Life in the United States has changed so radically over the past one hundred years that the most wearisome historians tend to become rhapsodic when they describe the new advances that have been made in technology, science, and medicine. We are usually told that early in the last century most Americans lived heroic but narrow lives, eking out a material existence that was insecure and controlled by seasonal changes, drought, and the natural fertility of the soil. Daily work chores were extremely arduous; knowledge, beleaguered by superstition, was relatively crude. Historians with an interest in science often point out that medical remedies were primitive, if not useless; they may have sufficed to relieve the symptoms of common diseases, but they seldom effected a cure. Life was hard and precarious, afflicted by many tragedies that can easily be avoided today.

In contrast with the men of the last century, men today, we are told, have developed nearly complete control over the natural forces that once were the masters of their ancestors. Advances in communication have brought knowledge and safety to the most isolated communities. The most arduous work has now been
taken over by machines, and material existence has become secure, even affluent. Common illnesses that once claimed the lives of millions are now easily controlled by a scientific knowledge of disease, effective drugs, new diagnostic devices, and highly developed surgical techniques. The American people, it is claimed, enjoy more leisure, better health, greater longevity, and more varied and abundant diets than did their forebears a hundred years ago.

On the face of it, these statements are true, but by no means are all the advances as beneficial as the historians would have us believe. Recent changes in our synthetic environment have created new problems that are as numerous as those which burdened the men of the past. For example, soon nearly 70 per cent of the American population will be living in large metropolitan centers, such as New York, Chicago, and Los Angeles. They will be exposed in ever-greater numbers to automobile exhausts and urban air pollutants. Perhaps an even larger percentage of the employed population will be working in factories and offices. These people will be deprived of sunlight and fresh air during the best hours of the day. Factory and office work, while less arduous than in the past, is becoming more intensive. Although the working day early in the last century was very long, "the worker worked comparatively slowly, and both the employer and employee gave relatively little thought to productivity." Today, employers require a greater output per hour from each worker. The use of machines tends to make work monotonous and sedentary, often exhausting human nerves as completely as manual work exhausted human muscles. Modern man is far less physically active than his forebears were. He observes rather than performs, and uses less and less of his body at work and play. His diet, although more abundant, consists of highly processed foods. These foods contain a disconcertingly large amount of pesticide residues, coloring and flavoring matter, preservatives, and chemical "technological aids," many of which may impair his health. His waterways and the air he breathes contain not only the toxic wastes of the more familiar industries but radioactive pollutants, the byproducts of peacetime uses of nuclear energy and nuclear weapons tests.

With the rise of these problems, dramatic changes have occurred in the incidence of disease. In 1900, infectious diseases, such as pneumonia, influenza, and tuberculosis, were the principal causes of death. Death from heart disease and
cancer occupied a secondary place in American vital statistics. Fifty years later, mortality rates from infectious diseases had declined to a fraction of what they had been, but the percentage of deaths from heart disease and malignant tumors had more than doubled. It is very difficult to obtain reliable comparative statistics on the incidence of chronic, or persistent, diseases, but we can regard it as almost certain that the proportion of chronically ill individuals in the American population has increased. In any case, millions of Americans today suffer from major chronic disorders. Nearly 5 million people are afflicted with heart disease; another 5 million have high blood pressure. More than 12 million suffer from arthritis, 4 million from asthma, and at least 700,000 from cancer. Additional millions suffer from diabetes, kidney disease, and disorders of the nervous system.

Because many of these illnesses claim the lives of elderly people, we tend to associate chronic diseases with the aging process, and we usually explain their widespread occurrence by the fact that people are living longer. Men must die of something. With a reduction in the number of deaths from tuberculosis, influenza, and childhood infections, the diseases of aging people, it is claimed, should be expected to dominate our vital statistics. But are these diseases strictly products of the aging process? Do we have any evidence that they arise from basic physical disturbances peculiar to senescence? The answer is almost certainly no. Many disorders which afflict young people are precisely those so-called "degenerative diseases" that physicians and laymen associate with the retrogressive physical changes of old age.

Consider the age distribution in the incidence of cancer. Although many types of cancer are found mostly after the fourth or fifth decade of life, a surprisingly large number of varieties occur most frequently in childhood, youth, and early maturity. Cancers of the kidney and the adrenal glands usually appear before the age of four. Bone cancers reach their highest incidence in the ten-to-twenty-four age group. Malignant tumors of the testes usually occur in infancy and at maturity. So deeply entrenched was the notion that malignant tumors are diseases of elderly people that for many years physicians often discounted early symptoms of certain cancers in children. We now know that cancer in children occurs in nearly all the major physical organs of the body.

