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Technology, Prediction, and Disorder

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I. The Forces of Change

Technology, Prediction, and Disorder

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The topic assigned to me joins in a familiar way science and technology. Not long ago this would have been irritating to pure scientists, and in particular to someone studying abstract mathematics. The connection is appropriate, however, because science is not very pure. Even mathematical logic turns out, to the surprise of most of those practising it twenty years ago, to be very useful in electronic brains. Science and technology have always been linked; and inseparably. As both Leonardo and Francis Bacon at the dawn of the age of science knew very well, knowledge is not only understanding and therefore good in itself, knowledge is also power, the mastery of nature. Predicting is at least one condition for controlling, for changing things, shaping them to human ends. And since many of the purposes of men conflict, knowledge also inevitably involves the power to destroy. The duality of peaceful and warlike uses of knowledge is intrinsic.

Just listing some new and accelerating technologies today, in the standard way for all talks on the future of technology, will suggest both the duality of impending change and the enormous scale of that change: nuclear energy; synthetic new materials; the techniques of bio- and chemo-therapy; space technology, computers or information machines, and the closely related technology of communication; and the possibilities of controlling weather both in the small and in the large. Let me run rapidly through this sample list.

In the development of nuclear energy, the two-fold application for peace or war is most obvious. Here the use for peacetime power has been slower than originally expected, though its long-term potential to replace fossil fuels still is very great. The tremendous scale of the

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change is directly visible in the use of nuclear energy in military explosives and in the transformation this has worked on military strategy and the power relations among states.

But the major change brought by the systematic exploration of nuclear reactions is likely to be in the massive transmutation of elements, a nuclear alchemy more fundamental than the chemistry of new materials and capable of almost unimaginable effects on our technology. In any case it is apparent that synthetic new materials will continue to benefit—and to disrupt—the world division of labor and the life of all of us, including especially life in the raw-materials-producing, less developed countries.

The widespread application of antibiotics and other modern medical and public health techniques will work wonders, as it has already, in the life span of people—and the possibilities of biological warfare illustrate the basic duality. But some of the *peacetime* uses sometimes seem as problematic as they are beneficial, as in the unexpected changes in the local balance of nature that have alarmed readers of Miss Rachel Carson, or in the critical case of the enormous and violent increase in the numbers of humans living—and needing work, food, and living space.

Space travel and space technology offer no promising solution for the population crowding problem. But the peacetime application in communication satellites is already patent, as is the use of satellites for detection and warning in time of war, and for the transmission of wartime commands and possibly for bombardment.

One of the central and fastest developments, of course, has been in computers or information machines, the so-called electronic brains. These have been essential in guided missiles and other aspects of military defense. They are playing a major role in almost all the other developments I have mentioned. They are in essence, as the name "information machine" suggests, an improvement in communications within a mechanism or an organization. Capabilities of communication, both in the sense of transmitting messages as well as in the broader sense that includes transporting men and materials, are accelerating enormously and are one of the plainest evidences of the increasingly tight—sometimes uncomfortably tight—connection of every part of the world to every other.

The last potential for changing nature that I shall mention, the ability to control weather, is still little understood; it is only in its dim beginnings in the small-scale, local attempts at rain-making. Even here, as public discussion has suggested, one locality might benefit at the expense of another, as in the diversion of water from a river. But the drastic changes in climate and in the atmosphere

which might be effected by men—and are the subject of speculation today—include changes in the level of the seas, possible flooding of continental shelves and coastal cities, the long-term warming of vast regions and cooling of others. Quite apart from their deliberate use in warfare, the possibilities of diverging interests here dwarf anything we have seen in the Arab-Israeli disputes over the River Jordan, or even the water disputes between California and Arizona.

