3 January 1958, Volume 127, Number 3288 SCIENCE

The Inexorable Problem of Space

Paul B. Sears

Discovery and communication are the two prime obligations of the scientist. On occasions such as this, however, the scientist has the added opportunity to examine broad issues in the light of his peculiar knowledge and experience. This I propose to do with respect to that limited segment of space in which we live, move, and have our being. For my subject was chosen long before man's most recent and dramatic invasion of outer space.

Science and Perspective

My thesis is that, among the practical problems of humanity today, our relation to immediate space is of critical importance. In developing this idea, I shall try to show that our applications of science have been both restricted and shortsighted. In terms of moral choice, we have looked upon science as an expedient rather than as a source of enlightenment.

To be specific, our very proper concern with the applications of mathematics, physics, and chemistry may be clouding the fact that we need biology in general and ecology in particular to illuminate man's relation to his environment. At present the biological sciences are largely sustained as utilities in medicine and agriculture, the social sciences for dealing with immediate ills. But we must not forget that all science is needed to guide the process of future evolution —cultural and physical—now so largely in our own hands. The nest of anti-intellectualism is being warmed by the ignorant, but some of the eggs in it may have been placed there by those who should know better.

Science and Policy

I have no quarrel with the exploration of outer space. It is a legitimate and challenging subject for scientific inquiry and bold experiment. Our optical and mathematical studies of it have long since given us that basic confidence in order without which there could be no science. But, as we extend our astronomy by whatever celestial acrobatics we can get away with, I should like to see some consideration given to relative values. We have a vast amount of unfinished business at our feet. The golden moment for the pickpocket comes when everyone at the county fair is craning his neck at the balloon ascension.

So far as the skies are concerned, we are feeling the natural soreness that comes from losing a sporting event we thought was in the bag. Actually, if my information is correct, the Russians had explained that they intended to launch a satellite, had indicated its probable size, and have promised to share the knowledge so gained. Since any ray of light should be welcomed in an atmosphere of gloom, it may help to recall that our Olympic athletes, in the face of leading questions from their interviewers, had nothing but respect to offer for the conduct of their Russian rivals.

Of course our present concern is much more than simple chagrin at losing a contest. What has happened in outer space raises a question about how outer space will be allocated and controlled. We fear, not unreasonably, that whoever controls the space around the earth can impose his will upon all who live on the earth's surface.

Though we grant freely the military significance of space experiments, our present hysteria seems to me to indicate an even deeper source of insecurity. We are beginning to sense that the elaborate technology to which we are so thoroughly committed makes us peculiarly vulnerable. And we are not wholly confident that the ideals of our civilization —so reasonable to us—will really stand up to free competition with other systems of thought. To the extent that this is true, we suffer from an initial handicap of morale.

The pattern of conflict is much the same, regardless of scale. Whether one is watching small boys in the school yard or great powers in the world arena, the preliminaries are marked by bad manners and vituperation on both sides. Missiles are piled up and seconds are assembled, the advantage going to the cooler, less hysterical side. The contestant who gets rattled is asking for trouble.

I do not envy our public servants charged with the delicate business of managing international relations. But I am firmly convinced that unless one is determined on war, there is merit in self-restraint and good manners, as well as in prudent measures of self-protection. I am also convinced that the choice of policy is not limited to boasting and belligerence on the one hand or craven appeasement on the other. We have no monopoly on self-respect and other human virtues, nor is there any merit in debasing the original meaning of the word *compromise* as we have done. We should deplore every display, whether by statesman or journalist, of dunghill courage that lessens the hope of mutual understanding, good-will, and ultimate collaboration among human beings.

Dr. Sears, retiring president of the AAAS, is chairman of the Conservation Program at Yale University, New Haven, Conn. This article is based on his AAAS presidential address, which was given 28 December 1957, during the Indianapolis meeting.

So far as purely domestic problems go, our almost hypnotic concern with outer space comes at a bad time. Outer space is one more item that diverts attention and energy from the prosaic business of setting our terrestrial space in order. And it has fostered an incredible type of escapism that must be experienced to be believed. One hears too frequently for comfort the sober assertion that we need not worry about depletion of natural resources, now that interplanetary travel is just around the corner! If such a comment came from jesters or cranks, it could be disregarded. But we hear it uttered with the solemnity and assurance of the true believer. No doubt we shall continue to hear it, despite the chilling analysis by Arthur Clarke, the British astronomer, in the November 1957 issue of *Harper's* magazine.

Actually this obsession is not a detached phenomenon. Rather it is the culmination of a new faith—the belief that technology will solve any problems that may confront humanity. Curiously, it comes at a time when the scientist is more suspect than he has been since the days of witchcraft and alchemy, as recent opinion studies show. A high proportion of people consider scientists to be queer fish, if not inhuman and immoral. For a parallel we would have to think of a religion which wants the favor of its gods but does not trust them for a moment.

