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10⁵ Per Square Mile

Isaac Asimov

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Professor of Biochemistry at Boston University School of Medicine, Dr. Isaac Asimov has written successfully to a broad audience, while presenting advanced ideas in mathematics, biology, astronomy, physics, chemistry, mythology, and the Bible. His *Biographical Encyclopedia of Science and Technology* is a standard reference work. Among the best known of his one hundred books are *Genetic Code* and *The Intelligent Man's Guide to Science*.

By A.D. 2550, less than six centuries from now, at the present rate of population increase, the density of Earth's population will be 100,000 per square mile. In other words, if, in 2550, all the Earth's population were spread out evenly over all the continents, including the Sahara, the Himalayas, and Antarctica, and including also the bottoms (or surfaces) of all the oceans, every spot on Earth would be as crowded as Manhattan today at lunch hour.

In *The Revolution of Hope* Erich Fromm raises another specter (and a frightening one it is, too) of a completely mechanized society in which "man himself is being transformed into a part of the total machine, well fed and entertained, yet passive, unalive and with little feeling." This is something to be vehemently fought against, for surely it is impossible to accept the dehumanization of man.

Is this the only imminent crisis that we face?

May not man be in less immediate danger of being dehumanized than Earth itself is in danger of being crowded with too much humanity?

To see what I mean, let us put the present day in the context of the grand sweep of human history.

Human history might, in its very broadest sense, be divided into: 1) Man the hunter, 2) Man the farmer, 3) Man the burner.

In the beginning, when the first creatures we can call hominid evolved in Africa about two million years ago or so, the result was not particularly impressive. The early hominids were food-gatherers, scavengers, carrion-eaters. Their numbers were few and they could not have shown much more promise of success than the modern gorilla does.

Intelligence, of itself, does not seem to have much survival value, certainly not as much, in the long run, as does sheer fecundity. Nevertheless, the early hominids had enough intelligence to make environment-controlling inventions and that, apparently, was what put them past the critical point and onto the path toward the present uniqueness of man. [264]

The discovery of flint and the methods for handling it, the technique of starting a fire, the invention of the spear and bow-and-arrow, all made hunting more efficient and broadened the scope of human activity.



By 8000 B.C., man, with the use of fire and clothing, had spread out of the tropical areas to which he was adapted and had occupied all the major land areas of the Earth (excepting always Antarctica). The total world population may have been about eight million. Nor could it have gone very much higher in a hunting and food-gathering economy.

About 8000 B.C., however, somewhere in the Near East, a fundamentally new way of life was worked out in the form of agriculture and herding. Food, both plant and animal, was cultivated and tamed. It no longer had to be hunted and it could be produced in greater concentration.

The technique of farming spread slowly out from the discovery center, and behind it like concentric ripples came other important advances: basketry and pottery, the use of metals, the invention of writing. Each advance made a considerable population increase possible.

By A.D. 1800 all the major land areas of the world were dominated by economies based on agriculture. There remained hunting and food-gathering societies but they could be exploited at will by those nations based on agriculture. Man the farmer ruled the world and population was then about 900,000,000 (0.9 billion). Nor could it go very much higher in a purely agricultural economy.

By A.D. 1800, however, again a fundamentally new way of life was worked out. Man had always burned fuel of one sort or another for warmth, light, and protection. By the end of the eighteenth century, however, he was burning it to lend power to the steam engine. He was burning wood, then coal, then oil and gas, finally uranium to place the vast energy sources of the nonanimal world at the disposal of mankind. With the Agricultural Revolution, Man the farmer had concentrated his food resources; now with the Industrial Revolution, Man the burner concentrated his energy resources.

Once again population was able to increase, and now, in 1970, we stand at something like 3.3 billion. Though there are scraps of hunting societies, and quite large sections of agricultural societies, it is the industrialized nations that effectively rule the world. Man the burner is king.

Judging by the past, we might say we are approaching the point where once again population is about as high as it can comfortably be under a given basic form of economy and that it is high time for a new radical innovation; an innovation that will again open a new horizon illuminated with a greater glory. [265]

This is the optimistic view: the cheerful extrapolation from two cases to a general rule; the feeling that since twice before new horizons opened when needed, this will happen over and over again in response to necessity.