A mere roll-call then of the possible changes coming in our power to change things can be inspiring. Or terrifying. And usually both. Sometimes, in fact, the possibilities are presented in pairs. We are told we will have either the cataclysm or paradise, a world of light. But even the paradise can be pretty terrifying, as is reflected in the fantasies of Aldous Huxley or in the current actual fears of automation. As a result, talks on the future of science and technology tend to be a competition in ominousness.

Prophets of technological change—or even a man writing an essay on impending changes in our enormous power to change things—may, I find, take on the awesome attributes of their subject matter. Some of all that massive power seems to rub off on the fellow who merely announces it, as if he could evoke the enormous benefits or the destruction he foretells, like a soothsayer or caster of spells. This has its advantages and temptations. Like the soothsayers, and unlike the messenger who brought bad news to the king in the past, messengers of technological bad news today have an assured welcome in the community. It is almost an occupation.

However, as I have said, control involves as a necessary condition successful prediction. And the prophecy business in technology is very shaky. Its aura of power is sustained in good part because we do not keep tabs on how pronouncements on the future of science and technology turn out. Such scorecards would almost always prove chastening. Even some of the successful examples of extraordinary prescience, I have found when I recently had occasion to look at them closely, were rather more like the prophecies of Nostradamus than predictions deduced from a finished scientific theory. There are, of course, many notorious examples of unsuccessful prophecies—plain bum guesses—by famous and excellent scientists. There was Simon Newcomb's demonstration, published a few years after the Wright Brothers flew at Kittyhawk, that "no possible combination of known substances, known forms of machine, and known forms of force can be united in a practicable machine by which men shall fly long distances through the air."[1] For Newcomb, an American scientist of the first

1. NEWCOMB, *The Outlook for the Flying Machine* in SIDE-LIGHTS ON ASTRONOMY 345 (1906).

rank, "this demonstration" seemed "as complete as is possible for the demonstration of any physical fact to be."[2] Then there was the great Rutherford's judgment, less than a decade before the first sustained nuclear chain reaction, that we were never likely to be able to control atomic energy to a useful extent. Forecasts by distinguished scientists of the growth and spread of nuclear weapons and rockets, in spite of a good deal of folklore to the contrary, far from being highly accurate, have hit not only the bull's eye, but on all sides of the target date; and sometimes these scattered shots in the dark were fired by the same marksman. This is nothing new. One of the best and most ambitious attempts to foresee the next ten to twenty-five years of our technical future was put out in 1937,[3] and among other things missed totally: nuclear energy, antibiotics, radar, and jet propulsion.

Large changes are clearly impending, but the inability to foresee how fast they will come or even what they will be should not surprise us. The difficulty is in part in the very nature of research. Finished science, or at least tentatively completed theory, enables us to predict. But trying to prophesy the *future* of science is something else again. It is predicting what we will discover, guessing what the dark will reveal when lit up. If we knew we would not need the research. "[I]t is in the nature of research," as Robert Oppenheimer has put it, that "you pay your 'two bits' first, that you go in and you don't know what you're going to see."[4]

When we think we know what we'll see or won't see, we sometimes don't do the research, even though we need it. The brilliant English geneticist, C. D. Darlington, has written very eloquently on the obstacles to further discovery that in this way can be erected within the ranks of science itself. "It is no accident," he thinks, "that bacteria were first seen under the microscope by a draper, that stratigraphy was first understood by a canal engineer, that oxygen was first isolated by a Unitarian minister, that the theory of infection was first established by a chemist, the theory of heredity by a monastic school teacher, and the theory of evolution by a man who was unfitted to be a university instructor in either botany or zoology."[5]

This resistance to the new within science itself troubles some of the proposals for departments or ministries of science and technology which come up from time to time, here and in England. Professor Darlington feels that great organs of authority, even in science—the

2. *Ibid.*

3. SUBCOMMITTEE ON TECHNOLOGY TO THE NATIONAL RESOURCES COMMITTEE, TECHNOLCGICAL TRENDS AND NATIONAL POLICY, INCLUDING THE SOCIAL IMPLICATIONS OF NEW INVENTIONS (1937).

