

on Science and American Society

Is the public's attitude toward the scientific enterprise shifting? What would such a shift portend for the future of American science and technology? In this exclusive interview, noted science writer Isaac Asimov offers his personal views on these and other issues relating to the state of science and science education in the United States today. The interviewer is Fred Jerome, Information Director of the Scientists' Institute for Public Information in New York.

FJ: Dr. Asimov, you have written several works offering a scientific guide to various parts of the Bible. Your latest book, *In the Beginning*, provides an in-depth analysis of the first 11 chapters of *Genesis*. In view of this, how do you feel about the increasing influence of what is called "creationism" and the political influence of the new wave of religious fundamentalists?

IA: I think it is most pernicious, and something to be fought in every way possible. I believe that the so-called "moral majority" is attempting to put blinders over the American mind, to remold public opinion in its own fashion, and to put an end to any scientific advance in the United States that isn't directly related to weapons and warfare. And I fear that, if the moral majority were to gain its ends, a dark age would descend upon the United States.

FJ: As this country's leading popularizer of science and science fiction, how do you feel about the recent report from the U.S. Department of Education which says that most Americans are headed towards "virtual scientific and technological illiteracy"?

IA: First, I'm not sure I ought to allow myself to be called the foremost science popularizer, because these days, I think by general consent the person holding that post is Carl Sagan. As to my feeling about the statement on illiteracy, I totally agree, except that I don't think this is something new. The American population, indeed the population of any nation, has always been largely scientifically illiterate; the danger is not so much that not enough people are going to know about science but rather that in some camps, science is viewed as the enemy. It's one thing not to understand science, and it's another completely to misunderstand science—to have people feel that scientists and technologists are evil, that their intentions are dangerous, and that only in healthful ignorance can we find salvation.

FJ: Would you say that this attitude toward scientists is a recent development?

IA: There has always been a certain amount of anti-intellectualism in the United States, but now it is focusing in upon science. There are many persons in this country with a considerable

amount of education who know nothing about science, who feel that, because they've learned the terminology, they can lead the fight against science, and do so effectively.

FJ: To what do you attribute this anti-science trend?

IA: For one thing, a major problem with science—something which is at the same time its greatest value to those of us who are science-minded—is its uncertainty, its incompleteness, its openness; that new discoveries are made and that the old ones are invariably tentative; that there is controversy over certain facts. All this gives people the feeling that scientists don't really know what they're talking about. Instead, they would rather turn to non-scientists—people who espouse thoughts which are complete, final, absolutely certain, and who, like the Bible, “have all the answers.” People want certainty. They don't want to be told that two and two may very well be four—until further evidence comes in. They would prefer to be told that two and two is definitely five and a half.

Another problem with science is that people confuse *knowledge* with the *uses* to which knowledge is put. In other words, if politicians, if economists, if industrialists all misuse scientific knowledge for their own short-term gains and, in the process, produce damage of one sort or another, the blame turns upon the scientists who have uncovered the knowledge and who, paradoxically, may be the only ones fighting against such misuse. For example, while it was scien-

least, brought about by our diminishing status as a world science leader. If our problems are to be solved, it will be through the medium of science and technology.” Where does American technology stand today, and is it competitive with that of other nations?

IA: I think that the American technological structure is decaying, that our industries are not in the forefront of technological development. I believe that respect for science is declining, as well as the numbers of young people we are training in science, and that even those whom we are training, we are training poorly. Thus the effect will be a continuing one. The most spectacular aspect of American technology in the last decade—space exploration—is being dismantled. Other nations, notably Japan, are taking over our leadership role in technology, and the Soviet Union is gaining on us in various aspects of technology. Even Western Europe is advancing technologically, which suggests that, if the situation isn't changed, the United States will become a decaying power.

FJ: Do you see any developments in this country which show a promise of reversing this decline?

IA: I see an increasing amount of grassroots support for the U.S. space effort and a growing realization that our going out into space is absolutely essential, not only for our own economy but for the world economy; that in order to be able to support our population, to be able to replace the decaying resource

nology and defense spending will hurt or help our country's scientific enterprise, and thus our world leadership position?

IA: In view of his support of the creationist viewpoint and his campaign criticism of evolution, my feeling is that President Reagan is not particularly science-minded. Therefore, I think that, given his general intention to cut government spending, he will cut any appropriations devoted to extending our scientific and technological knowledge unless he can be convinced that it has a direct and immediate application to defense technology. I imagine that a great many scientists will now, out of self-defense, have to justify their projects on the basis that whatever it is they're doing will help us militarily. You know what they'll say: the paperclips we make will hold together the plans which will be used to build a new bomb, and so forth. And no doubt this will work to a certain extent. All in all, I believe we are in for a dry spell under Reagan, and this is sad.

