalized children are probably consequences of an under input of informat (Gardner 1974). The possible association of the over input of complex and in gruous information with the etiology of schizophrenia has already been no

Integration and Response

As a dynamic homeostatic system, the organism constantly monitors its environment. As inputs interact with the receptor systems, the organism must seek to adjust itself in accordance with the nature of the various inputs. Inputs which fall within the environmental range for which the organism is adapted, and which thus cause little or no disturbance in the homeostatic state, demand a correspondingly minimal response, while inputs which produce considerable disruption of the organism's condition demand, and elicit, a considerably greater response (Selye 1956).

The organism, once subject to a disruptive input, may regain homeostable condition by either of two response mechanisms: 1) change biologically or 2)

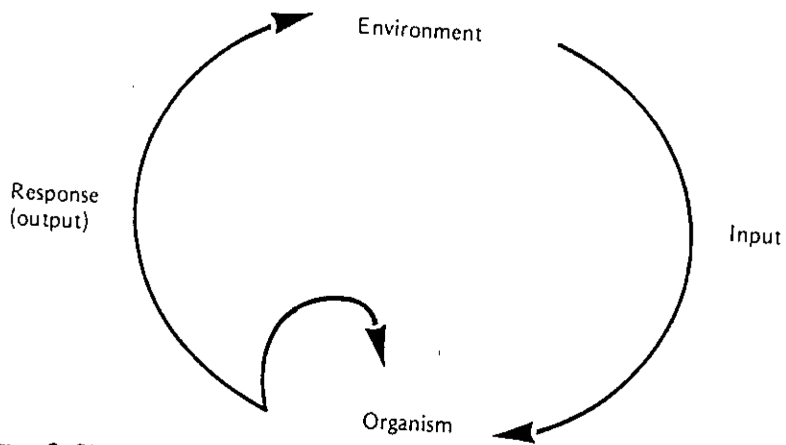

Figure 2. Simplified Environment-Organism Adjustment (Feedback) Loop

change the environment (see Figure 2). Biological changes or adjustments, changes that occur "below the skin" within the organism's body, will be discussed first. Eagan (1963) places delimitizations of the mechanisms of human adaptation into a temporal sequence of developmental acclimatization; long-term acclimatization, seasonal acclimatization, and short-term acclimatization. Stressing a slightly different response characteristic, Harrison delimits reversable versus inversable re-sponses (1966). Both of these delimitations are methodologically useful and should ɔe noted. These categorizations are functional in their relationship to duration of nput to duration and energetic cost of response.

Natural selection, driving force of evolution, may be viewed as the genetic djustment of organisms to the environment. Genetic adjustment takes place over enerations of time and is a population's means of adjustment.

Whereas biological responses occur within the body of the individual organ-m, environmental responses are of an extra-somatic nature. They directly attack ıe root of disease by altering the environment, specifically the cultural compo-ːnt. Efforts to screen the appropriate inorganic or organic input may be intensi-

fied in response to a new disease state. Medical practices may be instituted whic augment existing biological responses. There is however a growing concern f diseases (iatrogenic diseases) which are direct or indirect results of medical trea ment (Burnet and White 1972). Thalidomide, chlortetracycline and oral contr ceptives have resulted in unexpected effects for the users.

If the resources available to all of these potential responses are sufficier the organism will persist. The disease state may be terminated, for example, if tl pathogen is eliminated from the body or from the surrounding environment. other cases, the relevant input may simply be incorporated into the system; if balance is achieved, such a condition could only be termed disease in the stricte sense. If the resources are insufficient, the disruption will be fatal unless the prop stimuli are altered by factors external to the organism.

Application

The development of an ecological perspective is not new. There have been a numb of excellent studies which have attempted to understand the importance ecological factors in the disease process. In the present model we have consider the ecological perspective in more detail. There have been a number of studi which have demonstrated how insults cause disease, and how culture provides buffer between these elements of the environment. There are however ma instances in which culture increases the potential for disease. It was the understan ing of the relationship of culture to disease which renewed interest in the ecolo of disease.

Multifactorial Consideration of the Organism and the Insults

Although the analysis of the ecology of disease considered the relevant variables the disease process, the previous models dealt with the organism as a black box. treating the organism as a black box, the model fails to consider the organism a variable in the disease process. In our model we viewed the relationship of t organism to disease in terms of the receptor sites and response. Furthermore t model attempts to expand the concept of disease to include a number of chemic biological, social and psychological factors which can insult the organism, causi disease. Since the model isolates and integrates environmental factors, the dise receptor sites, and the response of the organism, the model is able to accommod a vast array of disease associations. For a disease in which an insult has been i lated, it enables one to visualize the interrelationships of the various factors whi influence the course of a disease. For disease of uncertain etiology, it suggests wa in which the etiology may best be viewed multifactorially. Atheriosclerosis, example, can be analyzed from the perspective of the relevant input: organic i balances of diet, internalized aggression, tension from symbolic input, and inorga material such as trace element, and the genetic makeup of the individual may h to explain the inability to arrive at an adequate unifactorial explanation for ather sclerosis.