4. OPPENHEIMER, THE OPEN MIND 7 (1955).

5. DARLINGTON, THE CONFLICT OF SCIENCE AND SOCIETY 5 (1948).

scientific journals and the schools, the royal societies—tend so quickly to get stuck in the mud that what we need instead of a Ministry of Science is a *Ministry of Disturbance,* "a regulated source of annoyance; a destroyer of routine, an underminer of complacency, an *enfant terrible.*"[6]

"Pure" (or fairly pure) science stimulated by the obscurity of its future, is moved to resolve uncertainty. But it is also troubled by false presumptions as to what that future might be, and the situation is rather worse for applied science or technology. One of the main reasons for this is that the progress of technology is not purely a matter of invention. It has to do with such grubby matters as costs, and uses, and competing purposes: in short, with politics, sociology, economics, and military strategy. When even a great physicist talks of the future of technology, he isn't talking physics, but of matters which, if less profound, are enormously more complicated. Experience and all the academic disciplines devoted to illuminating these matters shed only a very dispersed, flickering, and fitful light. But they are all we have.

The implications of present and future technology for our future course of action are much agitated in the current discussion. I am going to refer to two sorts of analyses to illustrate the limits of our understanding and the implications of these limits. Let me call the one the *Small World* and the other the *Big World* analysis.

First the Small World. All of the fast-growing technologies I have described earlier have in common that they enable us from any one point on earth to affect any other point and to do this with increasing speed and effectiveness. This will be true eventually of weather control—with massive possible effect. It is already nearly true of the possibilities of transportation and quite true of weapons delivery. It is nearly true of communications, but also of thought control. There is no longer space on earth simply to extend the area of operation of a technology. In this sense, we have run up against the finite limits of the earth. Not only can the range of delivery of weapons cover the earth completely from any point, but the area of destruction against unprotected targets is very large in relation to the accuracy of this delivery. There is very little time and room to absorb a blow and devise a response. The Atlantic and Pacific oceans and the distance from the Russian border to Moscow no longer suffice to shelter the United States and Russia. Moreover, the spread of nuclear weapons to more powers is likely to increase the instability, making both more complicated the problem of deterring surprise attack and more difficult the task of reducing the chance of war through "accidents" or

6. *Id.* at 50.

misunderstanding, or the like. The great mathematician, John Von Neumann, suggested that a war between existing nations of the current size and closeness, with weapons of impending range and destructiveness, would be as unstable as a war with the weapons of 1900 confined to Manhattan Island. For this reason he felt that the world had become "under-sized and under-organized."

One sort of inference typically drawn by scientists and technologists from this line of thinking (though *not* in his later years by Von Neumann) is the immediate necessity for world-wide agreement in controlling the technology of destruction—a control that amounts to organizing the separate sovereignties into one world—simply because the destructive implications of technology are so awful. To use the stark alternatives that were stated at the very start of the nuclear age, it is One World or None. One world, these technologists say, is a political necessity.

While scientists and technologists at the end of the war stressed with great urgency the necessity of one world, events, it seemed, were moving in another direction—towards the multiplication of sovereignties. Membership in the United Nations doubled and is on its way to tripling. It may be that the United Nations itself, with its one-nation one-vote and the large forum that it provides small powers, may encourage this multiplication. It offers some incentives to the leaders of small subdivisions of former colonies to achieve separate sovereignty status and to play a role on the world scene. In any case it is clear that we have not been going *steadily* toward one world.

This actual and growing diversity of the world receives some notice in the second view of the world and technology. That view I have for the sake of contrast identified as the *Big World.* It is represented by several distinguished diplomats, historians and writers on foreign affairs.

Let me read a central passage from the recent work of one who is all three: diplomat, fine historian, and thoughtful critic of foreign policy.