FJ: Do you think there is a chance that the space program, which not only enjoys popular support but also has a definite military component, might be an exception to that “dry spell”?

IA: I suspect that the Administration will want more “spy” and other defense-oriented satellites, but they are not going to be pushing, for instance, for solar power satellites because Reagan seems to believe thoroughly that all we have to do to find more oil is to look for it.

FJ: Any possibility that the Reagan Administration is likely to appoint a Science Adviser, or a Science Advisory Committee, who might have some effect on these policies? I mean, Eisenhower had Kistiakowsky, and there were other Science Advisers for other Presidents who urged some forward-looking policies . . .

IA: I believe that Nixon, however, lost interest in such things, and I'm afraid that Reagan has lacked interest in them from the start. Those who most eagerly support Reagan, are, I feel, sus-

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tists who made the nuclear bomb possible, it was also they who, from the very start, objected to its use.

FJ: You wrote in *Saturday Review* (August 1980) that “the decline in American world power is in part, at

content of the Earth's crust, we are dependent on the resources of space.

FJ: Do you anticipate any changes in science policy under the Reagan Administration? Do you think the Administration's emphasis to date on applied tech-

picious of scientists, whom they suspect of being liberals.

FJ: If you were appointed Science Adviser, which policies would you make top priority?

IA: The computerization of technology, together with the exploration and exploitation of space. And while I would want to see robots pushed, at the same time I would want to see certain social changes advanced to prevent a developing robot and space technology from having too negative an effect on human beings as far as displacement and job loss are concerned.

You can't have technological advance and social change without trying to take into account its effect on human beings. I think of what happened during the first Industrial Revolution in Great Britain and the absolute horror of the factory system in those early decades of the 19th century, before the reformers succeeded in gaining acceptance for their humane principles and demonstrated that more humane treatment of workers can lead to increased profits. Today, we must ensure that certain measures are taken to prevent the present technological revolution from again producing human misery on a grand scale and we have to avoid callously fluffing off such a situation by saying, "Well, that's the way it is if we're going to advance."

FJ: Could you be more specific about the social measures you would advocate in order to avoid these dehumanizing effects?

IA: First, we have to educate people for membership in a computerized society—to see to it that they understand computers, know how to use them, and aren't made obsolete by them. At the same time, we have to ensure that those people who are either too old or too temperamentally unsuited to work with computerized equipment will be able to locate jobs where knowledge of computerization isn't essential. This is a task for economists or social scientists, who, I assume, would know specifically how this should be done.



ISAAC ASIMOV

FJ: Recently there have been a number of cover-story articles in prominent science magazines dealing with society's fear of computers. According to all these articles, there is a fear that there's going to be an elite core of trained technicians running the vitals of society—which will all be computerized—and that this group will have a tremendous amount of power simply by virtue of their knowledge of this technology. Is "computer literacy" among our young people a way of dealing with this problem and, if so, what steps are the educational community, social planners, or the government taking to help them acquire such literacy?

IA: That I don't know. But I do know that people who are worrying about this are already too late. Throughout our lives we are at the mercy of many different groups of "experts" who run things

we don't know how to operate, that we can't guide in any way. For example, if there's a school custodians' strike, the schools have to close; a rail strike, the cities could starve. In each instance, we can only depend upon the experts' good will and expertise. The computer issue is just one more situation in which we find ourselves at the mercy of a group of experts.

FJ: What is the possibility of—and the danger—in our creating an army of robot-experts whom we will be even less able to guide and control?

IA: When you're a passenger in an airplane, how sure are you that the pilot is a good one, that he happens not to be drunk at the time, or ill? At every step during the day, you are placing your life in the hands of people whose expertise you can't judge. If we indeed think that computer experts are just going to be

button-pushers, then I should think more and more people would want to learn about computers—so they can check on this, so they can work things for themselves.

FJ: Is this aversion of yours to flying a reflection of your estimate of modern technology?

IA: Oh, no. I am sure, despite my previous remark, that the pilots of airplanes by and large are capable and educated, and are perfectly safe. You understand I was merely using it as an example. The reason that I don't fly is a purely irrational fear. It is by no means a carefully thought-out estimate of the dangers involved because I drive freely and without concern on the highways on holiday weekends, and that is a much more dangerous thing to do than taking an airplane, and I *know* it. This is purely irrational. Everyone has his irrational fears—this happens to be mine.

FJ: To come back to "robotics," isn't this a term you developed yourself?

IA: I invented the word, yes, without knowing it. I thought it was an everyday word.

