ADVENTURES
OF
THE
MIND
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The
False Images
of Science

By GERALD HOLTON

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Of the influences that shape man's actions, none is more powerful than the images we carry in our heads. Every subject is apt to invoke in our minds a specific image, made up of concrete information, misinformation, folklore, desire and prejudice. Thus, how people see themselves as a nation determines to a large extent how they will respond to any new challenge. The roles we play in our family life, particularly with respect to our children, depend greatly on what roles we assign ourselves in the society around us.

In the same way, our images of science vastly affect the relationship between science and society. Practically, these images determine the level and the sources of financial support, the quality and quantity of instruction offered, and the development of new scientists. The effects on professional morale and the goals scientists set for themselves—in short, on the scientists' image of their own work—are also considerable. But even more important is the role images play in deciding this urgent question: Can scientific activity be an integrated part of our culture, or will it be forced to develop independently? Right or wrong, ideas are powerful. Therein lies the chief danger of false images. Like bad grammar, bad images become dominant when they gain wide currency, and so undermine communication among thoughtful people. It is high time, therefore, to consider the prevailing public images of the role of science, using the most straightforward language possible.

Pure Thought and Practical Power. Each person's image of science is different from the next, but all are composed of seven main elements. The first goes back to Plato and portrays science as a tonic with double benefits—science as pure thought helps the mind find truth, and science as power provides the tools for effective action. The main flaw in this image is that it omits a third vital aspect. Pure science allows us to understand the physical world and, through its applications, allows us to control and change.

About the Author

Gerald Holton, professor of physics at Harvard University, is active in three fields—physics, teaching and scholarly editing. Doctor Holton pursues experimental research on the properties of materials under high pressures; he teaches and writes in the fields of physics and the history and philosophy of science; and he is also editor-in-chief of Daedalus, the journal of the American Academy of Arts and Sciences. Born of Austrian parents, Doctor Holton is thirty-seven years old. Photograph by Arnold Newman.
that world. But science also has a mytho- poetic function; that is, it generates an inner reality, a world of its own, and provides some of the meta- physical analogues of our own personal constructions of our ideology.

As a consequence, the methods of argu- ment of science, its conceptions and its models, permeate first the intellectual life of the time, then the tenets and usages of everyday life. Our language of ideas, for example, owes a debt to the science of statics and hydraulics and the model of the atom in its particular and sometimes powerful analogies in many fields of study. Guiding ideas—such as conditions of equilibrium, centrifugal forces, con- servation laws and the balance of energy or power, feedback, inertia and compli- mentarity—enrich the general arsenal of imaginative tools for thought. All philo- sophers share with science the need to work with concepts such as space, time, quantity, matter, order, law, causality, verification, reality.

A sound image of science must, there- fore, embrace this third function, in addi- tion to the first two, of interpreting and to practical applications. Howev- er, more usually, only one of the three is recognized. For example, folklore some- times depicts the life of the scientist as a lonely, isolated, divorced from life and beneficent action in the larger sense.

In some extent science was pushed in this way, and it contributed to the xenon- drous tendency of some philosophers to prophesy a general system of values and problems which science could not solve at the time. Newton himself, who was deeply interested in theology, wrote, "It is not to be conceived that mere mechanical causes could give the good or the bad to the do- mensions [in the solar systems]. . . . This most beautiful system of the太阳s could only proceed from the counsel and dominion of an intelligent and powerful Being.

The same attitude governed thought concerning evolution. It is well known that the theory of biological evolution, the doctrine of descent with modification, is more than a century old. Many scientists, including Thomas Huxley, stated that evolution is a fact of life. Indeed, when one begins to think about the evolution of life, it is as if the whole subject is not as it blanchemous. The re- verse is of course true. The very fact of the evolution of science, is equally precarious, for scien- tific knowledge continually grows, super- cede, revisions, and corrections, and the power to secure foundation for religious belief, as an ultimate justification of the facts that it teaches, is not the capacity nor the failure of man, but rather the limits of his science—not the limits of his science—but faith.

Today political overlayers make a wider understanding of science’s formation before our urgent and more difficult. "Religious propaganda," a recent dispatch in Iron Curtain countries advised, must be con- teracted by "scientific authent-ic propaganda" distributed by local societies for "the dissimulation of political and socialthinkers and innovators. Plateiacondemned goodbye social science for leading to impety and immaturity, and the same conclusion is given by the study of the history of science. In a sense, a world always has to do with creativity, innovation and new. A valid science is a product of freedom, particular and rapid, and therefore particu- larly useful. To the end of the 20th century, science now has so sharpened the knife edge of civilization that the maxim of science has been refined: one target area should be maintained at a prime target of suspension.

The fear behind this attitude is genuine, but not confined to science. It is also di- rected against writers, artists, philoso- phers, theologians, and the fact that science is just as asphyxiated. The re- verse is of course true. The very fact of the evolution of science, is equally precarious, for scien- tific knowledge continually grows, super- cede, revisions, and corrections, and the power to secure foundation for religious belief, as an ultimate justification of the facts that it teaches, is not the capacity nor the failure of man, but rather the limits of his science—not the limits of his science—but faith.