But why must that be so? The existence of horizon beyond horizon is not unlimited; there is an end, and a hard one too.

Our situation now is very much like the man who, wanting to fly, jumped off the Empire State Building. He did indeed have the sensation of flying and as he fell faster and faster the sensation grew more satisfying. By the time he passed the tenth floor, moving downward, he felt he had every right to extrapolate from what he had already experienced to a future in which he would outdo the jet planes in speed and maneuverability. Except that the truth was that ten floors below was the sidewalk—and the end.



What is equivalent to that sidewalk in the course of human history is —population increase.

Throughout the history of mankind, population has increased steadily. Why, then, ought we be more concerned with population increase now than we were previously? Since population increase has not destroyed us in the past but has served to increase our mastery over nature, why find doom in it now?

To see the answer, consider the length of time it takes the human population to double itself. If we take the estimates of world population at various times in history, we can come up with the following (admittedly very approximate) table for the length of time it took the population to double itself:

up to A.D. 100	1400 years
100-1600	900
1600-1800	250
1800-1900	90
1900-1950	75
1950-1970	47

What we are facing now, then, is not just the fact of population increase, but the additional fact that the *rate* of increase has itself been increasing steadily.

It took nine hundred years from the time, say, of Marcus Aurelius to that of William the Conqueror, for Earth's population to double. In the *next* nine hundred years, even assuming that the rate of increase goes no [266] higher but merely remains where it is today, Earth's population would multiply 500,000 times!

The reason for this steady rise of the rate of increase is not because more children are being produced. If anything, the birth rate has decreased over the centuries. It rests almost entirely with the decline in death rate. Fewer and fewer infants die, and those who survive live longer and longer until now the general life expectancy is over seventy years in the more advanced portions of the globe. The reasons for this are not hard to see either. Advances in agriculture increase the food supply, advances in transportation insure more efficient distribution, advances in the knowledge of nutrition, in medicine, in surgery.

Granted that we see the reason, let us also underline the fact itself. The population is not merely still increasing; it is increasing *at a faster rate than ever before*.

Does this fact alone presage doom? Isn't it possible that science, which is *also* advancing at a faster rate than ever before, will come up with ways of handling that population increase, so that the increasing numbers will continue, nevertheless, to live better and better?

Don't think it. It is quite easy to calculate the year in which at the present rate of increase, the total mass of human flesh and blood will be equal to the total mass of the known Universe (not only our own Earth and Solar system, but the mass of all the stars in our Galaxy and in all the billions of other galaxies beside). Such is the power of a geometric progress that this ridiculous extreme is not something to be attained in the far and misty never-never land of an impossibly-distant future. It will come to pass (in the-



ory) in the quite prosaic year of A.D. 8700.

Obviously, science, no matter how advanced, cannot deal with a mass of humanity equal to that of the Universe, especially when that mass is only a little over six thousand years in the future. If present conditions point to that ridiculous end, it is at least as obvious as $1+1=2$ that these conditions must change drastically.

For a second time, let us draw in our horns and consider the population changes that will take place not in millennia or even centuries, but in mere decades.

At the present rate of increase (assuming no further increase in that rate) the Earth's population will double in forty-seven years. By A.D. 2017, in other words, Earth's population will be 6.6 billion. That, at least sounds bearable, if possibly uncomfortable, so that we have a clear half-century in which to do nothing. But wait—[267]

The rate of energy consumption, the burning rate of Man the burner, has been increasing and will continue (for a while) to increase at a rate greater than the increase of population itself. Not only does population increase but per capita consumption of energy does, too.

It has been estimated that if things continue as they are, then by the time the population of the United States doubles, its energy consumption will have increased sevenfold. Presumably this is true for the world generally, too.

It seems reasonable to suppose that the rate of energy consumption can be considered a rough guide to the rate at which Earth's nonrenewable resources (coal, oil, exploitable ores, etc.) are being consumed; that it also parallels the rate at which Earth is being polluted by the products of burning and of industry generally.