Today, cancer is second only to accidents as a leading cause of death in American
children over one year of age. Although mortality rates for childhood cancers fluctuate from year to year, they have moved in a decidedly upward direction over the past two decades; for American children under fifteen years of age, they rose 28 per cent between 1940 and 1955. In 1959, cancer claimed 4100 lives and accounted for 12 per cent of all deaths in children between the ages of one and fourteen. These statistics make it hazardous to say that the illness is essentially part of the aging process. Strong reasons exist for suspecting that environmental factors contribute significantly to increases in death from cancer among young people.

The same suspicions can be extended to heart and vascular disorders. Until recently, heart disease in young people was caused primarily by infectious illnesses. Rheumatic heart disease, following streptococcal infections, claimed the lives of many children between the ages of ten and fourteen. Fortunately, the incidence of rheumatic fever has been reduced dramatically by the use of antibiotics. On the other hand, coronary heart disease was generally regarded as a typical degenerative illness of older people, attributable to the onset of vascular disorders well beyond the peak of life. The disease seemed to be a culmination of the aging process. This view, too, is no longer a deeply entrenched medical opinion. Atherosclerosis, the precursor of coronary heart attacks, is not a universal feature of old age. On autopsy, many an octogenarian has been found to have coronary arteries that a man in his forties would be fortunate to possess.

Even more disconcerting is the unexpectedly high incidence of coronary illness now known to exist among young people. During the Korean War, the U. S. Armed Forces Institute of Pathology performed a series of autopsies on the bodies of 300 American soldiers, most of whom had been killed in front-line areas. Careful attempts were made to exclude cases in which there had been clinical evidence of coronary disease. The investigators, Enos, Holmes, and Beyer, observed that the average age in "200 cases was 22.1 years. The ages in the first 98 cases were not recorded except that the oldest patient was 33... In 77.3% of the hearts, some gross evidence of coronary atherosclerosis was found."

In at least 12 per cent of the hearts, the obstruction of one or more major coronary arteries exceeded 50 per cent of the arterial passageway. These are extremely high figures for young men who presumably were qualified for military service. A
comparative study performed on the bodies of 350 Americans in Boston and 352 Japanese in Fukuoka "disclosed a considerable difference in the severity of coronary atherosclerosis" between the two national groups. In the American group every individual had some degree of atherosclerosis by the second decade of life, whereas Japanese could be found without the disease in the fifth and sixth decades. Comparing the extent of the arterial surface involved and the severity of the lesions found in the two groups, the investigators emphasize that "there was at least a two decade difference in the progression of atherosclerosis. The average American of age 40 and the average Japanese of age 60 presented comparable arterial disease."

In all probability, data of this sort merely supply us with fragmentary evidence of the extent to which chronic and degenerative illnesses are invading the younger age groups of our population. Many individuals seem to be succumbing to degenerative diseases long before they reach the prime of life. Not only is cancer a leading cause of death in childhood and youth, but the results obtained by Enos and his coworkers suggest that many American males between twenty and thirty years of age are on the brink of major cardiac disease. Although most of these individuals are likely to exhibit no clinical symptoms of vascular disorders-indeed, they would probably be regarded as healthy in routine medical examinations - it is reasonable to say that they are ill. If diseases of this kind represent the normal deterioration of the body, then human biology is taking a patently abnormal turn. A large number of people are breaking down prematurely.

Heredity, of course, may "play a role" - to use a well-worn qualification. But medical history warns us that genetic explanations of disease, particularly common diseases that afflict large sections of the population, are often a refuge for incomplete knowledge. Many such explanations are being contradicted by research. For example, it is very doubtful whether the "inherently' weak and sick, who presumably were rescued by modern medicine from the fatal infections of the past, are destined to be victims of cancer. In fact, there is good reason to believe that the body's mechanisms for resistance to cancers are entirely distinct from those that combat infections. ("The old idea that chronic diseases are 'degenerative,' or inevitable concomitants of aging," observes Lester Breslow, of the California State Department of Public Health, "is giving way to the modern idea that the origins of
chronic disease lie in specific external causes which can be discovered and thus controlled.”) With all due respect to genetics and to theories that attribute chronic disease to senescence, it would be more rewarding to examine the changes that have occurred over the past half century in man's diet, habits, forms of work, and physical surroundings.

Terminal cancer patients, whose initial resistance to experimental inoculations of cancer cells is virtually nil, may nevertheless offer marked resistance to harmful bacteria and viruses. A team of Sloan-Kettering researchers inoculated fifteen terminal cancer patients with live cancer cells and germs. Thirteen patients showed no resistance to the cells, which took root and formed vigorous cancers. This will not ordinarily occur in individuals who do not have cancer. But the same cancer patients produced effective antibodies against inoculations of disease-causing bacteria and viruses.

