THE PLACE OF TECHNOLOGY IN CIVILIZATION

By FRED HOYLE

"Technology controls civilization . . . the details and variations in social organizations are relatively unimportant . . ."

ONE OF THE THINGS that I have found over the years, in discussing matters with my colleagues in humanities, is a profound difference of viewpoint between the scientist and the humanist concerning the organization of society. I've noticed that after discussions into human problems, the humanities side usually ends by saying, "Well, all of these problems are really very complicated; a very large number of factors are involved—and *we* think that you scientists are always looking for explanations that are too simple."

On the other hand, reflecting the scientific point of view, I have maintained what I think is the standard belief, in science, that no matter how complicated a problem one has to deal with, a solution can always be found. Some of our scientific problems are indeed complex, but it is curious how often one finds the things that seemed impossible of solution at one time turn out to have a perfectly straightforward and understandable answer. I have felt for some years that the situation with human affairs may be much the same.

Perhaps I should extend this a little. When our friends in the humanities say that ordinary social affairs are very complicated, there is a sense in which they are perfectly right; human affairs are complicated in the

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sense that many factors are involved. But this does not really impress a scientist, because, in science, problems with many factors are often quite as easy to deal with as problems with only a few factors. Let me give an example.

Think about the air in this room. We know that the air is composed of a swarm of tiny particles—there are nearly thirty billion billion particles to the cubic centimeter—so you see that the total number is very large. It would be possible to argue that the whole problem of tracing the properties of all these particles is enormously complicated. They are all jostling each other, colliding with each other, and evidently a detailed tracing of their individual motions would be a problem of surpassing complexity. But that is not how the scientist goes about the matter. Instead of worrying about individuals, he tackles the problem of finding how the particles behave *on the average*. And a calculation of the average situation turns out to be simplified, not made more difficult, by the very complexity of the situation. In a word, the very complexity allows us to adopt the powerful methods of statistics.

The individual and society

This analogy comes close, I think, to the human situation. If one is concerned to describe the fate of a *particular individual, or of a comparatively small group* of individuals, then certainly one has a very complex problem on one's hands that probably cannot readily be solved. But if one is concerned to speak of the evolution of human society as a whole, then, just as with the gas problem, matters become comparatively simple. A great deal of what happens in our daily lives averages out when taken statistically. There are only a few factors happening at any given time that are going to have outstanding effects on the future.

To give you a simple example from history, take the case of Napoleon. Apparently, he produced enormous disturbances in his day, and everybody thought that the things he did were very important. But by now we can see that present-day society would hardly be any different if Napoleon had never lived. The political and military disturbances that he produced were transitory *and did not have a lasting effect. They have* averaged out to zero.

Simplicity in complexity

Well, that is the main background for what I am *going to say: that, while on the surface human affairs* are complex, underneath, on the large scale, things are really quite simple.

Perhaps next I ought to say what factors of the human problem I think to be important, and what factors I believe to be unimportant. First then, what are the things that don't matter? Here are a few of them: The constant striving of one community against another; war; the particular social organizations adopted by different communities. These are the things that we spend a great deal of time on, and these are the things that average out to zero. By contrast, the things that do matter are the making of technological discoveries, and this brings me to the case that I wish to make—that technology controls *civilization, and that the details and variations in social* organizations are relatively unimportant, except where the social organization in some degree affects technology itself.

Now, shall we look at the evidence for this view? One can readily see the importance of technology by comparing our present situation here today with the position of Stone Age man. Stone Age man had the same earth, he had the same resources as we have today, but he could do little with them. Why? Because he did not have the "know-how." He did not have the technology. Notice that Stone Age man was not lacking in brains. (We have pretty fair indication from certain activities of Stone Age people that their mental stature was not much inferior to ours, if it was at all inferior.) He was lacking in knowledge.

So we can certainly say that technological discoveries *make an enormous difference, because, if we didn't have* the "know-how," we would be back—right now, at this minute—in the Stone Age. I often think that the best reply to anyone who affects to despise technology would be: "You despise technology? All right then, back you go to the Stone Age!"

Technology in the Stone Age

Even to the Stone Age people themselves, technology was a very important matter. The Stone Age, which I am speaking of rather loosely now, lasted from about 200,000 years ago to about 6,000 years ago. Over that period there were important changes and great inventions. Man had very little 200,000 years ago. He didn't know how to clothe himself; he didn't even know much about how to provide shelter. His tools—his equipment for dealing with situations that might arise in hunting, for example—were no better than odd bits of stones that he had managed to pick up off the ground. Then, over the millennia, people discovered that one could make better tools, not by picking up stones in their natural state, but by shaping them.