In that case we see that by A.D. 2017, assuming that present trends continue, the rate of resource consumption and of environment pollution will be seven times what it is today.

But at the present moment we are already consuming Earth's resources at a dangerous rate. A recent estimate, for instance, states that Earth's readily available supply of nonferrous metals will be squandered within twenty years. If a half-century from now the demand for such metals is seven times the present quantity, where is it to come from? (We may, of course, learn to extract poorer ores and make more use of scrap for recycling—but will we develop such sources in half a century to supply seven times the present annual quantity?)

At the present moment, moreover, we are polluting the Earth's environment at a critically dangerous rate and are visibly poisoning the Earth to the point where many doubt whether mankind can rally its powers and its will to save the situation *even at its present level of danger*. What will we do a half-century from now if pollution reaches seven times its present level?

Clearly, our way of life must change drastically within the next half-century, then. But have we even that much time? Let's consider conditions as of today.

The United States consumes as much energy, right now, as the rest of the world put together. It consumes at least half of all the Earth's production of nonrenewable resources, and produces at least half of all the environmental pollution on Earth.

The other nations of Earth have as their goal (and who is to say them [268] nay)



the achieving of a standard of living equal to that of the United States. If by some miracle they were all to achieve it instantaneously, then *right now*, without the addition of a single individual to Earth's population, the rate of resource consumption and environment pollution over the planet as a whole would increase eightfold.

The planet could not endure this, so we are forced to the conclusion that we have already passed the point of no return. The Earth has already reached the point where it cannot possibly support even its *present* population at an average standard of living equal to that of the United States today.

Nor, in assessing our present danger, need we confine ourselves to physical factors only. What about the psychological difficulties that attend increased population?

There have been experiments on crowding among rats, and it has been clearly shown that physical and psychic failures attend such crowding. Is it possible to get some idea of how the intensity of such troubles increases as crowding gets worse? Does the intensity merely double when the numbers are doubled?

It seems reasonable to me to suppose that tension rises not merely with the number of people in one's vicinity, but with the number of different interactions possible with the people. And it is quite possible that the number of different interactions increases much more rapidly than the number of people.

Suppose, for instance, you have five men and five women and you set about pairing them in different ways. How many different combinations of one man and one woman can you produce among the ten individuals? The answer is $5 \times 4 \times 3 \times 2 \times 1 = 120$.

Now double the population and make it ten men and ten women. The number of different combinations is $10 \times 9 \times 8 \times 7 \times 6 \times 5 \times 4 \times 3 \times 2 \times 1 = 3,628,800$.

Without making too much of the exact figures, we can at least conclude that even a small increase in crowding can enormously increase tensions. Where the world as a whole is generally uncrowded, the tensions of crowding in limited areas can be (and have been, in the past) relieved by emigration. With the frontier escape valve gone, however, and with the world generally crowded, matters have changed, and have done so spectacularly for the worse.

Considering that already, at the present moment, the level of tension among the population generally (as evidenced in alienation, violence, drug [269] addiction, and other social ills) is the despair of concerned sociologists, what can we expect to be the result of even a *small* further increase in population?

It seems to me we must conclude then that the Earth is *already* seriously and dangerously overpopulated. If society exists now in a seemingly stable and even apparently still-improving condition, that must be only because 90 percent of the Earth's population is in a depressed condition which makes it possible for the remaining 10 percent to live well.

Mankind, then, would seem to be facing a situation quite unlike any it has ever faced before. Its problems now are by no means merely different in degree from any that have existed before; they are different in kind.

Until World War II (at latest) mankind has lived in an essentially infinite world—



one in which it could multiply at will, waste at will, poison at will, with the comfortable knowledge that in the foreseeable future, and certainly in the generation's lifetime, it would not be held to account. The suffering planet was large enough to absorb the man-made insult.

Now that has changed. Now we live in a finite world. Our numbers and our kind and level of technology are bringing us to chaos within the lifetime of those now living!

The consequences?

I think that before A.D. 2017 when Earth's population is expected, at present rates, to have doubled, the death rate will have begun its inexorable increase. As the food supply fails to keep up with the bounding population, as it even begins to decline absolutely through the poisoning of the environment, the great famines will start. Undernourishment will set up the foci of the great epidemics and with the withering of resources, industrialization will decline.