›nstruction of Prehistoric Population Epidemiology

model is easily adaptable to the epidemiological reconstruction of prehistoric historic populations. Evolving disease patterns through human history can be ːd in terms of the changing articulation of the components of the model. The .ve importance of inorganic and organic inputs and the efficiency of the l environment as a screen can be analyzed. The effect of evolutionary changes ıe exposure of the various receptor systems to new and varied inputs can be ːled. For example, dietary changes involved in the evolution of agricultural ms become important for their inevitable impact on the digestive system, and on the health status of the individual and the population. Increasing popula- size and density can be viewed in the light of their impact on the respiratory tion of pathogenic inputs. The use of various sorts of clothing would alter the ure of the dermal system to the environment. Some inputs would be screened, th ultra-violet radiation, while other factors might be increased, such as ecto- ites. The influence of rapidly accelerating cultural complexity can be seen as g an impact on both the informational reception and the psychological and ological responses of the organism. In short, then, it offers a means through ı the disease status of various populations may be analyzed from an evolution- ːrspective.

ːt of Disease on Cultural System

the impact of culture on the disease process have been investigated exten- . there have been few studies which consider the influence of disease on the system. It is true that disease has often been considered as a factor in the e of great civilizations. Lead poisoning, for example, was suggested as a in the collapse of the Roman Empire (Boyden 1973; Gilfillan 1965). Al- h the evidence in this specific case is speculative, there is an abundance of ocumented literature on the controversy of the role which plague played on ·onomic, political, and social fabric of Europe. The epidemics of plague in the ː 1300's killed as many as one-third of the population. It has been argued that ːasant revolt and the reformation were caused by plague-induced population e. Philip Ziegler (1969) has provided an excellent historical analysis of the tance of plague in Europe with respect to the peasant revolt and the reforma- While acknowledging the obvious disruption that was caused by the decima- f the population, the changes that led to the peasant revolt and reformation ɔccurring prior to the Black Death, and Ziegler suggests that the plague epi- ꞩ accelerated these changes.

Although historical studies of the great epidemics provide important informa- n the social and economic response to these catastrophic events, we need to more about the impact of less catastrophic and more endemic diseases on ıtion structure, technology, social organization and ideology of the group. ıodel which we have proposed will allow one to examine these changes. Armelagos and McArdle (1975) have discussed in general terms the impact

on small populations. Systematic studies of disease on social systems by Kunstadter (1972) and Neel et al. (1970) demonstrated that disease need not have a high mortality to disrupt the social system. Those individuals who become ill may not be able to fulfill their social obligations. Among the Yanomama, Neel and coworkers have demonstrated that measles, a disease which usually causes few deaths in technologically advanced groups, had a very high mortality rate. Death was not caused by a more virulent strain of the pathogen but by the social disruption caused by the measles among the Yanomama.

We are only beginning to investigate the effect of disease on the age structure of a population. Goodman, Jacobs and Armelagos (1975) have recently suggested that an epidemic effects all age segments in a virgin population, while an endemic or a recurring epidemic pathogen is more likely to involve younger and older segments of the population. Theoretically, the middle-age segment of the population has developed some resistance to the pathogen through previous contact, while the pathogen is novel to the younger age segment and the older age segment has lost its resistance with senility. In this sense, the segments of the population which are the primary producers are less affected and the society is more able to maintain itself. The survival of this age segment of the population also allows a rapid recovery since males and females in the reproductive age set are likely survivors and thus able to replenish the population.

It is a possibility that populations that are able to maintain pathogens endemically will not be as severely affected in their ability to increase as will populations of a lesser density; since small populations more frequently contact a pathogen novely, mortality is higher in the reproductive age segment of the group.

There are other methods which will allow one to test the impact of disease on a society. Haas and coworkers (1971) have measured energy to test impact of disease within a group. The formal application of energy flow (Thomas 1973, Rappaport 1971, Little and Moren 1976, Kemp 1971, Odum 1971) could provide one of the most useful tools in the study of disease. The cost of disease in energetic terms can be quantified and easily subjected to comparative analysis. Here the duration of responses both biological and environmental will gain increased importance.