> Many Americans seem unable to recognize the technical difficulties involved in the operation of far-flung lines of power—the difficulty of trying to exert power from any given national center over areas greatly remote from that center. There are, believe me, limits to the effective radius of political power from any center in the world. It is vitally important to remember this, particularly in the face of the fears one hears constantly expressed today that the Russians want universal power and will be likely to take over the world if we fail to do this or that.
>
> There is no magic by which great nations are brought to obey for any length of time the will of people very far away who understand their problems poorly and with whom they feel no intimacy of origin or understanding. This has to be done by bayonets, or it is not done at all. This is the reason

> why, despite all that is said about Soviet expansion, the power of the Kremlin extends precisely to those areas which it is able to dominate with its own armed forces, without involving impossible lines of communication, and no farther. There are geographic limits to the possibilities of military occupation; and such colonial regimes as can occasionally be successfully established at points remote from the ostensible center soon develop, as has been demonstrated time and time again since the days of the Byzantine Empire, a will and identity of their own and become increasingly ineffective as instruments. In this way, the exercise of centralized power is gradually reduced, once more, to something like its natural limits.
>
> What I am asserting is that universal world dominion is a technical impossibility, and that the effectiveness of the power radiated from any one national center decreases in proportion to the distance involved . . . .

This view of the world then stresses that power is finite, that it diminishes in proportion to distance from its center, and concludes that—at least for any length of time—world dominion by Russia or any other single power is a technological impossibility. The theory frequently goes with a stress on the apparent growth of many centers of power, and in particular the growth in the importance of small powers. On the whole this multipolarity is taken as making the world more stable. But as for One World, on this view it is *technically infeasible.*

It is something of a paradox, contemplating these two views of the world, that the technologists insist that One World is a political necessity and the diplomats and political historians assure us that it is technically infeasible.

The diplomats and historians who view the world as large compared to the limits of technology, show an attractive and persuasive awareness of the diversity of competing national goals, the problems in the exercise of power, and the factual limits both to power and to national ambitions. These are matters that technologists tend to brush over all too lightly. Nonetheless, this view of the world has problems. For one thing, though military power comes in several varieties, none that I have examined in terms of the technology of nuclear or conventional warfare today falls off so neatly in a straight line from the power center. Even for conventional combat sometimes the costs of getting to a theater of war are very small and the capabilities very large, compared to the costs and capabilities of moving about *inside* the theater. And since the comparative advantage inside the theater may depend on many highly local phenomena—terrain and local transportation and communication—it sometimes turns out that a distant foe actually has an advantage over one nearby, whose access through local roads, ports, and airfields may be very poor. In the case of nuclear war the cushioning effects of space are much more radically transformed. And how important distance is will depend on

what your objectives are. An aggressor may be considerably helped by proximity. But a so-called "second-strike capability" is likely to be aided by distance.

In any case the old geopolitical considerations on the balance of power which typify the Big World view, whatever their worth for past history, are too schematic and dubious to be very reassuring about the stability of the present world today.

Nor is the theory very reassuring about Soviet ambitions, though it seems the emphasis on the impossibility of world domination by any one power is meant to be. For one thing, all we are assured is that great nations will not obey a distant will "for any length of time." But even a short time—like the duration of the Byzantine Empire—could be unpleasant. Moreover, even if we assumed that total world dominion by a single power was infeasible, this is not completely comforting. A world divided between several nuclear-armed contending communist powers, for example, might, if possible, be even worse. And finally we must ask how the finite limit to the effective radius of power which is stressed by these writers compares with that other finite limit stressed by the holders of the Small World view. How does the technical limit of power compare with the size of the globe? To be specific, is it less than twelve thousand nautical miles? That's halfway round. Two paths of that length starting from the same center could meet at the opposite side of the globe.