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like a tree, ring by ring. Einstein did not prove the work of Newton wrong; he provided a larger setting within which some contradictions and shortcomings of the older physics disappeared.

But the impact of science as an ecological disaster can be subjected to a more severe critique. Regardless of science's part in the corrosion of absolute values, have those values really given us a safe anchor? A priori absolutes stand still over the globe in completely contradictory vacuums. Most of the holistic philosophies that have been carried out under the banner of some absolute philosophy, from the Artec masterpiece to the auto de fe of the Spanish Inquisition, from the massacre of the Hui People to the gas chambers. It is at best an optical illusion which makes the fourth dimension look so sincere and desirable to modern critics of the recent, "scientific" periods, just as it is the life of the "noble savages," as esteemed by eighteenth-century philosophers, has been seen as what it is, and who it is.

Science, as the last four images imply a revulsion from science. We might describe the next one as addition to science. Scientist divides all thought into two categories—up-to-date scientific knowledge and philosophical speculation. To write this to science, but most of its adherents are outside the movement. Among the social studies, for example, there are some of the seductive ideas that the mathematical sciences offer the only permissible models for successfully filling science.

A far more significant symptom of science is the growing identification of science and technology. The work of the huge sums spent annually on science and technology—about $10,000,000,000 this year in the United States alone—that is at least 8 cents devoted to real basic research.

Not long ago the typical scientist worked alone or with a few students and colleagues and built his own equipment with "love, string and sealing wax." Today he usually belongs to a group working under a contract with a sizable annual budget. In the research institute of one university more than 1500 scientists and technicians are grouped around a set of multimillion-dollar machines; the money comes from the government, whose ultimate aim is national defense.

In some cases, these large-scale scientific enterprises, when combined with administration, university science, industry and the military establishment, have rapidly become uneconomic to satisfy all three. The war against science has therefore become a large-scale operation with a potential for immediate and world-wide effects. It is not frivolous to call physics the livelihood of political science today. If for some reason all physicists in the United States headed for a computer, nobody would be more deeply disturbed than would the Congress and the State Department.

These are merely indications that we are passing through a revolutionary change in the nature of science. The effective cause was the perfection and dissemination of basic research by teams of specialists with widely different training and interests. The result is a splendid increase in scientific knowledge, but also the side effects such as analogous to those of sudden and rapid urbanization—a strain on the organization facilities of an administrative bureaucracy, the derestorization of some human relations, emigration. To a large extent, one of the most succesful fruits of the new science revolution will justify itself by the flow of results and the material benefits that will no doubt follow. The danger, the point where the new science can come true, lies in the stagnation of this negenti with the mechanism of scientific research may change. The nonscientist realizes that the old common-sense ways of understanding the world have become obsolete. Eyes and ears are rugged; knowledge is stubble under his feet; gone are the simple interpretations of solids, and the smoothness, explained, undecidable and open to change. About the basic concepts of modern science that define the character of part, reality, he knows only that he cannot grasp them and never will.

On the second level of ignorance, the contemporary intellectual fails to understand how the differences between one another with the religions as different as the way we eat in one cosmos. He has left behind those great systems which once comprised our intellectual and moral core—the cosmic view of the book of Genesis, Homer, Dante, Milton, Goethe, Kant. What he has left behind himself blinding fixed in a maze without the brutal fact is that to know science is to come to an understanding of the difference between the modern and the organized religion, which is this great challenge before intellectuals to-day. And nothing better illustrates the urgency and difficulty of this task than the false images prevailing about science.

For readers who wish to pursue the subject further, the following books are recommended:

**Holton, Geraod Introduction to Concepts and Theories in Physical Science Addison-Wesley Publishing Company $7.30**

**Holton, Geraod, Editor Science and the Human Mind Beacon Press $6.95**

**Frankel, Charles The Case for Modern Man Beacon Press $1.75**

**Brouwer, Jacob The Common Sense of Science Harvard University Press $2.00**

**Blanchard, Paul, Editor Education in the Age of Science Basic Books $4.50**

**What remedies suggest themselves? At the least, science must again be made a natural part of every intelligent man's common literacy—not because science is more important than other fields, but because it is an important part of the whole Jigsaw puzzle of knowledge. This would require means, through work at every level of education—for example, a good part of an eight-hour work week, as used to be the rule in good colleges fifty years ago. It would demand imaginative new curricula, strengthened standards of achievement, more recognition of excellence wherever exhibited by instructors or by students. Adult education, including the extension of the faculty and the pursuit of cultural aspects of science through mass media, is an obvious measure merit ing the support and participation of our best minds.

Here and there, to be sure, some efforts are being made in the right direction, but the total is pitifully small. Virtually nobody has been courageous enough to face the magnitude of the problem squarely, so large is the range and amount of knowledge needed before one can "know science" in any real sense. The converse need—namely, the humanistic education of scientists—is also urgent, but at least in principle it can be served with existing methods of instruction. The tools of humanistic study are still in touch with our sensibilities. This, unhappily, is no longer so in science.**