ENVIRONMENT AND ILLNESS

A balanced attitude toward environmentally induced illness has generally been the exception rather than the rule. In the past, as medical fashions changed, opinion would tend to swing from one oversimplification to another. For a long time, the germ theory of disease discouraged giving serious attention to the environment as a major factor in illness. Attempts to investigate the relationship between environmental change and disease were viewed as a regression to the pre-Pasteur days of medicine. The goals of research, it was declared, are to discover and destroy the microorganisms that cause illness. The physician was conceived to be locked in a struggle with microbes, and the human organism was regarded as virtually the only legitimate arena for waging this conflict. The synthetic and social environments outside man's body seemed irrelevant to the basic problems of diagnosis and therapy, except where sanitation and the isolation of individuals with communicable diseases were involved. (In a brilliant survey of this period, Iago Galdston observes that as late as the 1920's "few among the medical leaders gave much consideration (other than isolation, sterilization) to the 'conditions of person and environment' that favored the agents of infection. The attitude of the medical profession and of the public health workers was well reflected in the campaign slogans forecasting the stamping out of this or that infectious disease by the end of some ten, fifteen, or twenty years. The talk was of war, and the enemy was the
The tuberculosis bacillus, the gonococcus, the spirochete!

This view has never fully explained society's experience with tuberculosis. In Europe, tuberculosis had always flourished among the urban poor, but except for occasional flare-ups here and there, the disease had never assumed the epidemic proportions of cholera and typhus. With the Industrial Revolution, however, tuberculosis became especially widespread and virulent. The crowding of uprooted rural folk into cities, the impoverishment and overcrowding of the new industrial laboring classes, and the decline in nearly all standards of nutrition, health, and sanitation raised tuberculosis from a tenacious but controlled urban disease to an illness pandemic throughout the Western world. The disease did not begin to recede until sweeping reforms were made in the economic life of Europe and America. It was brought under control only after the working classes had achieved shorter working hours, higher income, better housing, and improved sanitation - in short, after the standard of living had been raised. It is no overstatement to declare that the social reformers who were instrumental in getting children removed from the factories and helped bring about higher wages and the eight-hour working day did more to control tuberculosis than did Koch, who discovered the tubercle bacillus.

When it became evident that the incidence of tuberculosis could be attributed to social factors as well as to the presence of a germ, another oversimplification took hold in medical circles. The disease was transformed into a model of environmentally induced illness. In respiratory tuberculosis, a simple, dramatic interaction seems to exist between an infectious agent and environmental conditions. On the one hand, without the tubercle bacillus there can be no tuberculosis; the germ is a disease-causing, or pathogenic, agent. On the other hand, many healthy people in Europe and the United States have had arrested cases of tuberculosis without ever knowing it. The bacillus may continue to exist in an individual's body with no noticeable impairment of the lungs or occurrence of the illness. In most cases, the germ becomes harmful only when physical resistance is lowered. All the elements in the relationship between the illness and the environment seem to be easily determined. A known and observable microorganism can be isolated from the sputum of all tubercular patients. The environmental changes that foster tuberculosis, such as a deterioration in diet and
working conditions, can be interpreted in terms of calories, minerals, vitamins, and even working hours. Normally the disease can be arrested by sufficient quantities of nourishing foods, by rest, and by the administration of drugs.

In contrast with tuberculosis, however, the specific causes of many chronic and degenerative diseases are very obscure. Illness may occur under "favorable" as well as "unfavorable" environmental conditions. Heart disease, cancer, arthritis, and diabetes - the most important degenerative diseases of our time - claim their victims from the well-to-do and poor alike. The environmental conditions that encourage infectious disorders, such as poverty and arduous work, are often absent from the lives of persons afflicted with a degenerative disease. The course taken by a degenerative illness is highly complex, varying markedly from individual to individual. The relationship between environmental change and degenerative disorders lacks the simplicity and drama encountered in cases of tuberculosis. Hence, any emphasis on environmental change in the study of heart disease, cancer, and similar illnesses still meets with a certain amount of reserve and distrust. Everything seems to be ambiguous - the environment, its relationship to the disease, and, at times, even the disease itself.

But the picture is not so bleak as it seems. An illness is obviously environmentally induced when it becomes widespread following a major environmental change. Sharp differences of opinion are likely to arise when the change conflicts with an entrenched point of view in a particular medical specialty. A specialist in tuberculosis, for example, will regard an environmental change as harmful when it results in a reduced consumption of food and in increased physical activity. Many specialists in heart disorders, however, will regard the same change as beneficial. The traditional image of a healthy man - a plump and relatively inactive individual with a hearty appetite - was created in the last century, when tuberculosis was by far the major disease. The new, emerging image of a healthy individual is represented by a lean man who eats sparingly and who engages in a great deal of physical activity. At first glance, we seem to encounter a sharp conflict of views over the factors that promote or inhibit environmentally induced illnesses. But on closer inspection it becomes evident that both views have a common point of departure, namely, in immoderate prescriptions for diet, work, and play. From the extremes of malnutrition and arduous labor, the environmental pendulum in the
Western world has begun to swing to the extremes of over nourishment and physical inactivity. Let us examine some of the dietary extremes. At the turn of the century, many Americans ate too little to meet their physical needs. Today, they eat too much. Although the average caloric intake may be falling, the decline in the need for food is moving at a faster rate than the decline in the intake of food. A farm laborer requires about four thousand calories a day to maintain good health. Engaged in light office work, the same man would seldom require more than two thousand calories daily. Yet it is doubtful whether most Americans engaged in sedentary work limit themselves to so modest an intake of food. They tend to overeat in relation to the work they do. In fact, the average American male over thirty years of age weighs about ten to fifteen pounds more than he should.