Opportunistic Application of Science

I do not question the tremendous accomplishments and future possibilities of technology. I yield to no one in my admiration for the cleverness, manual and intellectual, of those who apply science to meet the needs of mankind. But faith in technology is not faith in science or sympathy with the creative impulse of the scientist. The direction in which science is applied depends upon the values of the culture applying it even while science is in turn modifying the culture.

Our present applications of science are selective and opportunistic, neither wholehearted nor balanced. We are applying it out of all proportion to the elaboration of consumer goods, often to such an extent that vast sums must go into persuading people to desire what they have not instinctively wanted. The making of things has become so facile that their sale creates major problems in advertising and credit. As Max Beerbohm once put it, "Buy advertised goods and help pay the cost of advertising." Some of the keenest satire on advertising has come from advertising men themselves. Raymond Loewy, the famous automobile designer, has protested the corruption in car design that has resulted from too great facility—traditionally the death of any sound art. The current models waste space, materials, and fuel, violate good taste, and impose needless economic burdens on the public. And while we are applying science in this manner, we are blandly ignoring its highest function, which is to give us perspective and inform us about what we are doing to ourselves. Even the scientist, as Kubie has so ably shown, suffers from his lack of self-analysis.

On the whole, a man's actions are a response to his idea of the kind of world he thinks he is living in and to his concept of his own nature. That this is true is shown very practically in the history of human thought: No great religion is content merely to lay down maxims of conduct; it also develops its own cosmogony, its own pattern of the universe, to justify those maxims.

Our present attitude toward terrestrial space exemplifies with peculiar clarity our selective use of science. For living space, if we consider both its extent and quality, subsumes all other resources, being in that respect equivalent to the economist's technical concept of land. Yet the power of applied science has been overwhelmingly employed to exploit space, while those aspects of science which could illuminate its wise and lasting use are still largely ignored.

I am assuming at the outset that the human adventure on this planet is worth our best efforts to keep it going as long as possible. I am also assuming that man is capable of responsible judgment and conduct and that he has at hand much of the important basic information he needs. Finally, I am assuming that it is not enough for man to live by bread alone but that intangible, as well as tangible values are necessary to justify his persistence. If this be true, the question is, not how many people can exist on earth, but what kind of a life will be possible for those who do.

Limiting Factors

From New Jersey to Oregon one sees great egg factories, where highly selected strains of poultry are confined at maximum density and with maximum efficiency. Every need—nutritive, environmental, and psychological—is taken care of. These gentle, stupid birds have no responsibility but to stay alive and do their stuff. Yet they are at the mercy of any break in an elaborate technological mesh that keeps them going. And should a stranger burst abruptly into their quarters, the ensuing panic would pile them up in smothering heaps in the far corners of their ultramodern apartment. The underprivileged, pretechnological hen ran many hazards, but at least she had the freedom to scratch around for food and a sporting chance to dodge under a bush to evade the swooping hawk.

People, of course, are not poultry, but they are living organisms, subject to the limitations inherent in that condition. I am unmoved by any protest against applying biological analogies to human society. Analogy is one of the most powerful tools of the scientist. From physics to physiology, and notably in the latter, analogies suggest our models which we must then test and either accept or reject as the evidence may dictate. And besides, man is a living organism, as I have said.

Fortunately, in considering man's relation to terrestrial space, our models do not all come from observing other forms of life. We have some impressive ones furnished by our own species. Let us reserve them, however, for the present, and look at the other living things. Here from students of bacteria, trees, insects, or any of the sundry groups of vertebrate animals—fish, fowl, or mammal—we get the same story. No known form of life has been observed to multiply indefinitely without bumping up against the limitations imposed by the space it occupies. These limitations involve not only quantity but quality. And quality rests upon the pattern of that complex of factors, whether known or unknown, that are necessary to sustain the species in question. So far as environment is concerned, an ancient bit of wisdom sums up the situation: "A chain is no stronger than its weakest link."

This principle was recognized by Liebig in his famous law of the minimum: the growth of a crop is determined by the essential nutrient available in least quantity. It was restated more precisely by Blackman in his law of limiting factors: physiological processes are limited by the least favorable factor in the system of essential conditions. These statements rest upon controlled experiment. They are independent of the circumstance that an English political economist and parson, Malthus by name, had suggested that human populations did not, in fact, increase indefinitely beyond certain limitations of environment.

It should be emphasized, however, that the writings of Malthus did give the necessary clue that enabled Charles Darwin to formulate a reasonable explanation of the mechanism involved in the origin of species. Since there remain many misconceptions with regard to both Malthus and Darwin, it may be well to review the thesis of the latter. This thesis has never been successfully controverted, although there are perennial headlines "Darwin Refuted" whenever some detail of his work is brought into question. Briefly, Darwin had noted the universal tendency of organisms to vary and to transmit these variations to their offspring. Our knowledge with respect to these matters is now being applied daily by plant and animal breeders with the same effectiveness with which the phase rule is used in chemical engineering.

Darwin's second point was that organisms tend to reproduce far beyond their capacity to survive. This again in fact occurs, and is a matter of household knowledge among those who, as scientists, observe living organisms. The tagging of fish that return to the place where they began migration reveals that, despite the thousands of eggs laid by each female, not more than a few adults from each batch survive to make the return journey.