And the old empires, when you come right down to it, were rather impressive in extent. I have made some very rough estimates and some rather unreliable calculations. I find that a direct path from Byzantium to the farthest extent of Justinian's domain on the Iberian Peninsula comes within a factor of three or four of making it halfway round the world. Justinian did pretty well. Genghis and Kublai Khan did even better than that—and, as my friend John Williams points out, with ponies. Communications and transportation have improved by very much larger factors than three or four. It used to take from a month to two months to go from Byzantium to Rome. Now jets can make it in hours, rockets in minutes. And while no one who has put a telephone call through from Istanbul—today's Byzantium—to Rome would ever think that arranging the connection is done with nearly the speed of light, still, the improvement over Justinian is tremendous. On the technical limits the Small World theory and the technicians are more plausible.

Our adversaries are restrained, but not by what is technically feasible. Long before technical limits are reached, they are restrained by the diversity of their goals and by the costs of doing us in; and therefore by us. But the diversity of goals is essential. The diplomats

and political historians are on firm ground when—in contrast to most of the technologists writing on strategy—they stress the complexity and multiplicity of political objectives. The Communists are preoccupied with a good many other problems than doing us in by force of arms. There are all the indirect methods and there are the problems of their own internal development, and the quarrels with their friends as to which one will do us in and how, and a good many other domestic and foreign concerns. No country in the communist or noncommunist world has ever pursued the arms race with the single-minded ferocity assumed in the simple models constructed by writers on strategy and military technology. The world is getting small in relation to what is technically feasible, but it is not getting simple.

There are more severe limitations in the simplicity of the strategic and political views of the technologists. Technologists tend to treat these political and military problems as if they were pure technology. But as I have already suggested, in practice within any given nation a decision to speed the development and production of nuclear weapons or bombers or rockets will be affected by the costs of such a program, the many competing national purposes for which the same resources might be used, and the apparent rewards. The rewards themselves depend upon the behavior of other nations beyond national control, and the expected payoffs may in some cases be rather easily frustrated. So in spite of the great scientific competence of the English, their costly rocket program, the Blue Streak, turned out to be of very dubious value and was cancelled, not because of any technical failure in realizing the original plans, but because of the much greater capabilities the more powerful Russians have for getting countermeasures. Not nature, but the Russians, spoiled the original plans. Feasible Russian countermeasures would have found the Blue Streak vulnerable on re-entry from space, but even more vulnerable on the ground before it was ever launched.

Some scientists and technologists talk of the imminent appearance of rocket programs so cheap that they will be available not merely to poor countries, but to rather wealthy individuals, a new sort of nuclear dilettante. In fact, military programs for nuclear weapons and delivery systems with other than ornamental utility or totally irresponsible use are an enormous enterprise. They have been rather consistently underestimated. Until very recently studies of the diffusion problem considered only what it would take for new entrants to the nuclear club just to make bombs, as if the bombs would deliver themselves and be unopposed. And it is still extremely rare in such studies to consider the delivery problem in a serious way, with full account taken of the problems of operating and controlling nuclear

forces in the face of possible enemy counters.

The spread of nuclear weapons is a genuine problem and an important one. But the time scale for this diffusion and its characteristics have been woefully misrepresented by men who have taken the problem as one of improving technology to cut the cost of a standardized and universally desired product. When considered realistically, however, it becomes apparent that the product is highly complex and the standards it has to meet are continuously changing. Nuclear retaliatory systems have not been going down in price, but up. The first 100 B-58's, Atlas, or submarine-launched Polaris cost three to five times more than the first 100 B-47's. Wealthy dilettantes don't appear to be a very promising immediate market. In fact diffusion has gone very much more slowly than was predicted at the end of the war. And prophecy continues to be quickly outmoded by events. Only three years ago, Sir Charles Snow forecast at least a dozen new entrants to the nuclear club by 1966.[7] Nothing of the kind is likely to happen.