Not only does he overeat, but he eats too much of the wrong foods. The annual per capita consumption of sugar, for example, has increased enormously in the past fifty years. "Including sugar consumed in candies, syrups jams, and jellies, as well as for table use and in cooking," observes L. Jean Bogert, "sugar consumption in the United States amounts to over 100 pounds per person yearly, or about a half pound each day for every person in the country. Our annual candy bill is over a billion dollars and has increased over 1,000 per cent in the last 60 years." There has been no noteworthy decline in the overall intake of fats. Although the consumption of butter has fallen off, the per capita intake of margarine and hydrogenated oils has increased.

Has this new form of an old environmental excess played any role in creating the modern disease landscape? The answer is almost assuredly yes. Obesity is closely linked with diabetes. Although a predisposition to diabetes is hereditary, the disease occurs primarily in overweight individuals. Proper management of the disorder involves weight regulation as well as dietary control and the use of insulin. Surprisingly, there also seems to be strong statistical evidence that obese individuals are more disposed to cancer than those who maintain their proper weight. The evidence has been summarized in a popular work on nutrition by Norman Jolliffe, of the New York City Department of Health. "Life insurance figures show I that of all men who bought their policies at age 45 or over, a 25 per cent higher death rate from cancer is noted in that portion of the group which is 15 per
cent or more overweight. Overweight women have a 30 to 45 per cent greater chance of developing a cancer of the uterus than those who are not fat. There is also evidence from the experimental laboratory that normal weight mice are less susceptible to both spontaneous and induced tumor formations than fat ones."

A strong suspicion exists that diets high in dairy fats, animal fats, and hydrogenated oils are implicated in the rising incidence of coronary heart disease. During World War II, the reduction in the amount of fatty goods in the diets of the people in German-occupied countries was followed by a sharp decline in the number of deaths from coronary heart illness. When the occupation came to an end and animal fats returned to the diet, the coronary death rate rose dramatically. The data collected from occupied Europe led to studies of the eating habits of Bantu and whites in South Africa, native and Hawaiian Japanese, Trappist and Benedictine monks, and many other related communities where the effects of low- and high fat diets could be compared in a meaningful way. The Bantu, the native Japanese, and the Trappists, who consume very small quantities of meat and dairy foods, are not seriously burdened by coronary heart illness. Their counterparts, whose diets are rich in fatty foods, have a high incidence of the disease. It has been established by many researchers that the consumption of animal fats raises the level of cholesterol in the blood. The greater the amount of cholesterol deposited in the coronary arteries, the greater the chances of a coronary heart attack. It should be emphasized that the level of cholesterol in the blood can be raised by non-dietary as well as dietary factors and that high cholesterol levels do not necessarily result in vascular disorders. Nevertheless, there is strong statistical support for the belief that the high levels of cholesterol in the blood produced by a normally fatty diet contribute to the rising incidence of coronary heart illness.

These illustrations, needless to say, do not argue for the German occupation of Europe, the Bantu diet, or the virtues of monastic life among the Trappists. The Bantu diet is seriously deficient in nutrients vital to the maintenance of good health, and Trappist monks in contrast with the Benedictines, engage in a great deal of physical work. Many questions could be raised about non-dietary factors that may tip the scales for or against a high incidence of coronary heart illness. What role do certain undesirable habits, such as cigarette smoking, play in the occurrence of the disease? Is coronary heart illness promoted by physical inactivity
and obesity, as some authorities have suggested? Indeed, does any single environmental factor determine the incidence of vascular and heart disorders in a given community? Whatever may prove to be the relationship between these diseases and diet, other factors are suspected of contributing to their occurrence, notably stress, sedentary forms of work, smoking, and a poor genetic endowment.