Ecological Aspects of Ethnomedicine

The cultural response has traditionally focused on technological means for disease prevention, such as vaccines and social practice as quarantine to isolate disease. However, the ecological perspective must consider other aspects of the social and ideological response to disease. The ethnomedical approach which Fábrega defines is the way in which a culture defines disease, the way in which the group organizes themselves toward the treatment, and the social organization of the treatment. These ethnomedical factors should be considered in the ecology of disease. The ethnomedical approach has been an important area of study by medical anthropologists. It has, however, not been incorporated in most of the ecological studies of disease. In some sense, the ecological models have been used in the study of disease in technologically advanced societies. Disease is viewed in a biocultural perspective without attempting to analyze the ethnomedical response. The biocultural perspective examines the interaction of disease and cultural variables, but often fails to consider the impact that defining disease and the social organization of response and treatment has to the disease process. Our model attempts to resolve this shortcoming by focusing on the ethnomedical response as an aspect of disease ecology (1).

It would seem that if an ecological perspective is to be successful, it is necessary to incorporate the ethnomedical approach into the model. The incorporation of the ethnomedical approach will provide a link between the traditional studies of medical anthropology and medical ecology. In this way, ecological elements of disease as well as the ethnomedical response can be integrated, thus providing a more holistic approach.

The perception and definition of disease can have a significant impact on the ecological perspective. The perception of the disease is a reflection of social and historical factors, and the way in which a group defines disease can do much to shape the response which we make to disease. Zola (1972) and Fábrega (1975) note that a group defines a disease in order to combat it. The process of defining disease and the allocation of limited resources can be the means for exerting control which can affect the behavior of the group. Kunitz (1974) has shown that what is defined as a disease is not always the conditions which represent the greatest threat to the adaptation of the group, but often a reflection of social-political factors affecting the social unit.

There are various levels in which our model can be tested with a condition that has assumed relative importance in contemporary Western culture. Cancer is an excellent example of a disease in which the traditional models have not provided an adequate means for understanding and controlling this condition in the United States. Even a monumental governmental effort to "discover" the cause and develop a "cure" of cancer has not met with much success.

Strickland (1972) has presented an interesting analysis of the politics involved n the government's effort to control cancer. As early as 1928 there were outcries on the floor of the United States Senate to mount a national attack on cancer. There were attempts at developing a special governmental unit to wage a "war" on cancer and the Cancer Act of 1971 legislated the machinery for the organization to oversee the "fight" on cancer. Strickland (1972:260-290) describes the vast lobbying effort which even utilized Ann Landers to gain support for national legislation. Ultimately 1.59 billion dollars was authorized for a three-year period and developed National Cancer board and a National Cancer Institute whose Director would be ppointed by the President. Although the National Cancer Institute remained as a part of the National Institute of Health, its new status was elevated within the biomedical community.

The political and scientific attempts to develop a cancer cure have met with onsiderable criticism. The efforts to cure cancer have led to the fear that funds to ontrol other diseases might decrease in order to support cancer research (Greenberg 1975). Even the scientific research has been criticized. Cairns (1975) poir out that most of the basic cancer research involved attempts to discover a chemi which would control or inhibit the growth of cancer cells or an immunologi procedure which would prevent its development rather than attempt to prevent by changes in life style.

Cancer research has undoubtedly been influenced by a social setting with advanced technology and a medical system whose professional status was in p based on its success in controlling infectious disease. It is noteworthy that t major research efforts have focused on a single cure for cancer with attempts develop products of technology (chemotherapy and radiation) or vaccines. Sir vaccines were so successful in early efforts for infectious disease (Cairns 1975) was thought to be the most likely solution to cancer. While there has been so success in decreasing mortality from some forms of cancer (Frei 1975), over mortality has increased from 1940-1973. We now realize that a "cure" for cance going to be difficult to obtain since there are over one hundred pathological con tions classified as cancer. The research efforts in cancer research are beginning examine a myriad of environmental factors which are carcinogenic: diet, industr pollutants such as heavy metals, organic compounds. A major factor in our di culty in understanding which environmental factors produce cancer is the trem dous lapse in time of 10 to 20 years from exposure to the appearance of the canc An individual exposed to a carcinorganic agent for extended periods of time m not develop a lesion for many years.

Greenberg (1975:707-708) questions the accelerated support for cancer search based on developments in clinical as well as within basic science resear The fact that a cure of all cancers (including those effecting children) will incre life expectancy less than a year suggests that our research could be allocated ferently. However, the fear of death from a malignancy which may linger months or years seems to be a critical factor in the public support of cancer search.

The ecological perspective would suggest cancer might better be preven than cured. The ability to change life style to minimize predisposing an individ to cancer or to prevent exposure to environmental carcinogens might be m successful than immunology, surgery or chemotherapy.