Technologists who hold the small world view tend to assume not only that any country will acquire all means of destruction within its technical capacity, but also that once acquired these weapons are sure to be used—"sooner or later." So we have had a flood of predictions that nuclear war is statistically certain before the end of the decade.

The danger of nuclear war is a very real one. But this sort of prophecy has no empirical foundation whatsoever. Sometimes the certainty of nuclear war is presented as a mathematical matter. Given a fixed probability of war, no matter how small it is, so long as it is greater than zero, "sooner or later" the nuclear holocaust will come. In this form, however, the prediction is mathematically impeccable but trivial. It has no empirical content, offers no index for action. It tells us essentially nothing. An equally impeccable bit of algebra would show that the outbreak of the rule of law and eternal peace is statistically certain—"sooner or later." This argument would run: In any given year there is some probability that the total rule of law among nations and the peaceful settlement of disputes will come into being. This probability may be very tiny right now, but it is greater than zero. And not decreasing. Well then, "sooner or later . . . ." The parallel argument about the statistical certainty of nuclear war should be no more terrifying than this argument, for the statistical certainty of eternal peace is reassuring.

Such impeccable but empty statistical arguments are very common —even among Nobel Laureates in physics. Still more common is the assertion that the probability of war in any given year increases year

7. Snow, *The Moral Un-Neutrality of Science,* Science, Jan. 1961, p. 255, 259.

by year. For a variety of reasons, I believe this one simply to be wrong as a matter of fact. On the evidence of the greatly decreased vulnerability of our strategic force and the greatly increased centralization of command over nuclear weapons, the probability both of deliberate attack on the United States forces and of their unauthorized or "accidental" or miscalculated use has declined in the last decade.

Most frequently what we get are bare predictions that the probability of war is very high in some next period of years. However, I have recently run through the history of these predictions and can report something that is, at least partially, reassuring. They show a trend.

For example, one physicist of the first rank in 1945 was most pessimistic about the post-war years. He said, "If we manage to get through the next fifteen years alive, we shall probably emerge immune to atomic bombs." The next prediction I came across by this same physicist fell, as it happens, in the year 1960, that is, fifteen years later. He did not then feel that we were immune to atom bombs. But he now talked of the probability of war in the following *forty* years. Another physicist, a friend of mine and former colleague, was saying not very long ago that unless we had comprehensive arms control by 1970 the probability of war was extremely high. A little later he moved the date to 1975; and I was somewhat relieved to find him writing recently that, with average luck, we just might last out the century.

I do not intend to minimize the dangers of nuclear war. They are, as I have said, very real. I believe that the most important goal of both our national defense and our foreign policy must continue to be to reduce the probability of war, year by year, and step by step. However, there is no basis for the statements that are made almost every day which fix the length of our lease on life. I feel moreover that all the urgent statements indicating that the lease is nearly up have some very large defects. Most important, they pretend to a knowledge of the future which we do not have, a knowledge not only of the technology but also of the evolving political and economic scene. Second, they lead not to science or politics, but to eschatology: they point to the establishment on this finite earth in the near future of an improbably final arrangement for settling the deep antagonisms between the East and the West and in fact among all nations. In doing this they express our wishes, but not our sober estimates of the durability of the antagonisms themselves. They focus on time intervals that are very little understood and ignore some time constants on which we have a good deal of empirical evidence.

We are in the dark about the future of science and technology, still more about the long-term future of military and political developments

in the world arena. We should be extremely skeptical, therefore, if sweeping predictions on any subject come tied to a prescription, an exhortation for urgent and sweeping action. We have all heard the apocalyptic pairs of alternatives: "Destroy the Russians or they'll destroy us;" or "Disarm or face world annihilation." These are counsels of desperation, fear of the dark. They abandon not only patience, but intelligence.