Anyone who has observed, year after year, the nesting of robins in his yard has noted the consistent toll—from cats, jays, crows, and accidents—that serves to keep numbers down. And though the clutch of eggs is fairly uniform from year to year—implying a potential doubling of the robin population—the number of nests does not increase significantly, nor do these birds spread beyond a well-defined territorial range. Even though predators might fail to control their numbers, competition within the species would establish a threshold of limitation, as it did for deer when wolves were eliminated.

The final point made by Darwin was that the relatively small proportion of individuals surviving did so, not merely by random chance, but largely because they were those best fitted to cope with their environment. The less favorably endowed tended to be eliminated. Thus the better adapted lived to transmit their favorable variations. In this way he accounted for two great riddles of living nature—the immense variety of living things and the remarkable adjustments they show.

It is not my object here to justify Darwinian theory. It is enough to say that the theory coordinates more information than any alternative that has been proposed. This is all we have a right to ask in science. We need emphasize only one corollary—that the pattern of environment is built solidly into that of life. Survival rests upon this relationship. No organism known to biologists has ever, so to speak, had things completely its own way. Some, of course, are more "successful" than others, as the late L. O. Howard indicated in his famous dictum that the last survivor on earth would be a living insect on a dead weed.

Extension to Man

The rub comes when we attempt to extend these principles to our own species. As life has advanced from simple beginnings, it has played an increasing role in geological processes. Man is no exception. He is a world-wide dominant, the first such species in earth history. And through advancing technology he is producing tremendous changes. That this should confer a sense of power is understandable. But power is not the same thing as control. Only when power is balanced by responsibility is there control, as the record of our highway accidents attests. The corrupting effect of irresponsible power is an axiom in human history.

Is there any reason to believe that man is exempt from the rules that apply to living organisms in general? Or does the difference lie in his ability to learn those rules and profit by respecting them? Can we make use of known physical and biological principles in discussing problems that involve man? Can we view psychological and sociological considerations in the light of simpler and more obvious ones, or must we rely solely upon a higher level of discourse when we speak of man? These are not idle questions. I have mentioned the indignant protests against applying "biological analogies" to sociological problems. But it is one thing to hold that man is *merely* a physicochemical system, or *merely* an animal, and quite another to insist, as I must, that he is a physical phenomenon, and a biological one too, whatever else he may be.

Man's physical body occupies space, somewhere between two and four cubic feet of it. At his present rate of increase in the United States, he is set to double the aggregate volume occupied by human bodies in about 41 years. Continuing at this rate, it would be less than 700 years—say 22 generations—until there is standing room only, with each space of 3 by 2 feet, or 6 square feet, occupied. On this basis there is room for exactly 4,646,400 people in each square mile. I have perhaps been overgenerous in estimating the per capita area, but I did wish to leave space enough to permit each individual to reach in his pocket for the rent money when it falls due. A little after this the hypothetical human population would weigh more than the planet.

In thus giving rein to imagination I have in mind sundry pronouncements regarding the potential capacity of the earth, some of them to the effect that by proper scientific management it can take care of any conceivable increase in population. The numbers I have mentioned are both conceivable and begettable. The question is, are they supportable?

Some Examples

The most densely populated continent is Europe, with 142 people per square mile, as against Asia with 78, although the most densely populated areas are as yet on that continent. Australia follows with 31, then North America, including great areas of desert and tundra, with 23, while Africa and South America are nearly tied, with 17 and 16, respectively. The figure for the United States is 51, intermediate between that of Australia and Asia. Evidently cold fact, as so often happens, has not kept pace with theory. Either people do not breed as fast as they might, or survival rates are not what they could be. Actually both of these things happen, and in curious combinations. We may, I think, allow the battered bones of the Reverend Malthus to rest in peace as we examine a few case histories quite briefly.

First, however, let us retrace our steps for a glimpse at what we pleasantly call the lower orders of life. Abstracting an item from the valuable studies of Thomas Park, we learn that when populations of flour beetles reach certain densities, their rates of increase drop sharply. Among other things, these animals begin to eat their own eggs and pupae, a very effective way of slowing down the operation of the compound interest law. Whether this practice is due to a craving for food and water or simply to the fact that hungry beetles bump into eggs oftener than before, we do not know.

The lemmings in Alaska are likewise instructive. These small rodents, living and breeding under the snow, have a kind of pulsating population record,

abundance alternating with low density in fairly regular fashion. With summer melting, they are preyed upon by a variety of animals, including the Arctic fox and snowy owl. A third predator, the jaeger, a kind of sea hawk somewhat resembling a gull, has been studied by Frank Pitelka, who reported on it at the Berkeley meeting of the AAAS. When the lemming population is low or average, the jaegers space their nests and consume their prey in an orderly manner. But when the lemmings are at a peak, so that food should be no problem, the jaegers spend so much energy quarreling over nesting space and food that relatively few of them raise normal broods. So their numbers decline, but not primarily from lack of food. They do not urbanize well—or shall we say that when they attempt to urbanize they pay the usual penalty of a greatly lowered reproductive efficiency? For it is, I believe, an open secret that few cities of major size have heretofore maintained their population by their own birth rate—a situation that is probably changing through the rapid development of suburban life. Perhaps it is time for some modern Aesop to instruct us on manners and morals, using for that purpose the verified behavior of animals instead of their imagined words. Certainly we learn that for the jaegers plenty is not an inevitable road to biological success.

