Barry Commoner

SCIENCE & SURVIVAL

An eminent scientist shows how dangerous flaws in the structure of science threaten our existence and suggests what might be done to avert the ultimate blunder.

/ A Viking Compass Book

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For Gloria

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SCIENCE AND SURVIVAL

1

Is Science Getting Out of Hand?

THE age of innocent faith in science and technology may be over. We were given a spectacular signal of this change on a night in November 1965. On that night all electric power in an 80,000-square-mile area of the northeastern United States and Canada failed. The breakdown was a total surprise. For hours engineers and power officials were unable to turn the lights on again; for days no one could explain why they went out; even now no one can promise that it won't happen again.

The failure knocked out a huge network which was supposed to shift electric power from areas with excess generating capacity to those facing a heavy drain. But on that night the power grid worked against its intended purpose. Instead of counteracting a local power failure, it spread the trouble out of control until the whole system was engulfed and dozens of cities were dark.

The trouble began with the failure of a relay which controlled the flow of electricity from the Sir Adam Beck No. 2 power plant in Queenston, Ontario, into one of its feeder lines. The remaining lines, unable to carry the extra load, shut down their own safety switches. With these normal exits blocked the plant's full power flowed back along the lines that tied the Queenston generators into the U.S.–Canadian grid. This sudden surge of power, traveling across New England, quickly tripped safety switches in a series of local power plants, shutting them down. As a result the New England region, which until then had been feeding excess electricity into the Consolidated Edison system in New York, drained power away from that city; under this strain the New York generators were quickly overloaded and their safety switches shut off. The blackout was then complete. The system had been betrayed by the very links that were intended to save local power plants from failure.[1]

In one of the magazine reports of the great blackout, there is a photograph [2] that tells the story with beautiful simplicity. It shows a scene in Consolidated Edison's Energy Control Center. Stretched purposefully across the photograph is an operational diagram of the New York power system; an intricate but neat network of connections, meters, and indicators symbolizing the calculated competence of this powerful machine. In the foreground, dwarfed by the diagrammatic system and in curious contrast to its firm and positive lines, is a group of very puzzled engineers.

This same contrast between man and machine is expressed in the accompanying text:

> The Northeast grid was magnificently interconnected and integrated. But only machines spoke over it, one to the other. They asked each other mechanical questions and gave each other mechanical responses. No human responsibility had

immediate control over this entire system. Thus, no human being can answer the still-unanswered question: Why?

But this electronic thinking did not protect the people of the city.

It was required that New York come to the brink of chaos to refresh an old truth: People—men of frailty, judgment and human decisions—must control machines. Not vice versa.[3]

One man, however, if he had lived to see it, would not have been surprised by the great blackout—Norbert Wiener, the mathematician who did so much to develop cybernetics, the science which guides the design of complex electrical grids and their computerized controls. Cybernetics has produced electronic brains and all the other marvelous machines that now operate everything from election reports to steel plants; that have made the robot no longer a cartoon but a reality; that made the U.S.–Canadian power grid feasible.

Just six years before the blackout Dr. Wiener reviewed a decade of remarkable progress in the science which he helped to create.[4] He reported at that time on the development of a new kind of automatic machine, a computer that had been programmed to play checkers. Engineers built into the electronic circuits a correct understanding of the rules of checkers and also a way of judging what moves were most likely to beat the computer's opponents. The computer made a record of its opponent's moves in the current and previous games. Then, at great speed, it calculated its opponent's most likely moves in any given situation and, having figured those out, adjusted its own game, move by move, to give itself the best chance of winning. The engineers designed a machine that not only knew how to play checkers but could learn from experience and actually improve its own game.

Dr. Wiener described the first results of the checkers tournaments between the computer and its programmers. The machine started out playing an accurate but uninspired game which was easy to beat. But after about ten or twenty hours of practice the machine got the hang of it, and from then on the human player usually lost and the machine won.

Dr. Wiener emphasized this point: Here was a machine designed by a man who built into it everything that it could do. Yet, because it could calculate complicated probabilities faster than the man could, the machine learned to play checkers against the man better than he could against the machine. Dr. Wiener concluded that it had become technically possible to build automatic machines that "most definitely escape from the complete effective control of the man who has made them."

The U.S.–Canadian power grid is just such a machine. By following the rules built into its design, the machine acted—before the engineers had time to understand and countermand it—in a way that went against their real wishes.