The problems of research would be simplified immeasurably if every environmental factor that plays a role in degenerative illnesses could be isolated and its effects subjected to precise analysis. Such clear-cut results are likely to be the exception rather than the rule. More than may be suggested by comparative studies of diet, the importance of any factor in chronic and degenerative diseases varies from individual to individual, from region to region, and from illness to illness. In the case of cigarette smoking, for example, the amount of nicotine, tars, and other harmful substances taken in varies with the brand of cigarette, the quantity of cigarettes consumed, and the amount of each cigarette that is smoked. Some individuals may have a stronger reaction to a given intake of nicotine than others. Those who exhibit no apparent ill effects from the long-term intake of nicotine may respond very gravely to tobacco tars. Finally, in many individuals smoking may tip the scales in favor of degenerative diseases that are basically caused by a harmful diet, air pollution, and stress. The analyst is confronted with a constellation of factors in which each factor is meaningful only in relation to all the others.

And here a typical disagreement arises. In the absence of conclusive evidence that a single factor contributes to all cases of an illness, many researchers are inclined to distrust the constellation as a whole. Complexity is regarded as "ambiguity," and the relationship between environment and degenerative illnesses is dismissed as "vague." This kind of thinking is characteristic of our modern Weltgeist. "We prefer to study systems that can easily be isolated and approached by simple methods," observed Alexis Carrel more than twenty years ago. "We generally neglect the more complex. Our mind has a partiality for precise and definitive solutions and for the resulting intellectual security. We have an almost irresistible tendency to select the subjects of our investigations for their technical facility and clearness rather than for their importance. Thus, modern physiologists principally concern themselves with physico-chemical phenomena taking place in living animals, and
pay less attention to physiological and functional processes. The same thing happens with physicians when they specialize in subjects whose techniques are easy and already known rather than in degenerative diseases, neuroses, and psychoses, whose study would require the use of imagination and the creation of new methods."

This comment is still valid today, especially as it applies to attitudes toward complex, environmentally induced illnesses. The study of chronic and degenerative disorders still calls for imaginative departures from conventional approaches to disease. Tuberculosis can be explained by a germ and a number of clear-cut environmental factors. No such explanation can be found for many chronic and degenerative illnesses. Where a contributory factor, such as tobacco tars or a high intake of fatty foods, is evident in the occurrence of a disease, it may prove to be just one of many causes. Moreover, whereas a germ has its own fixed natural history, the factors that promote degenerative illnesses often originate in man's rapidly changing synthetic environment. The influence of environmental factors, in turn, can be seen only through the human organism, whose individual differences often make it difficult to achieve clear-cut analyzes.

But as research progresses, the role of environmental change in forming the modern disease landscape emerges more clearly. Many physicians are now convinced that cigarette smoking, obesity, stress, and a fatty diet have contributed significantly to the high incidence of atherosclerosis and cancer. The link between environment and illness is becoming difficult to ignore. This is not to say that every degenerative disease is environmentally induced. But it is becoming evident that all the revolutionary changes in our synthetic environment, from the rise of an urban society to the use of nuclear energy, have profound biological implications, and that these changes have added an environmental dimension to nearly every area of public health.

**THE HUMAN BODY AND ILLNESS**

The effect of our synthetic environment on health is difficult to gauge for still another reason; namely, the rigid, rather schematic approach to illness that generally prevails today. What, it may be asked, is disease? Or to put the question another way: At what point does a healthy individual become ill? These questions
are not easy to answer. But the difficulties involved deserve careful examination, for they are closely related to the problems created by environmentally induced disease.

Many physicians tend to approach the human organism with a fixed threshold of illness in mind. On one side of the threshold, the body is conceived as being in good health; on the other side, it is diseased and requires treatment. The line between health and disease is generally drawn as sharply as possible. The body ordinarily must reach a certain degree of disequilibrium and damage before it is regarded as ill. This approach would be excusable if it could be attributed merely to a fragmentary knowledge of the complex processes that take place in the human body. But the approach is due, in no small measure, to a lack of interest in the "healthy" side of the threshold, where the conditions for illness are slowly created by insidious changes in the organism. Ignorance is perpetuated by a complacent indifference to many of the basic problems involved in the transition from health to disease.

The validity of this schematic approach has been challenged repeatedly by the findings of modern research in biochemistry, particularly by the results obtained from studies of human cells. It should be a truism that the majority of human illnesses are fought out on the cellular, even the molecular, level of life. Whether we survive an illness or not depends on the number and types of cells that are damaged during the course of the disease. Ordinarily, however, we tend to regard the damaged tissues of the body as the passive victims of physical disorders. When infections occur, we think of white blood cells rushing to devour bacteria and of antibodies inhibiting the effects of toxins. We seem to believe that resistance to disease is exclusively the function of certain specialized organs and systems within the body. The health and resistance of cells that are involved in the more routine functions of an organism are seldom regarded as important in the prevention or outcome of an illness.