Yet the idea of plenty—in food in particular, in energy and minerals to a lesser degree—dominates the discussion by scientists of man's future. Some of this material is excellent, notably that by Harrison Brown, who not only understands the physical sciences but has biological sense and a conscience to boot. Too few, however, bother to read the fine print and observe the *if*'s in such analyses as his. Those who, like Osborn, Cook, Sax, and Vogt, concern themselves with space and numbers are written off as "pessimists," as though the fixing of a label adjudicates the issue and solves the problem.

It is the merit of the men named, including Brown, that they have raised not only a material but a moral issue that is too often neglected by those who proudly label themselves "optimists." The question is not only how much but what kind of life will be possible if humanity continues to hurtle along its present course. Russell, the Huxleys, and Berrill have all warned us of the inevitable loss of freedom and personal dignity that must follow the multiplication of numbers and the depletion of resources.

Physical Limitations and Cultural Influences

The findings of archeology are in agreement with recorded observations of prefarming cultures about the space requirements of hunters, fishers, and gatherers. For such folk the space requirements are great, by modern standards, being no less than three to five square miles per person where conditions are most favorable. The best estimates for pre-Columbian United States, even with such agriculture as it possessed, do not reach three million in about the same number of square miles. Specifically, the state of Ohio, some 40,000 square miles, mostly fertile and well-watered, does not appear to have supported more than about 15,000 Indians at the time of European discovery. Even the Basin of Mexico, with a highly efficient system of horticulture and an imposing array of domesticated plants, did not have numbers exceeding a million—one-third the population of the present Mexico City, which occupies only a fraction of the modern basin.

Yet we know that this rather moderately concentrated population experienced pressures of various kinds during the centuries preceding 1519. However the situation might be rationalized, the limitations of space, with regard to both extent and quality, were stern and tangible within the Basin of Mexico. The ancient chronicles are a record of floods, drouths, volcanism, and hunger. Toward the end of the Aztec Empire, in a desperate attempt to placate the angry gods, human sacrifice was stepped up until it reached scores of thousands—suggesting the rate of emigration that today serves to stabilize the population of Ireland, whose chief export is people.

Our judgment of the whole history of agriculture has been revamped since the 1930's. Dale and Carter have done this brilliantly, showing that every great center of power and civilization has been based squarely upon fertile space, and tracing the parallel decline of culture and the nutrient capacity of the soil.

Certainly human communities have, as a matter of record, more than once run hard into the physical limitations of their environment. Often they have intensified these limitations by their own activities. That man can preserve and even enhance the potential of his environment, I do not question. But I see no warrant for asserting that he has often done it or can do so indefinitely under his present pattern of behavior.

Limiting factors are not necessarily physical in the strict sense. Cultural disruption and spiritual discouragement may likewise act as restraints. This is believed to explain the well-known decrease of the native Indian population during the century following the Spanish conquest of Mexico. With little to live for, people may simply not have families, whatever the physiological facts and urges may be. Another instance is that of the slave population in Jamaica prior to 1842. The white population, numbering less than one-tenth that of the slaves, vigorously discouraged breeding among the slaves, since it was cheaper to buy new slaves than to propagate them. Nevertheless, the apathy toward life, attested by the high suicide rate among victims of the slave trade, is believed by competent authority to have been an important factor in the low effective reproduction rate among these pathetic humans.

If we come closer home, we have the significant drop in family size during our own depression of the 1930's. In this instance, the slow-down cannot be attributed to pressure from the physical environment, for the depression preceded the great drouth. Even then there was no real scarcity of food, merely a breakdown in the mechanism for its economic distribution. Presumably the direct pressure came from cultural anxiety, or what is sometimes called "social shock." Even the "recession" of 1949–50 produced a measurable effect, total births in 1950 numbering 17,000 less than in 1949.

We have, too, the earlier decrease in the British birthrate about 1921. This was the year in which Marie Stopes, already famous as a paleobotanist, enlightened the public on responsible parenthood. It was also a time of high postwar prices, and subsequently a time of flaming individualism. But it was not, so far as I know, a period of physical pressure from environmental forces. Having myself reared a family during the 20's and 30's, I can testify that in our own country there were many cultural pressures, neither physical nor economic, that encouraged one-child or at most two-child families. Not least among these pressures was increasing focus upon the personality and development of the individual child, at times to the point of morbid sentimentality.