FJ: It seems as if many people today are talking and writing about the possibility of "artificial intelligence," as it is called. Do you envision, in the near future, computers which will be capable of complicated thought, and even expressions of emotion; and do you think scientists should pursue such a goal?

IA: Robots are advancing with great rapidity, far more rapidly than I anticipated. When I started writing my robot stories 40 years ago, I did not really expect to see robots in my lifetime. Of course, the robots we see today are nowhere nearly as intelligent as those in my stories, but we are advancing. However, I am not concerned about their becoming "intelligent."

We must not look upon intelligence as a kind of unitary thing; that is, we must not assume that if two widely different objects are both intelligent, they must necessarily be of equivalent or identical intelligence. For example, we suspect there may be such a thing as dolphin intelligence, but, even granting

The New Science Adviser

In a move which should surprise no one reading this Environment interview, President Reagan has not selected Dr. Asimov to fill the key science role in his Administration. Rather, the President has chosen Dr. George A. ("Jay") Keyworth, a Los Alamos Laboratory nuclear scientist with a background in weapons research and defense technology, for the post of Presidential Science Adviser.

The appointment of Dr. Keyworth, which is still pending Senate confirmation but is generally considered to be without significant challenge, is being viewed with interest by members of the scientific and engineering community; many of them have interpreted Reagan's delay in filling the post as a signal that the Administration intends to downgrade the Science's Adviser's role and to proceed with further science-related budget cuts. The appointment has also drawn comment from others who, while acknowledging Dr. Keyworth's capabilities as a scientist, see his lack of previous experience in science-policy activities as making it difficult to predict the direction he will take and the degree of influence he might have on Administration policy. Keyworth himself regards his role as that of an adviser rather than a lobbyist-advocate.

In what the Washington Star (June 26) calls "an unusually candid maiden speech" delivered last month at an Amer-

ican Association for the Advancement of Science (AAAS) dinner seminar, Dr. Keyworth addressed both the issue of federal funding for basic research—stressing "the need for better targeting of research dollars"—and what he considers to be the key role of science and technology in this country—making "our country's military might second to none." At the same time, he acknowledged his belief that the United States can no longer afford to aspire to be first in scientific research across the board, a point of view which represents a radical departure from the publicly pronounced goals of his predecessors in the job.

In a recent SIPIScope interview (May-June 1981), Dr. Keyworth explained that, beyond national security issues, his "second" but "equal" concern is "the question of productivity and restoration of American preeminence in industry and what the role of government is in this objective." As to charges concerning the current Administration's lack of respect for science, as alleged by Dr. Asimov and others, Dr. Keyworth told SIPIScope: "I have not seen the slightest sign of a lack of respect for science." Moreover, according to the appointee-designate, "Rarely has there been an attitude in the White House that was more realistic or more conducive to the restoration of leadership in science."

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that, it is sufficiently different from our own human intelligence to preclude cross-species communication.

Unlike human intelligence, which has developed over three billion years out of proteins and nucleic acids by random changes, through the pressure of natural selection and with the single goal of *survival*, robots and computers are manufactured out of metal and electricity and solid state switches, a process which has only been going on for 40 years at the most. Moreover, it has not been random change, but change by human guidance, and its ultimate goal is not survival but *the uses imposed upon them by*

human beings. In view of these underlying differences, we might suspect that these two intelligences—even if equal quantitatively—might be very different qualitatively.

In fact, we can already see that it is so: computers in some respects, such as in their ability to perform arithmetical operations incredibly more rapidly and accurately than human beings, are already far ahead of us. And it may be that this is what computers and robots are best suited for—performing repetitive tasks and doing them rapidly—whereas human beings specialize in seeing things as a whole, making judgments

intuitively, insightfully, creatively. Now, it's difficult to see how computers can be programmed to perform these latter functions since we don't fully understand how we are able to do them. And even if we could program computers in this way, we would probably choose not to do so—not necessarily out of fear, but rather because it makes sense to specialize and to establish a symbiotic relationship in which both humans and robots together can advance further than either could separately.

There's not any danger of the computer replacing us. They will supplement us, and, for that matter, we will supplement them.

FJ: I'm wondering whether there might not be a contradiction between that optimistic view of the future of man and technology and your previously voiced concern about the power of those specialists who, both as individuals and as a group, are capable of acting on self-serving motives.

IA: The answer to that is that there is no *one* future; human beings make the future out of a vast array of possibilities. I prefer to consider the future in terms of the *ideal*, wherein all people act sanely and with judgment and decency.

Who is to say that we will? Well, if we do not, we can end up within a generation with a radioactive Earth. We can destroy ourselves in nuclear war, we can refuse to look at the difficulties of increasing population, and we can starve ourselves to death. We can, should we constantly look at only the short-term goals of our particular segment of the human race, kill ourselves in local wars and border skirmishes; or we can, should we perpetuate social injustice and inequities, destroy ourselves by our own violence and crime.