However, if uncertainty is hard to tolerate, it is nonetheless a very pervasive and hard fact of life. It demands today flexibility, preparedness to change direction with new knowledge, and the use of every shred of knowledge that we have. This last includes our knowledge of the glacial slowness of the cold war's receding. We have interests in common with our opponents, but we deceive ourselves when we talk of these as overriding all others. The utopian proposals urged today by so many scientists and technologists ignore the durability of our political problems by calling for a final and immediate solution.

As if the problem of peace were not enough to settle all at once, such prescriptions for its solution are frequently coupled with recipes for solving the extraordinarily resistant troubles of the less developed countries. It is frequently suggested that we can stabilize the peace and launch the less developed countries into self-sustaining growth at one stroke, simply by devoting all or most of the money spent on national defenses throughout the world to provide capital for these areas. Such formulae hardly take seriously either problem: keeping the peace or economic development. Economic and political self-development for the less developed areas is not at all likely to be accomplished either quickly or by any simple formula. Not, for example, simply by large infusions of capital.

Utopian hopes also flourish in the less developed countries. The stereotyped phrase, "the revolution of rising expectations," sometimes denotes the awareness by the poor of the great gap between the poor and the rich countries. But any suggestion that this gap is likely to be closed in a matter of years, or even decades, encourages false hopes. The stereotype would be better phrased "the revolution of excessive expectations." These problems of technological backwardness, like the problems set by the extreme advance in military technology, are not simply technological. They are embedded in traditional ways of life that offer small incentive to innovation.

Innovation in any case will be no cure-all. The facile assumption that headlong economic development has some automatic connection with the development of democratic forms is little evidenced. The fragmentary evidence available, for example, in the studies of Seymour Martin Lipset, suggests that in the periods of social dis-

location characteristic of rapid industrial advance, totalitarian forms may flourish. Advance, once achieved, can furnish a firm and partial basis for political democracy. But the process of innovation and swift technological advance can be painful. The ecstatic and violent millennial movements of medieval and reformation Europe exploded precisely at the times and places where change had uprooted peasants and journeymen, torn them from the support, as well as the constraints, of kinship, and thrown them into towns.

Millennial prescriptions of scientists and technologists in the advanced countries for the economic development of backward areas, with their simple stress on technology alone and the supply of industrial capital, sometimes even just electric power, form an unfortunately perfect match for some of the millennial characteristics of the leadership in newly independent countries.

John Von Neumann, who of all the scientists wrote most perceptively of our burgeoning technology and small finite world, did not draw the utopian conclusions of many who cite him. On the contrary, he wrote, "[I]t is unreasonable to expect a novel cure-all."

> For progress there is no cure. Any attempt to find automatically safe channels for the present explosive variety of progress must lead to frustration. The only safety permissible is relative, and it lies in an intelligent exercise of day-to-day judgment.
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> . . . . .
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> The one solid fact is that the difficulties are due to an evolution that, while useful and constructive, is also dangerous. Can we produce the required adjustments with the necessary speed? The most hopeful answer is that the human species has been subjected to similar tests before and seems to have a congenital ability to come through, after varying amounts of trouble. To ask in advance for a complete recipe would be unreasonable. We can specify only the human qualities required: patience, flexibility, intelligence.[8]

The sense of my own remarks is much the same. There are without doubt large changes in technology impending. But how fast they will come and just what they will be is not really predictable. Still less are the widespread political and economic consequences of these changes. The future of technology is dark—not black, but obscure. It is better, then, to direct our steps by the small and fitful illumination that we have and will obtain—to move with intelligence rather than simply to make one grand leap in the dark.

The actual rule of law is not likely to come all at once, like the mythical social contract of the eighteenth century philosophers. It will not break out all of a sudden. Instead, it is more likely to be built opportunistically and piecemeal like the common law.

8. Von Neumann, *Can We Survive Technology?*, Fortune, June 1955, p. 106, 152.

The changes coming are neither intrinsically benign nor malign. In any case they are best not viewed in terms of the apocalypse or the millennium. The apocalypse might come, but it need not. And the millennium is not about to.