Cultural influences can also act in the opposite direction, the classical instance being in the scriptural injunction to be fruitful and multiply and replenish the earth. Today, despite the staggering cost of education and the increasing cost of food—unchecked by our continuing agri-

cultural surplus—the four-child family is in vogue. Incredible though it may sound, it is through the influence of fashion (call it example or prevailing custom if you prefer) that many modern families work out their response to the problem of population and space.

Certainly the record suggests that population density is influenced both by the physical and the cultural environment. However these may operate, either singly or in conjunction, they find expression in the behavior of individuals, and individuals differ greatly. Indeed, one of the most difficult of problems is to sort out the strands—cultural, physiological, intuitive, and rational—that are interwoven into the fabric of individual values and conduct. As Russell has pointed out, and as those who style themselves "human engineers" know only too well, the new psychology has little comfort to offer about the importance of reason in human conduct. This would be especially true among those least capable of using it, yet I, for one, would not give up what confidence we have in it.

Coming now more specifically to the problem of space, we find that the grim facts in certain countries which we euphemistically call "underdeveloped" speak for themselves, as anyone who has visited the Orient, the West Indies, or certain portions of Latin America must honestly admit. Humane and successful efforts to improve health conditions in such areas have, to date, merely intensified the problem, while equally high-minded efforts to improve food production and distribution have only deferred a solution. Ceylon, where disease control has resulted in doubling the population in less than a score of years, is a classical example. Meanwhile, food production has not kept pace, and the usable area of the island has been increased only very slightly through drainage of malarial swamps.

Technological Vulnerability

Perhaps the one bright spot in this gloomy picture is that many of the leaders in these crowded countries are now frankly recognizing the problem and trying, according to their various lights, to face it. But while I would not suggest for a moment that we allow them to stew in their own juice, I do suggest that our own problem deserves more attention than it is getting. The very fact that we have a margin of safety not enjoyed in many parts of the world is both a challenge and an opportunity. Let me recite a few facts, even though they may be familiar.

That the productivity of our agriculture can be increased far beyond the limits of the present surplus is not questioned. But each increment in production calls for increasing capital outlays. The investment in machinery, to say nothing of that in fertilizers, feed supplements, maintenance, taxes, and insurance, frequently approaches the value of the land. The knowledge, skill, and competence of the successful farmer today rivals that tolerated in the practice of medicine fifty years ago. In that interval our farm population has diminished by more than a half, being now less than 20 percent of our total population. The pressure to keep costly machinery earning its way often results in extensive operations at the cost of personal attention to those details which prevent deterioration of the whole enterprise, and which, in the end, may make the difference between profit and loss. So meager is the margin that a significant and growing number of model farms are now owned by industrialists and other people of means to permit legitimate losses on their tax returns. So far as our ultimate food and fiber supply is concerned, we need not expect something for nothing. The late Robert Salter, surely a very conservative individual, pointed out that the high yields from hybrid corn were definitely being obtained at the expense of soil fertility. In the corn belt, yields of 100 bushels per acre are now about one-third as frequent as they once were. My guess is that farm surpluses will be only a memory within two decades.

Alternative methods of production are, of course, being proposed and investigated. Most of these involve increasing dependence upon elaborate technological devices, hence increasing energy, capital, and maintenance costs. Equally serious is the increasing vulnerability that comes from utter dependence upon elaborate technological systems. This can be illustrated by what has occurred when a brave and competent army, trained to rely solely upon mechanical transport, has faced in difficult terrain an enemy hardened to simpler and more primitive methods. It was illustrated by the comparative ease with which the Ozark hill people adjusted to a depression while their highly dependent urban neighbors were thrown completely out of gear for a long period of time.

I forbear to recite what would happen to some of our great urban centers in the event of certain entirely possible technological failures. This is information which ought to be classified if it could be. In October I observed the confusion following a two-hour power failure in the Grand Central area in New York City. Four days later an accident to a single car on the Merritt Parkway in Connecticut delayed traffic for an hour, during which time seven miles of motor cars were halted bumper to bumper. The analogy between extreme urbanites and the denizens of the egg factories mentioned earlier is too close to be comfortable. No doubt the subconscious realization of this accounts to some degree for the difference between our present mood and that of the Turks and Finns. These sturdy people proceed phlegmatically about their simple way of life in spite of their hazardous geographical position.

We too are a brave and peace-loving people. It is entirely possible that we are not so much moved by fear of an enemy as by lack of confidence in the structure of a system in which we are so deeply committed and involved. What I am saying is inspired by those who see in technology the complete answer to the world's problems. For I do not doubt that technology, like a human being, has the defects inherent in its own virtues. If, as I believe, it should be our servant and not our master, its advancement should be in the light of all scientific knowledge and not merely of those facets which are of immediate use. The biologist who attempted to apply his knowledge in defiance of known physical principles would be laughed out of court. Yet we seem singularly trustful of engineering projects carried out in disregard of ecological principles.