All of these possibilities exist, but so does the potentiality of behaving decently and, in so doing, creating for ourselves a perfectly marvelous future. A Russian journalist to whom I expressed this belief during a recent interview called me a "political vegetarian"—meaning, I think, that I was

too caught up in goodness and niceness in a world in which such commodities do not, in reality, exist, and that I was unwilling to discuss instead the way we can convert the real world into a smoothly functioning, advanced machine. My response to that would be that I don't believe we can turn the world, as it now exists, into such a machine, but neither am I content to believe that the world cannot be otherwise than it is. It may not choose to be otherwise, but it could be.

FJ: Which of these trends do you feel is gaining the upper hand today?

IA: My view changes according to what I see in the morning paper. Whenever I read of some atrocity committed because of something that scarcely seems worthwhile, something which has occurred because someone's so-called "national honor" is at stake, then my spirits fall and I begin to think we won't make it. However, when I reflect on the recent hostage crisis and see the outpouring of good will the human species is capable of and consider that during the 444 days of tension and crisis, those with their fingers on the bombs did not lose their tempers, nor behave stupidly, then I feel a little better about the world's chances.

FJ: To return to our previous discussion about the uncertainty of science,



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do you see a tendency among the popular science media—the magazines and TV series—to emphasize phenomena, breakthroughs, discoveries and to ignore the uncertainties, the mysteries, the questions?

IA: That depends. The stories run the gamut. Obviously, in order to maintain circulation, magazines must present something that will attract readers, and

all too often that material is concerned with the fringe areas of science or the breakthroughs—and the wonder of it all. At the same time, there are publications that are more responsible and that don't try to buy readers at the cost of scientific ethics.

FJ: David Suzuki, who is a professor of zoology at the University of British Columbia and popular TV-show host in Canada, recently expressed sharp disappointment with television as a medium for educating the public in science and cited its failure to get across the most important lesson of science: "critical thinking." Do you agree?

IA: We could hardly expect a TV show to be popular if it consisted only, say, of Isaac Asimov being philosophical and discussing the problem of critical thinking. What the visual media need is something splashy, special effects which give the viewer something to look at. That takes time and money, and doesn't leave much room for careful discussion . . . which, as I just said, could be expected to drive away viewers anyway.

FJ: A generation ago, after the first Soviet sputnik was successfully launched, American schools got a tremendous infusion of science and technology programs. Given that boost, how do you explain the "virtual scientific

and technological illiteracy" which you, and the U.S. Department of Education, believe to be descriptive of the state of so many in the nation today?

IA: We can give the schools all kinds of money and all kinds of equipment for teaching science. But what we continually fail to give them is teachers who know science. Nor can we expect to solve the problem overnight, by throw-

ing money at it. Rather, it's a slow process, one which requires gradual change. We have to teach the teachers first. And we have to stick with it.

The trouble is that all of this worked as long as we thought the Russians were ahead; but once we reached the moon, we said, "That's it," and we quit. Yes, we would have been a lot better off today if the Russians had stayed ahead of us.

traditionally commanded in this country, is still the problem today.

FJ: In 1979 you wrote that "since my hundredth book, my science fiction production has decreased a great deal." What caused this shift in emphasis in your writing and what are you working on now?

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FJ: As a former science teacher yourself, have you any specific approaches or improvements which you would recommend be introduced in science education?

IA: I really don't know. Every once in a while I feel drawn to what Garfield once said: that a real education was Mark Hopkins on one end of the log and a student at the other end. We are still at the point where good teachers are crucial to the education of students. While I hope that computerization will soon make it possible for students to make truly effective use of educational machines—to gather knowledge from a computerized library, and to study on one's own time and in one's own way—students will always need someone to turn to for advice and for an overall view of the material, that is, good teachers. Unfortunately, how we're going to get and keep them, in view of the low salaries and low respect they've

IA: I can't quite explain how I go from one thing to another; these enthusiasms just seize me. The big change for me came at the time the first sputnik went up, when I became aware of the fact that the United States needed to be more scientifically minded and that I could write good science books. I suddenly felt that what I should be doing was to use my expertise for that end. What I failed to anticipate was that publishers were also eager for science books at the time, so that I found myself scribbling them out as fast as I could write and making a reputation for myself as a science writer. Unable to say "no" to these projects, I left myself no time for fiction writing and no time to think about it. Now, however, my publishers are clamoring for a novel, even though I am currently at work on four huge nonfiction projects. They say: "We don't care." Of course they don't care. *I'm* the one who has to face those blank sheets of paper.

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