It is rather curious that two independent methods of shaping were discovered. In one case people took stones and chipped bits off until the required shape was left. The other technique was to take larger stones and to make tools out of the chippings. In one case it was the core that was wanted, and in the other case it was the bits that were chipped off that were wanted.

A fighting matter

The surprising thing is that great areas in Europe and Asia would use one system almost uniformly, and other areas would use the other system. I have no doubt that, when the two groups came in contact with each other, they fought fiercely over which way was best to cut up stones.

Then, men learned how to make more refined tools—axes, spears, the harpoon, and the bow and arrow. Bone needles were used in the making of clothes, and tents were made out of the hides of animals.

Even these crude developments made it possible to provide for more and more people on the earth. But the really great discovery that enabled man to increase enormously in number was, of course, agriculture. Without the invention of agriculture, made some seven or eight thousand years ago—without the deliberate sowing of seeds and the reaping of crops—no large-scale social organization would have been possible at all.

The origin of civilization

Agriculture made it profitable for people in certain regions to live together in farly large numbers, particularly in river valleys, where it was possible to use irrigation methods. In Mesopotamia, for example, productivity was so much increased that a large concentration of population arose. This was the beginning of the type of social organization that we call civilization. So the origin of civilization itself was made possible by a technological discovery—namely, the discovery of agriculture. (You will realize from this remark that I am using the world "technology" in a very wide sense; to cover both the acquisition and the application of knowledge. This includes the activity that we normally call "science.")

The greater number of people that could be supported by the discovery of agriculture led to further discoveries, of which the most important was the discovery of methods of working metals; in particular, of copper and its alloys. Also, because of people coming to live together in increasing numbers, it became important that methods of writing things down should be available, to tell where a man's land started and where it ended, how many cattle he had, and things of that sort. In this way, came the beginnings of the intellectual inventions of writing, and of numbers, and the beginning of calculation.

Achievements of ancient civilizations

So we see the technology of agriculture leading to civilization, and, following that, civilization itself producing several far-reaching discoveries. That really, however, is the sum total of what the ancient civilizations achieved, insofar as their achievements have effect on us today. It is true that they formed their different communities, that they had their social organizations, and they fought with each other in a never-ending series of wars—but by now those activities count not a jot. It is only the things they discovered that are of any importance.

When the next important discovery was made, it did not come from civilized people at all; centuries of disturbance and fighting so befuddled the wits of civilized man that he became incapable of making further discoveries. The next discovery, coming from a barbarian tribe, was the discovery of how to smelt iron; an enormous discovery, because iron is a cheap metal as well as a very strong one. Because of its cheapness it became possible for the common people to possess iron tools, in a degree that had not been possible when copper and bronze were the main metals. This meant that farmers no longer had to till the ground with crude stone ploughs, or hack away at it with stone axes. From then on they were able to have iron tools for farming.

Civilization swings West

This had a great effect in swinging civilization away from its origins in the East. It was no longer necessary for men to be congested in the river valleys. The greater territories around the Mediterranean Basin and in Western Europe became available, once iron tools for breaking up the earth were available. So we see the swing of civilization to the Mediterranean Basin. This change was aided by a gradual change of climate that had been going on for several thousand years, which was making the territories occupied by the older civilizations somewhat too arid.

Now I would like to say just a little about the Mediterranean civilizations, and about the Roman civilization in particular, because it was the Roman civilization that led into our own. The Roman society was in essence anti-democratic. It evolved into an aristocracy that controlled everything. The ordinary people were given practically nothing, and they got increasingly less as the civilization went on. Indeed, the aristocracy reached a stage where it could see little point in keeping large numbers of poor people alive, and the condition of the ordinary people was so depressed that the population began to fall, simply because the poorer people were not able to get enough to eat. As time went on, the population declined until the aristocracy even reached the stage where it was not willing to support the Roman army. It was this that caused the collapse of the Roman Empire.

Now the importance of this anti-democratic society, from our point of view, is that it continued on in Europe in the form of the feudal system. Under the feudal system, society moved along on a very low population level. The leaders took most of the productivity and allowed very little for the support of the ordinary people.