The Urban Sprawl

The most obvious and acute pressure upon space is in our great cities and surrounding metropolitan areas, whose existence and expansion depend upon technology. They and the associated industries and highways that connect them are absorbing agricultural land in the United States at the rate of some million acres a year. This means fewer orange and walnut groves in California, dairy farms in Georgia, truck and tobacco land in Connecticut, and less of the proverbially fertile valley land along the Miami in Ohio. All of these instances I have seen, as I have seen 15,000-acre tracts of the best farm land condemned for military installations when less productive sites could have been chosen.

There are some 500 major cities of

over 25,000 population in the United States. Assuming that they could be evenly distributed, and neglecting smaller towns and cities, each would be in the center of a rectangle roughly 80 miles square. I have seen a fair number of them in recent years and recall very few that were not sprawling out into suburbs with little heed to open space, recreation, agriculture, beauty, or even the protection of future values. An exception, as a taxi driver profanely informed me, was not growing because the local university had everything sewed up!

Since this problem of urban sprawl is now receiving intelligent attention in a series of articles in *Fortune* magazine, I shall note only that it is serious, immediate, and far from simple. Municipalities generally have powers of expansion and taxation against which the rural landscape is without defense.

And between cities, across the land, highway departments are busily freezing the nation into a permanent interurban geometry. Often, in fact if not in theory, they are responsible to no one but themselves and their Euclidean rule that the shortest distance between two points is a straight line. Only through leaders who will devise and citizens who will support better use of urban and highway space can growing blight be checked. Professional planners, who, by the way, are seldom summoned until it is too late for them to be of real use, now frankly regard the entire strip from Washington to Boston as one great metropolitan area. Any lingering doubts on this score should fade at the sight of a new throughway blasting its course among rocks and homes, across land and water.

At Washington, southern end of the megalopolitan strip, fateful decisions regarding the future allocation of American space are made. One of the cabinet members who has much to do with such decisions told a recent visitor, "For one individual who, like yourself, comes here to protest the exploitation of wilderness areas, parks, and other public lands, there are a dozen who come here to press the opposing view." No matter what the sympathies of such a public official, these are elementary facts of political life with which he must reckon.

There are, moreover, numerous agencies of government, not always in close harmony, that are charged to administer space and its resources. What happens is the resultant of many forces, including the pressure put upon Congress and the advice it receives from appropriate bureaus.

The late Colonel Greeley used to relate how much of our national forest space was reserved. Congress, alarmed at the rate at which Theodore Roosevelt was setting aside forest reserves, lowered the boom on him, but the law could not become effective until he signed it. During the few weeks of grace Roosevelt, Pinchot, and Greeley spent evenings sprawled on a White House floor with maps, for all the world like kids with a comic supplement, marking out forests while the President still had power to do so.

District of Columbia

Unlike most cities, Washington was built on a definite plan and is still under close supervision. But the unremitting pressure of housing, traffic, and waste-disposal problems is a constant threat to the space required for recreation, let alone for esthetic values, traditionally a matter of concern. Among other things, the Potomac is notoriously polluted, and the pressure for schools and other public facilities in the overflow region outside the district is a headache to all concerned. In these environs, as around growing cities all over the country, one sees a wilderness of houses built to sell. And the buyer is usually more concerned with pushbuttons and gadgets than with sound construction. It takes no prophet to visualize what the condition of these potential slums will be in less than a generation.

New York Area

Not quite midway to Boston is Jersey City and the whole complex of sleeping towns for New York. As of October 25th of this year the authorities of Jersey City were weighing the relative merits of pails versus paper milk bottles to dispense drinking water. The reserve for Jersey City and nearby places was then enough for about one month. Not even that flower of technology, the modern city, is exempt from the pressure of natural forces. Nor should this be surprising. While the per capita demand for water rises, so does the area that is waterproofed and designed to get rid of rain as fast as it falls.

Even the air is a problem. One approaches the Hudson through one of the most unsavory mixtures of gases on earth. What smells bad, with such noble exceptions as Limburger and Liederkranz, is seldom good. New York City, whose canyons full of fumes are no bed of roses, is within the same general zone of turbulence. The resulting uproar reminds one of the classical dispute as to which stank worse, a goat or a tramp.

New York City illustrates what might be called a space paradox. As its population has grown, so has the per capita space, except possibly in some very congested areas. At the same time, the rural areas, whose emigration supplies the growth of nearly all major cities, have fewer people. Farms are increasing in size; fewer men are farming larger farms. Everyone is getting more space while the population rises. The answer is, of course, that the rural man who becomes urban is not getting more space than he had—simply more than he would have had had he moved into the city a generation ago.

New England

Further north, in New England, we encounter other interesting problems of space. Most of them involve conflicts of interest, often elements of minor tragedy. I have in mind the annihilation of homes for which money cannot compensate. One such, whose sturdy hand-made beauty, books, pictures, and furnishings represent the slow accretion of high cultural influence—not mere personal luxury—is now untenable because no better way has been found to dispose of the garbage of an expanding dormitory population than to burn it nearby. In southern Massachusetts I saw the occupants of a group of new homes trying to repair the damage of flood in a site which was notoriously subject to high water. The unwary newcomers who bought these houses did not know this, and no one warned them.