One month after the great blackout, there occurred in Salt Lake City, Utah, a little-noticed event that can take its place beside the power failure as a monument to the blunders which have begun to mar the accomplishments of modern science and technology. There, nine children from Washington County, Utah, entered a hospital for tests to determine whether abnormal nodules in their thyroid glands were an indication of possible thyroid disease: non-toxic goiter, inflammation, benign or malignant tumors. Fifteen years earlier these children had been exposed to radioactive iodine produced by fallout from the nearby Nevada atomic test site.

It will be some time before any one can tell whether the incidence of thyroid nodules in this group of children is statistically significant, and if so, whether the nodules are really due to fallout. But regardless of the outcome, the mere fact that health authorities felt compelled to look for an effect of fallout on the health of these children is itself a surprise.[5]

The chain of events which brought the children into the hospital began in the 1950s when the AEC started a long series of nuclear explosions at its Nevada test site in the conviction that ". . . these explosives created no immediate or long-range hazard to human health outside the proving ground." [6] But among the radioactive particles of the fallout clouds that occasionally escaped into the surrounding territory was the isotope iodine-131. As these clouds passed over the Utah pastures, iodine-131 was deposited on the grass; being widely spread, it caused no alarming readings on outdoor radiation meters. But dairy cows grazed these fields. As a result, iodine-131, generated in the mushroom cloud, drifted to Utah farms, was foraged by cows, passed to children in milk, and was gathered in high concentration in the children's thyroid glands. Here in a period of a few weeks the iodine-131 released its radiation. If sufficiently intense, such radiation passing through the thyroid cells may set off subtle changes which, though quiescent and hidden for years, eventually give rise to disease.

Like the Northeast blackout, this too is a chain reaction. Where the blackout reaction chain took minutes, the iodine-131 chain took days and in a sense years. But in both cases the process was over and the damage done before we understood what had happened.

Modern science, and the huge technological enterprises which it produces, represent the full flowering of man's understanding of nature. Scientific knowledge is our best guide to controlling natural forces. In this it has been magnificently successful; it is this success which has given us the marvels of modern electricity, and the tremendous power of nuclear bombs.

The power blackout and the Utah thyroid problem have cast a shadow—small, but deeply troubling—over the brilliance of these scientific successes. Is it possible that we do not know the full consequences of the new power grids and the new bombs? Are we really in control of the vast new powers that science has given us, or is there a danger that science is getting out of hand?

2

Sorcerer's Apprentice

We are surrounded by the technological successes of science: space vehicles, nuclear power, new synthetic chemicals, medical advances that increase the length and usefulness of human life. But we also see some sharp contrasts. While one group of scientists studies ways to provide air for the first human visitors to the moon, another tries to learn why we are fouling the air that the rest of us must breathe on earth. We hear of masterful schemes for using nuclear explosions to extract pure water from the moon; but in some American cities the water that flows from the tap is undrinkable and the householder must buy drinking water in bottles. Science is triumphant with far-ranging success, but its triumph is somehow clouded by growing difficulties in providing for the simple necessities of human life on the earth.

Our Polluted Environment

For about a million years human beings have survived and proliferated on the earth by fitting unobtrusively into a life-sustaining environment, joining a vast community in which animals, plants, microorganisms, soil, water, and air are tied together in an elaborate network of mutual relationships. In the preindustrial world the environment appeared to hold an unlimited store of clean air and water. It seemed reasonable, as the need arose, to vent smoke into the sky and sewage into rivers in the expectation that the huge reserves of uncontaminated air and water would effectively dilute and degrade the pollutants—perhaps in the same optimistic spirit that leads us to embed slotted boxes in bathroom walls to receive razor blades. But there is simply not enough air and water on the earth to absorb current man-made wastes without effect. We have begun to merit the truculent complaint against the works of the paleface voiced by Chief Satinpenny in Nathanael West's *A Cool Million:* "Now even the Grand Canyon will no longer hold razor blades."

Fire, an ancient friend, has become a man-made threat to the environment through the sheer quantity of the waste it produces. Each ton of wood, coal, petroleum, or natural gas burned contributes several tons of carbon dioxide to the earth's atmosphere. Between 1860 and 1960 the combustion of fuels added nearly 14 percent to the carbon-dioxide content of the air, which had until then remained constant for many centuries. Carbon dioxide plays an important role in regulating the temperature of the earth because of the "greenhouse effect." Both glass and carbon dioxide tend to pass visible light but absorb infrared rays. This explains