Yet many human disorders would be difficult to explain without acknowledging the significance of general cellular well-being. An example is supplied by pellagra. Pellagra is caused by a deficiency of niacin, a member of the vitamin-B complex. A lack of niacin or of the amino acid tryptophan (a chemical precursor of niacin) produces a broad spectrum of disorders, ranging from skin eruptions to mental
aberrations. As the disease progresses, changes occur in the tissues of the mouth followed by ulcerations, a slough of dead cells, and the proliferation of disease-causing germs. At this stage, secondary infections, such as trench mouth, often set in. The infections are caused primarily, not by the germs, many of which are present in healthy individuals, but rather by molecular changes within the cells which slowly lower the defenses of tissues in the mouth. The cells that line the mouth and tongue are in ill health. To borrow the words of a great American nutritionist, they have suffered a loss of "tissue integrity." The decline in cellular health, often very protracted and insidious, may not be clinically perceptible for a long time.

The concept that cells can be in ill health long before the appearance of symptoms in the form of a conventional disease, receives strong support from cancer. (Cancer cells can be regarded as ill not only because they are abnormal and produce disorders in the organism as a whole, but also because their biochemical processes seem to be impaired. For example, Otto Warburg, of the Max Planck Institute for Cell Physiology in Berlin, has advanced the theory that cancer is due to changes in the manner in which cells obtain energy. According to Warburg, cancer-causing substances damage the cell's respiratory mechanisms, causing it to obtain energy by fermentation. In cases in which cancer is caused by viruses, the cells can be regarded as infected; their reproductive apparatus is controlled or deranged by the presence of an alien agent.) Many functional differences distinguish cancerous from non-cancerous cells. Cancer cells not only multiply uncontrollably at a given site; in many cases they also spread, or metastasize, to vital organs elsewhere in the body. Metastasis accounts for most of the lives claimed by the disease. Normal cells multiply in a regulated manner and, except for certain highly specialized cells, never migrate from the tissues in which they originate. Careful studies of the development of cancer in experimental animals suggest that cells seldom become malignant until they have passed through many gradations of ill health. Any meaningful discussion of the disease must take account of healthy cells, cells in varying degrees of ill health, precancerous cells, which impart abnormal characteristics to tissues, and finally true cancer cells, which reproduce uncontrollably. Few if any of these gradations are likely to manifest themselves in noticeable symptoms of disease. Although the transition from normal to
precancerous and cancerous cells may occur very rapidly, it is highly probable that the majority of malignant tumors arise only after a cell and its descendants have silently traveled a long road from health to a precancerous and then a cancerous state.

That this kind of deterioration can occur should not surprise us. Cellular metabolism is so complex that many things can go wrong in a cell without producing major symptoms of disease in the organism as a whole. A living cell engages in an enormous variety of chemical operations in which extremely complex molecules are built up and broken down at a rapid pace. A delicate balance exists between the absorption of nutrients and the excretion of waste products. If this balance is altered a trifle for any length of time, dysfunctions will occur in the cell. If it is altered a bit more, vague symptoms of illness may appear. If blood or oxygen is denied to certain organs of the body for a very short period of time, irreparable, even fatal, damage will occur.

But many disorders may persist without ever assuming an overt form. The activities of cells, tissues, and organs may be retarded; adverse changes may occur in the body's complex metabolic functions; in time, physical activity may be impaired and longevity reduced. If changes of this nature occur in a large number of individuals, our standards of public health may be lowered imperceptibly. Such individuals will not be regarded as ill in the conventional sense of the term. In fact, until they are afflicted with cancer or heart attacks, they will satisfy all the schematic criteria for glowing health.

Fortunately, the need to give greater attention to covert, or subclinical, disturbances in the human body is gaining increasing recognition. For example, it is worth noting the way in which former U. S. Surgeon General Leroy E. Burney discusses the hazards that are created by low-level concentrations of chemical toxicants in water. "They are not killing us or making us clinically ill. But how does the human body react to steady doses of diluted chemicals? What happens if the concentration increases, either suddenly or gradually? We cannot say that we know the answers." The same problem is raised by Robert A. Kehoe, of the University of Cincinnati. After a review of the toxicants, physical hazards, radioactive pollutants, and "welter of activities" created by our synthetic environment, Kehoe asks: "But what are the consequences, through the working life time, of the frequent, almost
daily, impacts of individual and collective insults of minor or sub-clinical severity?"
Attention should be focused on Burney and Kehoe's concern for sub clinical
damage, a concept that is not particularly congenial to the outlook of the American
medical community.

It is difficult to see how the problem of sub clinical damage can be ignored in
investigations of cancer and nutritional disorders. Researchers are constantly
seeking better methods for the early diagnosis of malignant and pre-malignant
tumors. But diagnostic techniques, however desirable, are not at issue here. If it
can be inferred from the complexity of man's metabolism that ill health can exist
long before it becomes medically evident, it follows that the greatest care should
be exercised in changing man's environment. Where changes are desirable, they
should be preceded by meticulous and imaginative studies. And where changes are
necessary, every precaution should be taken to minimize any ill effects they may
have on the human body. It would be utter folly to introduce needless changes in
man's diet, forms of work, habits, and physical surroundings without investigating
their effects from the broadest perspective of public health.