It was, in fact, the floods of 1955 that revealed most dramatically what can happen when important fields of science are neglected while others are being applied to the limit in technological development. Manufacturers of electronic equipment, optical instruments, and precision tools certainly keep abreast of scientific developments. Yet in locating their plants they took risks which no geologist, or competent botanist, would have sanctioned had his opinion been sought. Not only did they expand their activities upon the hazardous flood plain, but in many instances they intruded upon the channel itself, thus making bad matters worse. The old water-mill builders took no such chances. Their homes were on high land, for they knew and respected the power of water.

New England, northern end of the

great metropolitan strip, offers many other examples of the pressure of humanity upon space, although it has no monopoly in this respect. The West Coast, the most rapidly growing area in the nation, may be more graphic, for it lacks any protection from past cultural inertia. But in New England one may see a losing struggle to preserve esthetic and recreational values in the face of an insistent desire to expand industry, cater to the automobile, mine for gravel and rock, convert the rivers into free sewers, and in divers other ways capture the nimble dollar.

In these respects New England is no worse—and no better—than other parts of the nation. Two-thirds of its hinterland are now covered with forest, largely of poor quality, occupying land that was once farmed and later grazed during a booming wool industry. Yet this two-thirds of the area produces not more than ten percent of the rural income. In contrast to this, I know a Danish forest of 2000 acres that furnishes year-round employment to 50 men and 20 additional during the winter months, all at a profit. True, the New England soils are often thin and not highly fertile, but the chief trouble seems to be that we have consistently used up the finest trees, while the Danes since 1800 have been saving them for seed stock. Even though one cannot increase space, proper measures will greatly increase its yield. Inferior races of trees are just as wasteful of space as inferior breeds of livestock on pasture and farm. While New England forests even in their present poor condition add vastly to the beauty of the countryside, the time is not too far distant when their products will be needed. European experience shows that good yield is quite consistent with esthetic value.

Pressures upon Space

Across the continent, with infinite variations due to local conditions, the problem of space is growing in urgency. Ultimately we shall have to face the purely physical fact of increasing numbers on a finite area containing finite resources. Of these resources, water is now getting some of the attention it deserves. But we should keep other substances in mind, recalling that we, with less than 7 percent of the world's population, are now absorbing more than 60 percent of the world's mineral production, or ten times our quota.

Meanwhile, the general pressure is complicated by conflicts of interest. Different groups and individuals see different possibilities in the same area, and all alike wish to secure the most from it. As great cities grow they become more, rather than less, dependent upon widening circles of rural land—for water, milk and other food, transport, recreation, housing, labor, and income. It is interesting to consider the sources of support for the four world territories that have more than 10,000 people to the square mile. They are, in order, Macao, a shipping and commercial center, Monaco, a gambling resort, the District of Columbia, where taxes are collected and spent, and Gibraltar, a military post! No great concentration of people is ever self-sustaining. The Valley of the Nile, which has had perhaps 1000 people to the square mile for millenia, depends upon the vast headwater areas reaching south to Lake Victoria for its water and fertility. The same principle applies to the crowded downstream river margins of China and India.

The time must come when we shall have to deal openly, honestly, and realistically with the basic biological fact that numbers of organisms cannot multiply indefinitely within a finite area. And since our own species is under discussion, we must face the unparalleled conditions of increasing numbers and biological dominance combined with accelerating mobility, power, speed, and consumption on the part of the individual. Eventually we must come to grips with these fundamentals. Meanwhile we can, in my judgment, help matters greatly by admitting that conflicts of interest do exist, identifying them, and establishing some order of priority for conflicting claims.

I have no easy solutions to suggest. The first step in dealing with a scientific problem is to make it clear. This I have tried to do, aware of the fact that in our society solutions must be worked out by common consent—generally a painful process. There is a maxim among medical men that more mistakes come from not looking than from not knowing. So far as space is concerned, both looking and knowing are involved.

Training in Science

Much concern is now being expressed for better science training. Here at least we can make a sound, if modest, beginning. Training in the rudiments of science—asking, observing, and reasoning—should begin along with training in the mother tongue and be a part of the same process. College science, training as it does both scientist and citizen, should be taught in context with the rest of human knowledge and experience. It should certainly be a convincing and challenging aspect of education. How far it falls short of these ideals one can discover by asking those who have been exposed to it. Always excepting those who have an innate taste for science, the average college graduate, in my experience, does not retain enough for literate conversation upon the subject, let alone enough understanding to use it in civic affairs. Too often his mood is one of active distaste.

As a rule he has been required to take *a* course in *a* science weighted too often for the benefit of those who must go on in the particular field. How many times I have been told by colleagues: "We must teach it this way, or our students will not be ready for the next course." Such a philosophy misses the fact that by sacrificing insight to detail, fine intellects that might be potential candidates for further work may be lost.

Nor does the mischief stop there. No one science by itself can give that balanced view of the world of nature so essential to the citizen in our modern culture. A peep-show, no matter how good, is no substitute for a panorama. Until citizens, administrators, engineers, and businessmen become aware of the broad sweep of science, we may expect to see it applied, as it has been so largely, for immediate return rather than ultimate and lasting benefit.