A shortage of people

In such a condition, about a thousand years ago, something rather curious happened. Devastating plagues began to sweep across Europe. In these plagues a very large proportion of the population died; a third or sometimes a half of the people might be wiped out in a matter of a few months. Now, in a population which was already down to a very low level, such a plague was a far more serious matter than it would have been to the overflowing populations of the earlier civilizations.

The effects of the plagues turned a low population into a real shortage of people.

This had two important effects; one was the search for machines that would take over the work for humans, so that human muscle-power was no longer required. Thus, we find a tremendous spurt of invention, starting about a thousand years ago. This was the start of modern technology, which has accelerated as the centuries have gone by.

The second effect was a reversal of moral values. The shortage of people led to the basis of our modern ideas of the value of the individual. What had started under the Romans as stark anti-democracy evolved into the most democratic society that the world has ever seen. Our present sense of values, our ideas of liberty, our bills of rights, are a product of Roman anti-democracy—a curious reflection.

The average share

This brings me to the last part of my talk. I would like to pin my conclusions down to a sharp form, and then to examine very briefly their implications. Technology decides how much we can produce. If we take the productivity of a community and divide the productivity by the population, then we arrive at what can be described as the average share. The average share decides in a very large measure the evolution of a community.

I would regard the general spirit of activity which is present here in the United States as in a large measure due to the fact that the average share is increasing and has been increasing for some time. In contrast, if we take the opposite case, where the average share decreases, then we have ample historical evidence to show that decadence and collapse is likely to ensue.

I think that the issue of whether a civilization rises or falls is really as simple as this—a rise if the average share is increasing, a fall if the average share is decreasing. If, indeed, I am at all correct in imagining that this is a basic feature of human organization, then we can reach very firm conclusions in regard to the future. We can see that the way into the future is to plan that the average share increases rather than decreases.

Now this is a matter that raises very important questions, because our productivity is something that is not guaranteed to us. It is true that, in a large measure, the earth will continue to yield its agricultural productivity so long as we have the machines with which to deal with our agricultural problems. But if we were suddenly reduced to using stone tools, then, of course, our agricultural productivity would decline enormously. So it is obviously vital that we maintain our industrial technology. The maintenance of our industrial technology is dependent largely on whether we can maintain a large supply of power and of essential metals.

As regards power, the position is not immediately serious. We now derive most of our power from coal and from oil. It is true that supplies are limited—one might say limited to about 500 years—but even if we imagine that we reach the stage where coal and oil become exhausted, then, even so, there remains the possibility of using either atomic power or solar energy.

Speaking personally, I don't think that atomic power is going to be able to take over in the long run from coal and oil. I think it will become a useful addition, but it is hardly an ultimate solution. On the other hand, plenty of energy is falling on the earth's surface every day, being radiated from the sun. Plants manage to use some of this energy. Indeed it is this energy that keeps us going physically; when we eat, we are in effect using the energy supplied to us by the sun. Eventually we shall probably be forced to use the sun's radiation in order to run industrial machinery. This would have the great advantage that effectively no limit exists to the length of time that the sun will make its radiation available. It will remain available for some thousands of millions of years, and that is as long as most of us wish to look ahead.

When we come to metals, the position is more serious, however. Already the lifetime of worked mineral deposits is of the order of fifty years for many metals. It is true that new discoveries may extend this a little, but we can see ahead of us, possibly not in our own lifetime but at least in the lifetime of our children, the day when metal deposits, in the concentration that we now regard as economically useful, will become exhausted.

The problems ahead of us

This doesn't, of course, mean that the total supply of metals will be exhausted, because we can always go to lower and lower grades of ore. But when one goes to lower grades of ore, new processes are required to enable the ore to be smelted in an economical way; that is, by the expenditure of a reasonable amount of energy. Unless such processes can be found the consequences will be serious. If it should become extremely troublesome, for instance, to smelt a very low grade of copper ore, then effectively we shall have lost our supply of copper, which means that we shall have lost the most effective material for use in our electrical machines. So, for this reason, I would say that anyone who discovers how to smelt very low grade ores in an economical way will have a far greater effect on the future of humanity than any of our other apparently more important political activities.

The case of copper is illustrative of the problems that lie before us. Our present technology certainly is not going to be enough. New and important developments will be necessary—and in the not very distant future—if civilization is to avoid running into a period where the average share begins to decline disastrously. And I say again that the time when this problem will overtake us is really not very far away. The time is short, but if we realize the importance of what we are doing, of technological processes, of industrial know-how, then although the time is short, I think it is perhaps sufficient.

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