In summary, the traditional approaches to an understanding of the dise process in human population have been limited. Earlier approaches to the un standing of disease within contemporary and prehistoric human populations fai to consider ecological factors which played an important role in the disease prof of these groups. The ecological perspective provides an integrative approach understanding the interaction of the individual, the environment and the popu tion in the disease process. It should be useful in the prediction of outcome specific clinical or epidemiological situations, and also in the reconstruction homo sapiens' past disease experiences.

Note

1. The reason why the ecological perspective has failed to consider the ethnomedical factors is partially a result of historical factors. Since its inception, medical anthropology has traditionally viewed disease as a given and attempted to study the cultural response to disease in a closed system. For example. Ackerknecht's (1942b, 1945c) influential studies of the sociocultural response to disease argued that we need not consider the ecological factors such as biological adaptation of the host and pathogen. In his view, Ackerknecht seemed to make a distinction between primitive and Western views of disease. For example, in his analysis of disease in a Western group, Ackerknecht (1945b, 1946) incorporates the ecological and environmental factor as well as the biological response of the organism and pathogen into his model of disease. Yet in these studies, ethnomedical factors are not considered. In a similar manner, the ecological approach to disease reflected in the research of physicians and physical anthropologists (May 1960, Dubos 1965, Audy 1971) utilized a model which considered a "scientific" approach to disease in which the interaction of cultural and biological factors in the disease process were considered. While the investigation suggested how technological factors (Livingstone 1958), social organization (Hudson 1965), and ideological elements (Glasse 1970) may inhibit or enhance the disease ecology of a group, these studies seldom attempted to discuss the ethnomedical response to disease. Little effort is made to examine how our perception may influence the disease process.

Edward E. Hunt, Jr.

Ecological frameworks and hypothesis testing in medical anthropology

This paper is a historical review of ecological approaches in medical anthropology and related fields. Five examples of ecological research are given in some detail, together with a final section which discusses some newer theoretical positions and prospects for further activities in this area.

An important contrast is evident between field work by ethnologists and ecologists in medical anthropology. Ethnological research is typically undertaken by single investigators, who often use local assistants and amass a sizeable body of qualitative evidence from interviews and from close observations of the community under study. By contrast, ecologists in medical anthropology generally draw on more quantitative data, pay more attention to biological aspects of disease, and tend to be eclectic in their collection of evidence. Many ecological studies have resulted from the collaboration of teams of investigators from a variety of disciplines.

In contrast to the practice of many cultural anthropologists, especially in the

past, ecologists in the health field tend to focus on explicit and te
and to be attracted to newer scientific fashions, such as systems
puter simulation. Although these multivariate approaches do not
dependent variables, the ecologist may use them as devices to
direction of causation in an ecosystem. Indeed, many of the varial
of health and health care come from the triad of sciences of pop
phy, evolutionary genetics, and epidemiology. The five studies
this paper all focus on populations, sometimes drawing on mor
population sciences in a single investigation.

Although interest in the ecology of health and disease is g
the past, the idea that a people's health is related to its environme
years old. It can be argued, for example, that Moses used his eco
to the advantage of his Hebrew followers. He grew up in Egyp
burdened by environmental pollution (Dixon 1972). After an ep
severe water pollution, which even the frogs could not tolerate,
series of further disasters to the health and well-being of the E
talized on ethnic differences in resistance to disease in liberating
bondage (Exodus 1-12). The ancient Greeks, too, applied ecolo
public health. Ackerknecht (1965) states that the philosopher Em
have had a system of drainage canals built in the Sicilian city of
of controlling malaria. In his treatise *About Airs, Waters and P*
Hippocrates and his school (ca. 400 B.C.), evidence is presente
local climates on human health in different Greek city-states (Ro

The intellectual climate of Greek, Roman, Arabic, and
ever since has repeatedly given rise to writings on the effects
human health (Ackerknecht 1965). By the nineteenth century
considered geography and history as closely parallel disciplines
unity is still evident in the work of some scholars. For exam
knecht, who has contributed to the present volume, is a me
historian of medicine, and a medical anthropologist.

Until late in the nineteenth century, the Mosaic or Hip
medical ecology was very much alive. One of its major advoc
ential pathologist, anthropologist and statesman, Rudolf Vir
fostered general anthropology in Germany, but medical geogra
1883-1886).

As medicine became more effective both in the laborato
in the late nineteenth century, medical geography and ecolo
declined except in two important areas. One was the sanitatic
of colonial peoples, or tropical public health, which clung to
ecological frameworks. The second area was environmental
health, which for many decades has studied the diseases of me
environment of the work place (V. R. Hunt 1975).

In the eighteenth and nineteenth centuries, although mo
nologists were physicians, their contributions to medical anthr