When the last dregs of population increase are added to the sharpening battle for food and survival, tensions will exacerbate to the point of thermonuclear war, perhaps, or to the lesser but more prolonged agony of worldwide anarchy.

The first half of the twenty-first century would therefore see a precipitous drop in population and a total, or nearly total, dismantling of man's technology. The second half of the century will then see a new equilibrium, with perhaps a few hundred million human beings scratching a living out of the soil amid the ruins of a past civilization already fading into the dimness of the past.

Can we console ourselves with the thought that however horrendously [270] evil the process, mankind will have an opportunity to recover and build again, and using the experience of the past as guide, develop a second and far better Golden Age?

I'm afraid not.

The new and very low equilibrium achieved by the wild destruction that is sure to come if our present direction is not drastically changed, will not only have destroyed most of the human race—it will have, by then, destroyed many other forms of life as well. The entire fabric of ecology will have been dangerously weakened and torn; the very habitability of the planet will have been compromised.

The Earth will be as it has never been before; its soil destroyed and poisoned in such a fashion as may take not decades or centuries but millions of years to restore; its resources squandered and scattered to the point where it will take not millions of years but hundreds of millions to reconcentrate.

Can mankind make a comeback with its technology gone and with the planet utterly ruined into the far-distant future? How?

For those dedicated and concerned with righting man's inhumanity to man and to nature, it is a painful irony that such a love can never come to pass if no one lives.

It is not man's humanity alone that is threatened with disappearance, but man himself!

To stave off the doom, we must first recognize something fundamental about the important problems that face the world today. The population increase, the squandering of resources, the prevalence of pollution, the exacerbation of tensions—are prob-



lems that are each planetary in nature, problems that can each be solved only on a planetary basis.

Not even the most powerful single nation can solve any of these problems by itself, or solve them within its own borders alone. A solution, even a good one, applied to only a small portion of the Earth's total area and population is no solution at all if the problem remains unsolved elsewhere.

Will it do any good, for instance, for the United States (within its own borders only) to achieve population stability, resource conservation, depollution, and tension ease, if the rest of the world continues as at present? The chaos will come anyway and overrun us.

And even if we succeeded in holding off the forces of ruin flooding in from all sides and maintained ourselves as a kind of island of technology [271] in a surrounding ocean of barbarism and death, how long will this remain possible? Even today we maintain ourselves only at the expense of half the resources of the rest of the world. Remove that rest of the world and force us to live on our own fat, and our technology will wither and join the rest of the world in the dust heap.

No, the major problems must be solved everywhere or not at all. This means cooperation between the various nations (the various industrialized nations at a bare minimum). The cooperation must be sure and unflinching, for we have no time for games.

To put it briefly, we need a world government; some body which is powerful enough to enact a course of policy that will apply over the Earth generally and with sufficient police power to enforce compliance.

In the end, if there were time, this is exactly what would happen. In general, the history of man (particularly in its more progressive periods) has seen a more or less steady increase in the area and population of the dominating political units. Given enough time, then, we would expect a world government to be the final flowering of political evolution.

The trouble is that we don't have enough time for its "natural" evolution. Its evolution must be hastened. However strong an emotional attachment we may have to our various nations, we must recognize that their independence has been an illusion for a long time, now. When an oil tanker of Nation A can foul the beaches of Nation B; when an exploding nuclear test bomb of Nation C can spray the air of Nation D with radioactivity; when DDT used by Nation E ends up in fish caught by the ships of Nation F—how independent is any nation?

And at the present moment in history, to cling to a mythical national independence that doesn't exist is suicide.

But suppose we do achieve a world government. How do we go about solving, through world action, the dreadful problems that face us?

We must continue to use resources; but we must use them with utmost economy and we must reclaim all we can of those used.

We can't help polluting, but we must do so minimally and with every effort to remain within the environment's capacity for self-renewal.

We can't relieve tensions altogether, but we must do all we can to soothe and bring



together.