Environmental changes should be studied not only in relation to the more dramatic
effects they have on man; study should also be focused on the subtle changes
produced in tissues and bodily functions. In addition research should be directed
toward disorders that may arise years after a new product is offered for public
consumption. Whenever an inessential product is suspected of being harmful to
man, its sale or distribution should be prohibited. The concept of environmentally
induced illness should include all structural levels of the human organism and
encompass not only present but also future generations.

MAN AND THE NATURAL WORLD

Unfortunately, the amount of research devoted to environmental health falls far
short of current needs. Many important problems are being neglected for want of
funds and trained personnel. Where research is intensive, it is often fragmentary
and uncoordinated. "Separate approaches to specific problems have had great
practical value," notes a recent report by the Surgeon General to the House
Appropriations Committee. "They have provided effective mechanisms for getting
at critical phases of important problems... But the many and complex
interrelationships among those problems have become increasingly apparent, and it is obvious that they must be considered as parts of a whole... To achieve a 'total view,' there must be an integration of research and control methods. The knowledge and skills of many professional specialties - physicians, engineers, physicists, chemists, educators, statisticians among them - must be further coordinated in seeking scientifically sound answers to the many challenging questions in the field of environmental health."

These words are more a complaint against the absence of a "total view" than a tribute to "separate approaches to specific problems." Time is running out. Many passages in the Surgeon General's report would be dismissed as doleful exaggerations if we were not aware of the fact that they come from an official and highly responsible source. "New chemicals, many of them with toxic properties or capabilities, are being produced and marketed, and put into use at a rapid rate," the report observes. "These include plastics, plasticizers, additives to fuels and foods, pesticides, detergents, abrasives." An estimated "400-500 totally new chemicals are put into use each year... Although many commonly used chemicals are checked for toxicity, much is still unknown about their long-term potential hazards." The report warns that while "the modern supermarket and frozen food locker permit the use of a wide variety of foods, with resulting nutritional benefits,... modern methods of growing and processing foods introduce new hazards of pesticide spray residues, preservatives and other food additives, and even contaminants related to packaging, which require attention for control." An ominous generalization at the beginning of the report could well serve for its conclusion: "It is not being over dramatic to suggest that threats from our environment, actual and potential, can not only generate wholly undesirable effects on the health and well-being of isolated individuals, but under certain circumstances could affect large segments of our population and conceivably threaten the very existence of our Nation."

Despite the frankness of the Surgeon General's report, the federal government not only has failed to meet these problems resolutely but has directly and indirectly contributed to them. The indirect contribution was made through inaction. It took nearly a half century of debate, both in and out of Congress, to obtain national legislation which made manufacturers legally responsible for pre-testing food
additives. Until 1959 the job of establishing whether a food additive was harmful was performed by the Food and Drug Administration, and attempts to prohibit the use of such additives often involved long and costly judicial proceedings. The same legislative procrastination is now being encountered in connection with new environmental health problems. Although air and water pollution has reached staggering proportions, national legislation to combat it is creeping forward at a snail's pace. At the same time, government-subsidized nuclear energy programs are creating one of the most hazardous sources of air and water pollution in man's environment. The harmful consequences of these programs outweigh any improvements that may have resulted from recent laws to control food additives. On balance, the over-all situation is deteriorating with every passing year.

The problems of our synthetic environment can be summed up by saying that nonhuman interests are superseding many of our responsibilities to human biological welfare. To a large extent, man is no longer working for himself. Many fields of knowledge and many practical endeavors that were once oriented toward the satisfaction of basic human wants have become ends in themselves, and to an ever-greater degree these new ends are conflicting with the requirements for human health. The needs of industrial plants are being placed before man's need for clean air; the disposal of industrial wastes has gained priority over the community's need for clean water. The most pernicious laws of the market place are given precedence over the most compelling laws of biology.

Understandably, a large number of people have reacted to the nonhuman character of our synthetic environment by venerating nature as the only source of health and well-being. The natural state, almost without reservation, is regarded as preferable to the works of modern man and the environment he has created for himself. The term "natural" tends to become synonymous with "primitive." The more man's situation approximates that of his primitive forebears, it is thought, the more he will be nourished by certain quasi-mystical wellsprings of health and virtue. In view of the mounting problems created by our synthetic environment, this renunciation of science and technology - indeed, of civilization - would be almost tempting if it were not manifestly impractical. An unqualified idealization of the natural world involves an acceptance of many environmental conditions that are distinctly unfavorable to human life. Until the advent of civilization, nature shaped
the course of human evolution with severity, visiting death on all individuals who could not satisfy her rigorous requirements for survival. Millions of people are living today who could not have met the demands of a more primitive way of life. They would have perished on the battlegrounds of natural selection as surely as the young and fit are now destroyed on the battlegrounds of modern war.