Education and Self-Discipline

Let us, therefore, avoid the folly of thinking that science can be separated from the broader problem of education and self-discipline. The present hue and cry for more and better science education could easily lead us into the trap that caught the Germans in 1914. More and better science teaching we must have, not merely to produce needed scientists, but to create an atmosphere of scientific literacy among citizens at large. Only by general understanding and consent can truly creative science be sustained within our system of society and its results applied for the ultimate welfare of mankind.

Liberal education today should require not less than two years of college science, based on a skilfully planned and interwoven sequence dealing with time, space, motion, matter, and the earth and

its inhabitants. Nothing less than this is adequate for a proper appraisal of the natural world and our role as a part of it. This experience should be obtained at the hands of men who believe in it, who have status with their colleagues, and who are in intellectual communication with each other. There is no place for loose ends or superficial business in such an enterprise. Nor can it be carried on without the actual contact with phenomena in laboratory and field. Science that is merely verbalized is dead stuff.

But to this end it is equally essential that the educated individual must acquire such experience in the context of history, the arts, and an understanding of his own species. As a rough objective, I would propose turning out a product aware of what is going on around him in the world of nature and of man, able and willing to relate the present to the past and to the future in both thought and action.

To do this we must recognize with greater frankness than we have that there are vast differences among individuals. Let us learn to look upon these differences with respect, as a source of enrichment rather than discrimination, training each, honoring each, and expecting service from each according to his gifts. Let not the slow impede the fast, nor the fast bewilder and condemn the slow.

With a population set to double in less than half a century, with a national space which, though vast, is finite both in area and quality, with each individual making growing demands, moving faster and further by a factor of at least ten, we have on our hands a problem without precedent in geological history. But if we sense the problem and believe it worth solving, we can solve it.

Our future security may depend less upon priority in exploring outer space than upon our wisdom in managing the space in which we live.

Eskimo Longevity in Northern Alaska

Vilhjalmur Stefansson

Eskimo longevity in pre-white times is at best a matter of informed guessing, for "they took no care to reckon the years as they passed." But in northern Alaska their health, and other factors that bear on longevity, have been under study since 1852, and the records seem trustworthy. Beginning with the 1890's we have statistics resting on birth, baptism, and death certificates made by medical missionaries. Based on these formal documents is the conclusion that the longevity of northern Alaska Eskimos is greatly inferior to ours. By extrapolation, many have concluded that longevities were similarly inferior in the pre-white time. This extrapolation I now propose to scrutinize through the transition stage of Eskimo culture, from the first wintering of white men at Point Barrow in 1852 to the beginning of formal records, say around 1900.

A Recent Opinion

For this review, I take departure from one of the most recent of well-based longevity guesses, that of a doctor who was for 16 years in charge of the Presbyterian medical mission at Barrow, Alaska.

A preliminary year among the Eskimos was spent by Henry W. Greist and by his trained-nurse wife, Mollie Ward Greist, at Cape Prince of Wales on Bering Strait, during the season 1920–1921. In 1921 the Greists took charge of the Barrow mission and hospital, to remain till 1937. Greist died at his Indiana home in 1955, after finishing, but without publishing, a book, "Seventeen Years With the Eskimos." Mrs. Griest has lent me the manuscript and permits me to quote from its chapter XXIV:

"For untold centuries . . . the Eskimo of the far North had solely a carnivorous diet. . . . He was healthy . . . with rosy cheeks, with vigor and brawn. . . . He suffered from neither tuberculosis nor any venereal disease; and had rheumatism, if at all, to a limited degree. Barring accidents, starvation during lean years, or epidemics of unknown character, he lived to a very great age with his teeth intact, but worn to the gums since he used his teeth as a third hand. . . . When starches and sugars were introduced by the whalers and traders he at once began the development of carious teeth, something he never had had previously."

Earliest Observations

Having cited this recent opinion, I turn to the oldest one known to us: "Observations on the western Eskimos and the country they inhabit; from notes taken during two years at Point Barrow by Mr. John Simpson, surgeon R.N., Her Majesty's Discovery Ship *Plover*" (London, 1855).

During the second of his 1852–1854 winterings, Simpson counted 309 persons at the larger of the two villages and estimated the smaller at about three-fourths of this number; this made a total resident population, whom he saw continuously, of about 540. As transients, during the summer boating and winter sledging seasons, he must have seen an additional similar number. He reports, therefore, on about 1000 people for two years.

"These people are by no means the dwarfish race they were formerly supposed to be. . . . [They] are robust, muscular and active, inclining rather to spareness than corpulence. . . . In the young the complexion is comparatively fair, presenting a remarkably healthy appearance . . . before middle life, however, this, from exposure, gives place to a weather-beaten appearance, so that it is difficult to guess their ages. . . . The expression of the countenance is one of

Dr. Stefansson is consultant to the department of northern studies, Dartmouth College, Hanover, New Hampshire.