The delicacy of the task is so enormous under even the most favorable conditions that it is clear we could not possibly succeed if that task were made steadily more mountainous by increasing population. [272]

To make everything else possible, then, the first task is to stabilize the population and to look forward to a system of planned population decrease.

But how?

Here again it would seem that mankind faces a problem different in kind but not in magnitude from every problem that has ever faced it before. Never at any time in history has motherhood been anything but an honorable and revered estate. Never at any time in history has a baby been anything but the dearest being one can imagine.

Yet it is now going to be forced upon us, however much against our will, to consider motherhood and babies, more often than not, as antisocial.

This must be so because if we are to decrease the Earth's population without increasing the death rate, we must insist that each woman leave behind her less than two children (on the average).

But how can we force a woman to have very few children? Shall we simply pass a law saying that every woman must be sterilized after she has had her second child? It is conceivable we might come to that, but is there no other way out?

For thousands of years social pressures have favored conception. Women have been carefully educated into believing that their highest fulfillment was as wife and mother; parents of many children have been honored; the sex act has itself been regulated by defining as perverse every action which yields satisfaction without danger of conception.

All this has been sensible enough in an empty world and in one where the death rate was so high and life expectancy so low that it took maximum fecundity to insure even a small population increase.

In our present crowded world, with its low death rate and long life expectancy, the old notions, hallowed though they be, are, when put into practice, a crime against humanity.

Women must not be encouraged to think of themselves as baby factories. Birth-control devices and methods must be further improved and made available to all; their use taught matter-of-factly in the schools; and their employment encouraged as a positive social good.

Perhaps there ought to be a complete turnaround in our attitude toward the sex act itself. No longer must we insist that only that is wholesome and "natural" which will have the greatest chance of leading to conception. Shocking as it may seem, why not encourage those practices [273] which do no physiological harm, give relief from sexual tension, and run no risk of conception?

The aging rulers of Church and State, who are certain to live out their lives before the ruin engulfs mankind, have no right to condemn a younger generation to that ruin by insisting on the mores which they had to live by in another and long-dead world.

But can we, in the space of a generation or so, so utterly overturn our long-



accustomed political system as to accept effective world government, develop effective methods of population control, and accept a nonconception-oriented sexual outlook?

The chances would seem small indeed. The alternative is so ultimately horrible, however, that I can only hope that the initial terrors of the disaster-to-come will drive us headlong into the less distasteful out of urgent respect for our lives.

And if we come through? If we manage to establish a rational society (even if at the cost of serious losses), what will the characteristics of that society be? Can we avoid computerization?

I think not.

We must understand what computers (or at least the computers of this century) are. They are problem solvers. They are mechanical devices that do merely what slide rules do (or pen and paper), only much, much faster. If we turn to computers, it is only because we need answers faster than the human brain can supply them, and in the world of the future, when we are hoping to draw back from the brink of catastrophe by tip-toeing across an ice-coated tightrope, quick answers, *very* quick answers, are exactly what we'll need.

To be sure, we mustn't make a god out of the computer; a computer can't give us an answer that is more correct than the material and instructions we feed into it. But let us not make a demon of the computer, either. The human brain cannot always give an answer more correct than the material and instructions fed into it, any more than the computer can.

To be sure, the computer can't take into logical account those factors that can't be made quantitative—like sympathy, love, generosity, concern. But then neither are our brains infallible under emotional challenges.

The question is, finally: Can a computerized society coexist with human individuality? Can mankind at one and the same time have its computers and avoid dehumanization? [274]

In our present society—right now—perhaps not.

It is the essence of my argument, though, and my hope, that if there is to be a computerized society, it will be of a nature far removed from our present one. A computerized society should be one that has recognized the dangers about to fall upon us today and has been able to draw back at the cost of an enormous self-directed change in precisely those things it had always held most dear. It will be a society that had proved itself capable of placing reason and intelligent concern before ingrained fixity of thought and feeling.

Such a society will be mature enough, I am quite certain, to be able to handle computers as tools and not as masters; to appreciate people as human beings and not as cogs.

And then, if we can but come through the nearly totally black prospect of the near-future, we may find that what has opened up to us will be a bright and hopeful far-future.