A much greater impediment to a rational outlook, however, springs from a tendency to ignore man’s dependence on the natural world. The extent of this dependence cannot be emphasized too strongly. The great diversity of racial types reminds us that human communities have followed their own distinctive lines of evolution. Each has adapted itself over many millennia to different climatic and physical conditions. Many subtle differences in needs exist among human groups, indeed among individual types. "Changing conditions of life affect individuals and groups," observed Wade H. Brown, of the Rockefeller Institute, a generation ago, "but as individuals differ in respect of their inherent constitutional equipment, they differ also in their reactions to influences of all kinds. Some are capable of immediate and complete adjustment, others are slow to respond or are incapable of adjustment, so that when members of a group are subjected to a change in the conditions of life or are exposed to infection under favorable or unfavorable conditions, the response obtained varies according to the capacities of the individual." Medicine and technology are providing only partial compensation for the harmful effects of new diets, changed modes of work, and unfamiliar climates. Technicians can supply a fair-skinned man with air conditioning in hot tropical regions. They can clothe a Negro in effective heat-retaining garments in the cold northlands. But these measures are only ad hoc solutions to the threat of extinction. In their new environment, both men must function as limited individuals, restricting their activities and normal mode of life.

At the same time, we should not lose sight of the needs all men have in common. Every human being has minimum requirements for certain nutrients. Although human diets may be modified by differences in climate work, and available foods, these modifications usually represent differences in nutritional emphasis, whether on proteins, carbohydrates, or fats. The human body must be employed in a variety of physical activities, or it will weaken and health and possibly longevity will be adversely affected. New toxicants dangerous to men of one race are equally
hazardous to men of other races. The appearance of these toxic agents in the atmosphere, water, and foods threatens the health of every human being. As we shall see later, the extent to which they threaten man may differ appreciably from the extent to which they threaten other species, so that experimental work with animals does not always disclose the damage the new toxicants produce in human beings. For the present, it should be emphasized that the limits of environmental change were staked out by forces well beyond human control. After eons of biological evolution, man is subject to unrelenting anatomical and physiological demands. If these demands are ignored, he faces the revenge of his own body in the form of early debilitation and a shortened life span. His basic needs for optimal health have largely been decided for him by his long development as a unique animal organism. Lastly, man must live in harmony with myriad forms of plants and animals, many of which are indispensable to his survival. In the long run, a fertile soil is just as important for human health as clean air and water. Adequately nourished animals are as necessary for man's well-being as adequately nourished human tissues. Any serious disorders in the land or in plants and animals eventually produce disorders in the human body. Man tends to weaken and give way to illness as the natural preconditions for his health are undermined by erosion, disease, or pollution. Nearly all the abuses he inflicts on soil, plants, and animals are returned to him in kind, perhaps indirectly, but all the more malignantly because the damage is often far advanced before it can be seen and corrected.

We tend to view problems in the world of living things - the biosphere - with the same schematic approach that we bring to environmental health problems. We demand evidence of a marked injury to man's natural surroundings before we are ready to agree that there exist problems that require solutions. We make sharp distinctions between order and disorder in nature, just as we draw a sharp line between health and disease in man. Nevertheless, the same kinds of qualitative problems we encounter in the physiology of human beings reappear in ecology; that is, in the study of how living things interact with one another and with their environment. Every organism has its own environmentally induced illnesses. The environmentally induced diseases of plants and animals, like the chronic and degenerative diseases of man, are due to a multiplicity of factors. And just as many
disorders may persist in man without ever assuming an overt form, covert illness may persist in plants and animals without ever producing clear-cut symptoms of disease.

The caution that should be exercised in changing our synthetic environment should also be exercised in changing the biosphere. Never before in man's history has there been a greater need for what Ralph and Mildred Buchsbaum call the "ecological viewpoint" toward man's influence on the natural world. This viewpoint is "the conservative view of man's relation to his total environment. It holds that an environmental setting developed by natural selection over many millions of years must be considered to have some merit. Anything so complicated as a planet inhabited by more than a million and a half species of plants and animals, all of them living together in a more or less balanced equilibrium in which they continually use and reuse the same molecules of the soil and air, cannot be improved by aimless and uninformed tinkering. All changes in a complex mechanism involve some risk and should be undertaken only after careful study of all the facts available. Changes should be made on a small scale first so as to provide a test before they are widely applied. When information is incomplete, changes should stay close to the natural processes which have in their favor the indisputable evidence of having supported life for a very long time."

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