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-
ploy function: that is, it generates an in-
visible mythology and provides some of the me-
chanisms by which a society can generate the
visions of its ideology.

As a consequence, the methods of ar-
gument of science, its concepts and its
models, permeate first the intellectual
life of the time, then the tenets and usage
of everyday life. Our language of ideas, for
example, owes a debt to the science of
statics and hydraulics and the model of
the quantitative two-dimensional.

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, invariant com-
plementarity—enrich the general arsenal of
imaginative tools. I think that science is
keenly aware of its relationship with the
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 two referring to theory for-
ning and to practical applications. How-
ever, 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 other sense.

So to some extent science was pushed in this direction by the increas-
gening tendency of some philosophers to promote the rise of science
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 any light to such important ques-
tions (in the solar system). ... This most
beautiful system of the suns, planets, and
comets could only proceed from the
conceit and wisdom of an infinite and
powerful Being." The same attitude governed
thought concerning the natural world before the
theory of geological evolution, the discovery of the principle of
biological evolution, and the origin of the
Galaxy before modern cosmology.

This aspect of the conflict between scien-
test and religion results largely from a
misunderstanding of the concept of
vision. To base one's religious belief on an
experience of the scientific method is as
foolish as it is blasphemous. The re-
volution in the basic concept of science, is equally precarious, for
scientific knowledge continually grows, super-
vised and confirmed by the test of the
method. Science has always been the most
secure foundation for religious belief, as, for
example, for most religious thinkers have
accepted science in order to follow it.

The third and the least understood of
these, and the one to which I think we are
most prone to fail, is the concept of
knowledge. Science has always been the
most secure foundation for religious belief, as, for
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The fear behind this attitude is genuine,
but not confined to science. It is also di-
ected against writers, artists, philoso-
physicians, theologians, for whom the
one common denominator is a belief that
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Not long ago the typical scientist worked alone or with a few students and colleagues and built his own equipment with a "love, sweat and tears". 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. Many changes occurred in the university science, industry and the military establishment in the last three decades. Science has thereby become a huge-scale operation with a potential for immediate and worldwide effects. It is not frivolous to call physics the liveliest political science today. If for some reason all physicists in the United States needed a call for a conference, 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 production and dissemination of new research by teams of specialists with widely different training and interests. The result is a splendid increase in scientific knowledge—out of which the side effects are analogous to those of sudden and rapid urbanization—a strain on the organization facilities of an administrative bureaucracy, the depersonalization of some human relations. To a large measure, this development is unavoidable. The new scientific revolution will justify itself by the flow of results and the material benefits that will no doubt follow. The danger, the point where the judgment of the judges will begin, is a friction between the mechanism of scientific research and the social setting that sustains it.

The new science requires a new kind of scientist. The unorthodox, withdrawn individual, on most great scientific achievements have come from the past, does not fit well into the new system. We must keep a special place for the individual scientist—him—if only to symbolize our commitment to science itself rather than to the new machinery. Society, on the other hand, will also have to hold out against the seductive urge to adopt generally the pattern of organization justified by the quality of creative results in a specialized profession.

Might few nonscientists would be likely to suspect a hoax if it were suddenly announced that a team of astronomers who claimed that a new light brighter than hydrogens had been synthesized on earth, or that scientists had beaten Russia in a secret race to establish a manned observatory platform at the surface of the sun. Apparently anything can happen these days; science has no inherent limitations. Thought, the image depicted science as magic, the scientist as a wizard; as we learn on our conversations, we tend either to fear him or to accept him as the proverbial everything. Like the other false images of science, this one is partly an educational problem. All our voracious consumption of technical devices, all our talk about science, and all the monuments and money that are spent on developments cannot hide that most of us are content to remain completely ignorant of science. In a recent nationwide survey, nearly 40 percent of those who had attended college confessed they had not even graduated in a course in new physical or biological science. Those who did devoted generally less than 10 percent of their courses to these sciences. Moreover, in science classes they miss all too often the kind of teacher who can impart to the average student a wider appreciation of both the inherent powers and the inherent limitations of science, who can show how to distinguish challenging from trivial problems, how to detect the insidiousness hidden in the solution by which to dig it forth.

The root of the failure. To expose the falsity of the current images of science is not enough, any more than is treating symptoms rather than the disease itself. The inadequate scientific education the general student receives at all levels is not enough to explain the distortions, but only in part. When we try to understand why people hold these views and why they are so filled with too little knowledge about science, we discover that the major share of the blame does not lie with the ordinary citizen. In this matter he is only taking his cue from the intellectuals—the writers, scholars, lawyers, politicians, scientists and all others who deal professionally in ideas. Among the scientists themselves, busy with exciting work, no one has the time and energy to do anything save to stop their laboratories for a few minutes and tell the public what they are studying. But no one who has taken his time and energy to do anything has yet been able to make a substantial change in the public image of science. We discover that the major share of the blame does not lie with the ordinary citizen. In this matter he is only taking his cue from the intellectuals. But they, too, are not without blame. For example, one has a laboratory and thinks, "What can I do with this knowledge? What can I do with this knowledge?"

Among the roots of the intellectual's conflict are...